

Xeriscaping in arid climates

M. Malakar^{*1}, P. Acharyya² and R. Bhargava²

¹Department of Horticulture, University of Calcutta, 51/2, Hazra Road, Kolkata- 700019

²ICAR- Central Institute for Arid Horticulture, Bikaner 334006

*Corresponding authors e-mail: moumitamalakar7@gmail.com

(Received: 27.07.2015, Accepted: 7.01.2016)

Abstract

Xeriscape is a systematic concept for saving water in landscaped areas. Xeriscaping (zer-i-skaping) is a word originally coined by a special task force of the Denver Water Department, Associated Landscape Contractors of Colorado and Colorado State University, USA to describe landscaping with water conservation as a major objective. Even though dry-only landscaping can be quite spectacularly colorful, and even lush, limited areas of more highly watered landscape are completely consistent with wise water use. There are vast arrays of wonderful plants indigenous to all regions, non-invasive introduced plants, that are well adapted to the local regional climate, are wonderful additions to landscaping that uses water frugally. Xeriscape is not necessarily a lawn less landscaping. Some lawns, even of species that are more highly watered, can be consistent with wise water use. "Less-lawn landscaping," rather than "Lawn-less landscaping" is an appropriate statement. On the contrary, well planned Xeriscapes are splendid examples of beauty and diversity.

Key words: Xeriscaping, Xerigation, Xerimulch, Arid.

Introduction

The term "arid" has a range of connotations that vary by culture and historical period. For some, it implies barren wastelands, while for others it evokes landscapes of biological, cultural and aesthetic richness (Anon., 1986). From a scientific standpoint, aridity refers to a scarcity of moisture, in which precipitation is exceeded by potential evapo-transpiration. These varied climatic patterns of water deficit interact with physiographic conditions to produce a variety of arid and semiarid environments (Aga Khan, 1996). Due to this water is a precious resource in high desert and efficient water use is the responsibility of all residents, businesses and public agencies. States of North-western India has a wide range of climate that varies from extremely arid to humid. Desert area generally receives meagre precipitation per year and contain some of the most uninhabitable regions on earth. So the successful development of water-smart-gardening can be an exciting challenge to convert those desert regions into cool, green landscapes full of beautiful plants maintained with water-efficient practices.

Xeriscaping is commonly referred to as water-wise or water-smart gardening (Dwiggins, 1985). Conserving water conservation techniques with landscaping is a concept known as "Xeriscape" or "Dry Landscape". Xeriscaping (zer-i-skaping) is a word originally coined by a special task force of the Denver Water Department, Associated Landscape

Contractors of Colorado and Colorado State University to describe landscaping with water conservation as a major objective (Jhon *et al.*, 1991). The derivation of the word is from the Greek "xeros," meaning dry, and landscaping thus, xeriscaping (Wilson and Feucht, 1996). Xeriscaping combines sound horticultural practices to conserve water while maintaining a beautiful landscape. Professionals and homeowners can take an aggressive and positive attitude toward water conservation in landscape design and management. When basic horticultural principles are employed with an emphasis on water efficiency, landscapes use much less water and are drought tolerant.

Principles of Xeriscaping

The seven water-saving principles of xeriscape landscaping are not new; they have been practiced in the landscape industry for decades. Combining all seven into a comprehensive program of landscape water conservation is what makes Xeriscape landscaping unique (McLean, 1989).

The principles are:

1. Planning and Design
2. Zoning Plants
3. Soil
4. Efficient Irrigation or Xerigation
5. Turf and Turf alternatives
6. Xerimulching

7. Maintenance

Each of this principle should be used while designing and managing landscape. 30 -60% water-use can be reduced if employed on this basic principles of xeriscape (Anon., 1985). In fact, a well-planned xeriscape can be attractive, colorful and very rewarding. Often it is thought that a Xeriscape means the use of all native or low water use plants, resulting in limited plant selection. However, xeriscapes can incorporate hundreds of plant choices including trees, shrubs, evergreens, perennials and grasses (Klassen and Gilpin, 1999).

Planning and Design: Creating a water-efficient landscape begins with a well-thought-out landscape design. When designing a new landscape or renovating an existing one, planning the landscape on paper is the best place to begin. The first step in planning a water-efficient landscape is selection of site followed by drawing of the lay-out of the existing building, driveway, walks and vegetation. Existing trees, shrubs and flower beds are allocated on the design. Careful notes are to be made on sun and wind exposure, topography and drainage. Relationships among all site features are to be considered. Modifications that require grading, paving or construction should be planned at this stage. Existing shade

trees should be left wherever possible because shady landscapes are cooler and need less water than sunny areas. The size of the lawn area is to be decided as often lawns are the single largest user of water in the landscape, so reductions in lawn areas should be done wherever possible. Switching to a more drought-tolerant lawn species can also reduce watering needs.

The site's microclimate is to be outlined on the plan. Microclimates are areas within the design that have environmental condition that differ from the adjacent areas. It also influences the plant selection. For example, a large shade tree on the southern side will lower the temperature and mitigate water demands. Cooler shady areas on the northern side forms a good environment for shade loving plants.

Zoning Plants: The concept is to place plants with the same requirements for water, soil and sunlight into the same areas or hydrozones (watering zones) (Amy Jo Detweiler, 2005). The landscape plant can incorporate "hydrozones" areas within a design that receive either low, moderate or high amount of water. All plants within a zone have the same water requirements and can be watered as a group to make efficient use of irrigation water. Certain planting areas can be designated as low-water-use-zone having low-water requiring plants, will receive little or no extra water after their

Types of Hydrozones

Hydrozone	Supplemental water requirements	Plant type (s)
Very Low	Required for plant establishment.	Most natives.
Low	Some required during growing season	Most perennials, some trees & shrubs.
Moderate	Regular amounts required during growing season	Fruit trees, ornamental trees & shrubs.
High	Regular amounts required during growing season	Turf grass, vegetable gardens.

establishment. A few limited high-water-use-zones may be introduced for specimen plants as an accent or focal point. A vegetable garden or flower border may be considered for this zone. Plant varieties and placements are to be planned accordingly.

Soil: Properly conditioned soil is of vital importance to the health of landscapes. Creating a good soil environment is the key to successful water conservation. In sandy soil, water moves quickly through the profile while in very sandy soil, water and valuable nutrients are also lost due to leaching below the root zone. In sandy soils addition of organic matter can only increase water and nutrient-holding capacity, aeration and drainage. Regardless the soil type, the general

rule of thumb is to amend the native soil with 1/3 organic matter.

Xerigation: Efficient irrigation is the basis of a successful Xeriscape.

Proper irrigation practices can lead to 30 to 80 percent water savings (Christopher, 1988). Tremendous amounts of water are applied to lawns and gardens, but much of it is never absorbed by the plants. Some water runs off because it is applied too rapidly and some water evaporates from exposed, unmulched soil; but, the greatest waste of water is applying too much too often.

Lawns: Turf areas should be irrigated differently than shrub

borders and flower beds. North and east exposures need less frequent watering than south and west exposures. Most lawns receive twice as much water as they need. The key to watering lawns is to apply the water only when the grass needs it. The best types of irrigation for turf grass areas include low pressure, low angle sprinklers that provide head to head coverage. This creates a deep, well-rooted lawn that efficiently uses water stored in the soil. Wilting and discoloration are signs of water stress. At the first sign of wilting, watering should be done within 24 to 48 hours before serious injury occurs.

Trees and shrubs: Newly planted trees and shrubs once established should be watered less frequently so they develop deep roots and are able to withstand drought. For trees, shrubs, and perennials micro-sprays, drip emitters, or bubblers are used. The feeding root system of a tree or shrub is located within the top 12 inches of the soil and at the "dripline" of the plant (Sweeney, 1988). Water and fertilizer are applied from just inside to a little beyond the dripline.

Irrigation systems: The irrigation system should be so designed that plants receive only the water they actually need. By zoning an irrigation system, grass areas can be watered separately and more frequently than ground covers, shrubs

and trees. Sprinkler and drip irrigation can be used together to conserve water in the landscape. A permanent sprinkler system can be more water-efficient than a hose-end sprinkler, but both systems require little maintenance and apply large volumes of water in a short time. In areas where water quality is poor (i.e., high salt content), drip irrigation is safer for landscapes. There is little chance that water applied through drip irrigation will be wasted by evaporation or runoff (Springer, 1994).

Now-a-days Smart Watering Application Technology (SWAT) are used for xeriscaping as it monitors and use information about environmental conditions for a specific location and landscape. This information includes soil moisture, rain, wind, the plants' evaporation and transpiration (ET) rates, and in some cases, plant type and is used to determine when to water providing exactly the right amount of water to maintain lush, healthy growing conditions (Privette, 1987).

Turf and Turf Alternatives: When designing the landscape, it should be kept in mind that turf grasses need more water and maintenance than most other plants. Proper site preparation in establishing turf is essential in maintaining a healthy, water efficient lawn. To conserve water, the size of the lawn may be reduced by including patios, decks, shrub beds and

Examples of drought tolerant grass species.

Common name	Scientific name	Particulars	
Bermuda grass	<i>Cynodon dactylon</i>		Good drought tolerance; produces dense turf; poor shade tolerance; plant seed or sod.
Buffalo grass	<i>Buchloe dactyloides</i>		Excellent drought tolerance; produces thin turf; poor shade tolerance; plant seed or sod.
Centipede grass	<i>Eremochloa ophiuroides</i>		Low maintenance; tolerates partial shade; tolerates drought; plant seed or sod.
Zoysia grass	<i>Zoysia spp.</i>		Produces dense turf; good shade tolerance; good drought tolerance; plant sod.

Xerimulching: Mulch should be used wherever possible. A good mulch conserves water by significantly reducing moisture evaporation from the soil. Mulch also reduces weeds, prevents soil compaction, and keeps soil temperatures more moderate (Gouin, 1973). The ideal application for a mulch layer is adding between two and five inches on top of the soil. If it exceeds then cutting off of the oxygen supply to the plant's root system can result in root death (Powell, 1982).

Wood and organic mulches: It allows for oxygen to get to the root system more easily than rock or stone mulches. Wood and organic mulches will also return some nutrient components back to the soil over time as it breaks down.

Rock and stone mulches: It can also be used selectively. Rock mulch will stay in place more effectively, especially in windy areas. Rock mulches also absorb more heat and may scorch the roots or leaves of heat sensitive plants. Like any other mulch, it must be selected to fit its place of use.

Maintenance: All gardens, including xeriscapes, need routine, seasonal maintenance to preserve the beauty and health of landscape. Maintenance includes pruning, mowing, watering, weeding, fertilization and integrated pest management (IPM). In general, xeriscapes require less maintenance than traditional landscapes, and even less as the Xeriscape matures (Scott, 1986). A healthy, maintained landscape is also more resistant to drought, heat, freezing, disease, and insects. Winter watering is critical in a high desert environment where plant materials tend to desiccate through the winter months. Under such situations watering should be done to new plantings every 4 weeks when the ground is warm enough to absorb water (Robinette *et al.*, 1984). Trees, shrubs, and perennials can be fertilized once during the growing season in spring or early summer with a slow release fertilizer. Late summer should be avoided. Minimum amount of organic fertilizer can be given to turf to avoid additional water use and increased mowing as a result of too much nitrogen. Weeds have to be eliminated to prevent them from competing with desirable plants for water and nutrients. Once a weed seed bank is established, seeds can stay viable for many seasons.

Conclusion

Water is a vital concern for everyone in desert area because it is a limited and fragile resource. Many people believe that watering landscapes is a nonessential luxury. In times of severe drought, rationing may limit the amount of water we can use for our lawns and gardens (Knox, 1995). Therefore, arid or desert habitants have a special responsibility to conserve water and protect its quality. Xeriscaping conserves water in the landscape without sacrificing beauty and plant diversity. By following these principles, anyone can proudly create their own xeriscape landscape.

References

- Aga, Khan. 1996. Sustainable Landscape Design. In *Arid Climates. The Aga Khan Trust for Culture Alternatives with Low water Needs. California Agriculture*, 23(2):11-17.
- Amy, Jo Detweiler and Patrick Griffiths. 2005. An Introduction to Xeriscaping in the High Desert and Pictorial Plant Guide for Central and Eastern Oregon. Central Oreg Cities Organization Publishing, Oregon State University Extension Service, United States pp.34-37.
- Anon, June. 1985. Xeriscape. Conserving Water Through Creative Landscaping. *Journal of Landscape & Irrigation*, 34(8):62-70.
- Anon, March 1986. Plants for Xeriscaping. *Journal of American Society of Horticultural Science*, 26(2): 90-98.
- Christopher, Thomas, April 1988. Drip Irrigation: Conservation of water to the south-east, Pictorial Plant Guide for Central and Easter Oregon, Clemson university. pp. 28-38.
- Dwiggins, Pam. 1985. Xeriscape- The New Word in Landscaping. pp. 56-71. National Wildlife Research Center (U.S), Research campus of Colorado State University in Fort Collins.
- Gibeault, Victor A., Jewell L. Meyer., Autio Richard. and Ralph Strohman. 1989. Turfgrass Alternatives with Low water Needs. *Journal of California Agriculture*, 43(6): 20-22.
- Gouin, F.R. 1993. Utilization of sewage sludge compost in horticulture. *Hort. Technology*, 3: 161-163.
- Huddleson, S. and Hussey, M. 1997. *Grow Native: techniques of selecting cultivars. Journal of American Society of Horticultural Science*, 11(8): 45-50.
- Jhon Kelly, Mary Haque, Debra Shuping and Jeff Jahner, 1991. Xeriscape landscape water conservation to the South-east, Clemson university. pp.33-39.
- Klassen, S. and Gilpin, J., 1999. Alberta irrigation in the old and new millenium. *Canadian Water Resources Journal*, 24(1): 61-69.
- Knox, Kim, ed. 1995. *Landscaping for Water Conservation: Xeriscape*. pp.48-60. Jointly published by City of Aurora and Denver Water, United States.
- McLean, David, May 15, 1989. Xeriscape in Florida: A Concept that Needs the Growth.
- Powell, B., 1982. Soils of the Gatton Research Station, Queensland Department of Primary Industries Bulletin QB82005, Brisbane, Australia.
- Privette, C.V. 1987. Irrigating Your Lawn and Garden. pp.49-55. Clemson University Cooperative Extension Service Circular 580.
- Robinette, Gary O and Nostrand Reinhold, 1984. *Water Conservation in Landscape Design and*

Examples of drought tolerant tree species.

Common name	Scientific name	Particulars
Large Trees (above 30 feet)		
Pine, Limber	<i>Pinus flexilis</i>	Very flexible branches on this evergreen, hence the name. Needles in groups of five are bluish green. Attractive silver bark and large cones. 
Southern Magnolia	<i>Magnolia grandiflora</i>	 Large, striking evergreen tree with large, dark green leaves up to 20 cm (8 ") long and 12 cm (4.5 ") wide, and large, white, fragrant flowers up to 30 cm (12 ") in diameter, widely cultivated in warmer areas. The timber is hard and heavy, commercially used to make furniture, pallets and veneer.
Oak, Bur or Mossycup	<i>Quercus macrocarpa</i>	A handsome tree with an irregular growth habit and interesting moss-like covered acorns. Dark green leaves. Very adaptable in tough environments and long lived. 
Golden Rain Tree	<i>Koelreuteria paniculata</i>	 Deciduous tree with a broad, dome-shaped

Small Trees (20 to 30 ft)		
Choke Cherry, Amur	<i>Prunus maackii</i>	Attractive, shiny, coppery -red peeling bark. Clusters of white flowers, followed by purplish red fruit. 
Khejri	<i>Prosopis cineraria</i>	 It is the state tree of Rajasthan, India. Leaves are bipinnate. Branches are thorned along the internodes. Flowers are small and creamy -yellow. The tree is found in extremely arid conditions, with rainfall as low as 150 mm annually; but is indicative of the presence of a deep water table. As with some other <i>Prosopis</i> spp., <i>P. cineraria</i> has demonstrated a tolerance of highly alkaline and saline environments (Huddleson,1997).
Indian Red Pear	<i>Protium serratum</i>	 It is a medium sized tree with branchlets densely yellow, velvety, grey velvety when old. Flowers light green in colour borne in densely velvety panicles in leaf axils.
Rohida	<i>Tecomella undulata</i>	It has trumpet shaped flowers and leaf margins are wavy, drooping branches with greyish brown bark, suitable for arid climate. It is an important timber -yielding plant of Rajasthan and commonly known as Marwar teak or Desert teak. 

Examples of drought-tolerant shrubs.

Examples of drought-tolerant shrubs.				
Common name	Scientific name	Exposure	Particulars	
Dwarf shrubs (1- 3 ft.)				
Red yucca	<i>Hesperaloe parvifolia</i>	Sun	Red flowers on tall spikes.	
Dwarf nandina	<i>Nandina</i> spp.	Sun/shade	Reddish evergreen foliage.	
Dwarf pittosporum	<i>Pittosporum tobira wheeleri</i>	Sun/shade		Small, round evergreen.
Dwarf Chinese holly	<i>Ilex cornuta rotunda</i>	Sun/shade	Glossy evergreen foliage.	
Abelia	<i>Abelia grandiflora</i>	Sun		Mostly suitable for arid regions.
Sage	<i>Salvia greggi</i>	Sun	The flowers are borne on racemes and can be red, pink, purple, orange, or white.	
Small shrubs (3-5 ft.)				
China rose	<i>Rosa chinensis</i>	Sun		Hardy; long-blooming; pest-resistant; varieties: Old Blush (pink) and Cramiosi Superior (red).
Tea rose	<i>Rosa odorata</i>	Sun	Hardy; long blooming; pest -resistant; excellent varieties: Mrs. B.R. Cant (rose), Mrs. Dudley Cross (yellow) and Duchesse de Brandant (pink).	

Tea rose	<i>Rosa odorata</i>	Sun	Hardy; long blooming; pest - resistant; excellent varieties: Mrs. B.R. Cant (rose), Mrs. Dudley Cross (yellow) and Duchesse de Brandant (pink).	
Juniper	<i>Juniperus</i> sp.	Sun	Tough, evergreen shrub; many varieties available.	
Dwarf palmetto	<i>Sabal minor</i>	Sun/shade	Trunkless, bushy palm.	
Gardenia	<i>Gardenia jasminoids</i>	Sun	Produce white fragrant flowers throughout the summer.	
Common lantana	<i>Lantana camera</i>	Sun	Small tubular shaped flowers having four petals and arranged in clusters at the end of stems and colours including red, yellow, white, pink, blue and orange which differ depending on location, age and maturity.	
Medium Shrubs (6-9 ft. tall)				
Althea	<i>Hibiscus syriacas</i>	Sun		
Central Texas sage	<i>Leucophyllum</i> sp.	Sun	Dusty grey evergreen foliage; blooms throughout summer.	Upright; deciduous; many colors; summer blooming.

Central Texas sage	<i>Leucophyllum</i> sp.	Sun	Dusty grey evergreen foliage; blooms throughout summer.	
Chinese horned holly	<i>Ilex cornuta</i>	Sun/shade		Glossy evergreen foliage.
Italian jasmine	<i>Jasminum humile</i>	Sun	Sprawling evergreen; yellow summer Flowers.	
Forsythia	<i>Forsythia intermedia spectabilis</i>	Sun/shade	Yellow spring flowers . 	
Pomegranate	<i>Punica granatum</i>	Sun	Large, upright shrub; orange blooms; edible fruit; dwarf variety: Chico.	
Winter honeysuckle	<i>Lonicera fragrantissima</i>	Sun/shade		Fragrant clusters of white flowers in winter.
Chinese privet	<i>Ligustrum sinense variegatum</i>	Sun	Deciduous shrub, flowers are white, with a four lobed corolla 3.5	
Variegated pittosporum	<i>Pittosporum tobira variegata</i>	Sun/shade		Green/white variegated evergreen shrub

Crape myrtle	<i>Lagerstroemia indica</i>	Sun	Shrubby to tree -like; summer blooming; many flower colors available.	
Oleander	<i>Nerium oleander</i>	Sun	Evergreen foliage; summer blooming; many colors available.	
Vitex	<i>Vitex agnus-castus</i>	Sun	Tree-like; flowers blue or white; summer blooming.	
Lilac	<i>Syringa vulgaris</i>	Sun	Deciduous blooming shrub; adapted to alkaline soil.	
Mock orange	<i>Philadelphus coronarius</i>	Sun	Fragrant white blooms in late spring.	
Russian olive	<i>Eleagnus angustifolia</i>	Sun/shade	Gray foliage; yellow flowers; evergreen for windbreak plantings.	
Windmill palm	<i>Trachycarpus fortunei</i>	Sun	Tree-like; fibrous bark.	
Spanish dagger	<i>Yucca gloriosa</i>	Sun	Inflorescence is a panicle up to 2.5 m (8 ft) long, of bell-shaped white flowers.	

Bougainvillea	<i>Bougainvillea glabra</i> or <i>Bougainvillea brasiliensis</i>	Sun	 It can be grown as a hedge, groomed as a ground cover, pruned as an espalier, trained as a tree or contained in a pot in a variety of shapes. It comes in many colors. i.e. Purple, lavender, carmine, scarlet, red, pink, orange, yellow and white. Single and double flower forms are available. Its bracts appear on the ends of new growth. Habitat -Well drained sandy desert soils, slopes and rocky soil.
---------------	--	-----	--

Examples of ground covers

Common name	Scientific name	Particulars
Creeping juniper 	<i>Juniperus horizontalis</i>	The leaves are arranged in opposite decussate pairs, or occasionally in whorls of three; the adult leaves are scale-like.
Mondo grass 	<i>Ophiopogon japonicus</i>	An evergreen, sod-forming perennial plant, leaves are linear, 20–40 cm long, flowers are white through pale lilac, borne in a short raceme.
Periwinkle 	<i>Vinca minor</i>	Flowers are solitary in the leaf axils, they're violet purple in colour.
Himalayan sarcococca 	<i>Sarcococca hookerana humilis</i>	It produces aromatic white flowers throughout winter followed by black berries.

Examples of Hedges.

Common name	Scientific name	Particulars
Korean boxwood	<i>Buxus microphylla koreana</i>	Low growing to 2 1/2 feet high, this shrub does well in a hot, dry climate. It can be sheared to a geometric shape or left untrimmed and still be a tidy plant.
Photinia	<i>Photinia x fraseri</i>	Moderate to fast growing shrub to 10 feet high. Has reddish-bronze leaves in Spring and white flower heads that can be as big as a small saucer. Sometimes suffers from lack of iron (chlorosis).
Indian Hawthorn	<i>Raphiolepis indica</i>	Best known as a low mounding plant with dark green leaves and pretty pink blooms in the spring. Relatively low water usage.
Myrtle	<i>Myrtus communis</i>	Fine textured, bright green foliage that does not need much trimming. It has small white flowers and, later, blue-black berries. Low water usage with good drainage required. Makes a wide hedge.
Indian Fig Cactus	<i>Opuntia ficus-indica</i>	Extremely drought tolerant, cold hardy and a fast grower. This plant can reach around 15 feet in height and 10 or more feet in width. Flowers are typically yellow-orange, large and very showy. Fruits green to purplish-red. Cactus thorns are modified leaves.

Maintenance. *Journal of American Society of Horticultural Science*, 10(2): 7-10.

Scott, J.W. 1986. A useful Category of historical analysis. *The American Historical Review*, 91(5): 1053-1075.

Springer, Lauren. 1994. *Waterwise Gardening*: Prentice Hall Gardening. *Journal of American Society of Horticultural Science*, 31(9): 56-61.

Swenerton, Steve. 1988. Water Conservation: Tomorrow Has Arrived. *Journal of Landscape & Irrigation*, 21(6): 84-85.

Wilson, C. and Feucht, J.R. 1996. *Xeriscaping: Creative Landscaping, Gardening Series & Basics*. pp. 427-432. Fact Sheet No. 7.228. Colorado State University Extension, Department of Agriculture, United States.

Winger, David. ed. 1996. *Xeriscape Plant Guide*. pp. 12-18. Fulcrum Publishing, Denver Water organization, AWWA, United States.

Physiological and biochemical changes in ber (*Zizyphus mauritiana* Lamk.) due to *Pestalotiopsis* fruit rot

S. L. Godara, Ashok Kumar Meena* and Anand Kumar Meena
Department of Plant Pathology, College of Agriculture,
Swami Keshwanand Rajasthan Agricultural University, Bikaner- 334 006 (Rajasthan)
Corresponding Author e-mail: ak_patho@rediffmail.com, anandraj.km@gmail.com
(Received: 27.03.2015; Accepted: 15.02.2016)

Abstract

In the present experiment, different physiological and biochemical parameters of ber infected with *Pestalotiopsis* fruit rot were studied. The sites of inoculation of ber fruits were tested and the inoculation at epicarp surface was found most sensitive and showing maximum severity of *Pestalotiopsis* rot. The mature and ripe stage inoculated fruits exhibited maximum severity. Changes in biochemical activity indicated that the level of total soluble solids, acidity, ascorbic acid and phenols in healthy ripe and semi-ripe ber fruits were higher as compared to infected ripe and semi-ripe fruits. The total soluble solids in inoculated semi-ripe fruits was significantly lower than uninoculated semi-ripe fruits and inoculated ripe fruits, it was lower than uninoculated ripe fruits. The level of acidity in the inoculated ripe and semi-ripe ber fruits was significantly reduced than uninoculated ripe and semi-ripe fruits. The level of ascorbic acid in inoculated ripe and semi-ripe fruits was significantly low over control. The healthy fruits (semi-ripe stage) of ber had much larger amount of ascorbic acid as compared to the diseased fruits. The activity of total phenols was higher in healthy and diseased semi-ripe fruits (0.62 and 0.48 mg/100 gm fruits) as compared to healthy ripe and diseased ripe fruits (0.52 and 0.19 mg/100 gm fruits), respectively.

Key words: *Pestalotiopsis palmarum*, ber, total soluble solids, acidity, ascorbic acid and phenols.

Introduction

Ber (*Zizyphus mauritiana* Lamk.) is one of the most ancient and common fruits consumed by people of India. It is often called the poor man's fruit. Fruit spoilage at post-harvest stage has gained the greatest significance in view of the loss incurred. Understanding on the mechanism of fruit-rot will help to prevent fruit losses caused by pathogenic fungi. A large number of fungi cause rotting of ber fruits in the market. The most frequently occurring fungi are *Pestalotiopsis palmarum*, *Alternaria alternata*, *Cladosporium oxysporum*, *Rhizoctonia solani*, *Fusarium solani* and *Aspergillus niger*. Average incidence of various fruit rotting diseases ranged from 2.0 to 15.3 per cent (Jat *et al.*, 1997). Nevertheless, fruit rots are also important problem of orchards and markets in arid and semi-arid regions. *Pestalotiopsis* rot of ber fruits, caused by *Pestalotiopsis palmarum* (Cooke) Steyart is a major post-harvest fruit rot. Ber fruit rots have been identified as major problem next to powdery mildew. Endemic forms of fruit rot diseases are persisting in Western parts of Rajasthan (Nallathambi *et al.*, 2000). The injuries on three sites of fruit surface viz., stem-end, epicarp and stylar-end can occur during harvest or handling. To understand the impact of different types of site of infection on disease incidence and severity of *Pestalotiopsis* rot in ber fruits, the present study was conducted

and attempts were made to analyze the site of infection, the activity of total soluble solids, acidity, ascorbic acid and phenols in ripe and semi-ripe stages of ber fruits un inoculated and inoculated with *Pestalotiopsis palmarum*.

Materials and Methods

Effect of inoculation sites on disease development

The semi-ripe fruits collected from Bikaner fruit market as well as Horticulture farm (College of Agriculture, Bikaner) were brought to the laboratory in paper bags. The fruits were surface sterilized with 0.1 per cent mercuric chloride and injured in the following manner: (1) Pricked with sterilized pins at stem-end (2) Pricked in epicarp (3) Pricked at the stylar-end (4) Control (uninjured and inoculated) (5) Control (uninjured and un-inoculated).

The fruits were pricked to a depth of 2 mm on fruit surface. The injured and uninjured fruits were separately inoculated with spore suspension (10^6 spores/ml) of *Pestalotiopsis palmarum*. The injured and control fruits were surface sterilized (dipping in HgCl₂ 0.1 per cent for 2 minutes followed by three washings with sterilized water) and then separately inoculated with *Pestalotiopsis palmarum* by dipping them in spore suspension for 2 minutes. The fruits were then air-dried for 15-20 minutes. The inoculated as well

as un-inoculated fruits were placed in sterilized polythene bags and four fruits were accommodated in each bag and incubated at 25 °C.

Effect of fruit ripeness on disease severity

Fruits of uniform size at following stages of ripeness were inoculated by the pin-pricking method. (1) Unripe fruits (green in colour) (2) Semi-ripe fruits (light pale colour) (3) Ripe fruits (fruit surface tone yellow). Fruits at these three stages were inoculated with uniform amount of inoculum. The inoculated fruits were placed in polythene bags and incubated at 25 °C. The experiment was arranged in completely randomized design. The fruits were examined daily till the appearance of the symptoms to record incubation period. The disease incidence and disease severity were recorded on 4th, 8th and 12th day of inoculation.

Effect on biochemical changes

Total Soluble Solids (T.S.S.) : Pulp from five randomly selected infected as well as healthy fruits were taken and macerated for juice extraction and total soluble solids of the juice was determined by using a hand refractometer of 0-30 per cent range. The values were corrected at 20°C and expressed as per cent total soluble solids of the fruit juice (A.O.A.C., 1990).

Acidity: The acidity was determined by diluting the known volume of clean juice, filtered through muslin cloth and diluted with distilled water. The dilute juice titrated against standard N/10 sodium hydroxide solution using phenolphthalein as an indicator. The appearance of light pink colour was marked as the end point. The result was expressed in terms of per cent acidity of the fruit juice (A.O.A.C. 1990).

Ascorbic acid : 10 ml of sample was taken and made up to 100 ml with 3% metaphosphoric acid and filtered. Pipetted 10 ml of filtrate into a conical flask and titrated with the standard dye to a pink end-point.

Phenols: Total phenols were estimated by the method described by Bray and Thorpe (1954). One gram of sample was ground with a pestle and mortar in 10 times volume of 80 per cent ethanol. The homogenate was centrifuged at 1000 rpm for 20 minutes. The supernatant was filtered and the residue was re-extracted with five times volume of 80 per cent ethanol, supernatant was cooled and evaporated to dryness in water bath. The residue was then dissolved in 5 ml of distilled water. Different aliquots (0.2 to 2 ml) were then pipetted out into test tubes and the volume in each tube was made to 3 ml with distilled water. Then 5 ml of Folin-ciocalteu reagent was added in each sample and mixed thoroughly. After 3 minutes, 2 ml of 20 per cent sodium carbonate solution was poured in each tube and thoroughly mixed. The tubes were then placed in a boiling water for one minute. After cooling the

absorbance was measured at 650 nm against a reagent blank. The corresponding phenol content was plotted on a standard curve, which was prepared by taking different concentrations of catechol ranging from 10 to 50 g/ml in water.

Total sugar content: Total sugar content was determined by colorimetric method using anthrone reagent. One ml of diluted fruit juice (100 times) 4 ml of anthrone reagent was added, heated, for 20 minutes in a water bath, cooled to room temperature and absorbance was measured at 630 nm on Spectronic-20. The amount of sugars present in the juice was plotted against standard curve prepared from glucose. The content was expressed on percentage basis (Dubois *et al.*, 1951). Reducing Sugar content was measured by following "Nelson's modification of "Somogyi's method" (Somogyi, 1952).

Results and Discussion

Effect of site of inoculation on severity of Pestalotiopsis rot of ber fruits

On 4th day of inoculation, the semi-ripe ber fruits showed incidence of the rot irrespective of the site of inoculation (Table 1). The fruits inoculated at epicarp (60%) and stylar-end (60%) showed higher incidence of Pestalotiopsis rot than in fruits inoculated at stem-end (40%) fruit surface. The severity (9.56%) of the rot in fruits inoculated at epicarp was more than in fruits inoculated at stem-end (7.69%) and stylar-end (6.13%). The inoculation at epicarp rendered significantly higher severity than the fruits inoculated at stem-end, stylar-end and controls (uninjured inoculated and uninjured uninoculated). It can be concluded that all the sites of inoculation differed significantly from uninjured controls.

On 8th day of inoculation, the fruits inoculated at epicarp, stem-end and stylar-end showed higher incidence (100%) of Pestalotiopsis rot on fruit surface than uninjured inoculated (25%) fruits. The severity (19.06%) of the rot inoculated at epicarp was more than in fruits inoculated at stem-end (15.31%) and stylar-end (13.56%) fruit surface (Table-1). The inoculation at epicarp rendered significantly higher severity (19.06%). The disease severity of the rot was at par in fruits inoculated at stylar-end (13.56%) and stem-end (15.31%) and rendered significantly higher than control.

On 12th day of inoculation, the fruits showed higher incidence (100%) of the rot on the different sites of inoculation than control (40%). The severity (46.88%) of the rot in fruits inoculated at epicarp differed significantly from stylar-end (28.75%) and stem-end (34.38%) surface of the fruits. The lowest severity (8.00%) of the rot was recorded in fruits uninjured inoculated (control). The uninjured uninoculated fruits (control) remained rot free on 4th, 8th and 12th days of inoculation.

Effect of fruit ripeness on disease severity of Pestalotiopsis rot of ber fruits

On 4th day of inoculation, the ber fruits inoculated at

ripe stage showed higher disease incidence (60%) of Pestalotiopsis rot than in fruits inoculated at semi-ripe (40%) and unripe (20%) stages. The unripe stage of the fruits showed lowest disease incidence than semi-ripe and ripe fruit stages of ber, after 4th day of inoculation. The disease severity of the rot in fruits inoculated at ripe (12.13%) stage was more than in fruits inoculated at semi-ripe (8.63%) and unripe (7.06%) stages (Table 2). The inoculation at unripe stage rendered significantly lower disease severity than the fruits inoculated at semi-ripe and ripe stage of the fruit.

On 8th day of inoculation, the fruits inoculated at unripe, semi-ripe and ripe stages showed 100 per cent disease incidence. The disease severity (19.38%) of the rot inoculated at ripe stage was more than in fruits inoculated at semi-ripe (16.56%) and unripe (14.38%) stages of the fruit (Table-2). The disease inoculated at ripe stage rendered significantly higher severity than the fruits inoculated at semi-ripe and unripe stages.

On the 12th day of inoculation, at all stages of fruit maturity 100 per cent incidence of the fruit rot was recorded. The severity of the rot in fruits inoculated at ripe stage (36.25%) was more than in fruits inoculated at semi-ripe (26.25%) and unripe (23.13%) stages (Table 2). It can be concluded that among the three stages, the ripe stage was found to be significantly most susceptible for the fungal infection. The inoculation at ripe stage rendered significantly higher disease severity than the fruits inoculated at semi-ripe and unripe stage.

Biochemical changes in ber fruits due to *Pestalotiopsis* infection

Effect on total soluble solids: The level of total soluble solids decreased in the fruits inoculated with *Pestalotiopsis* over healthy fruits in control. The total soluble solids in inoculated semi-ripe fruits (10.00° Brix) was significantly lower than uninoculated semi-ripe fruits (12.09° Brix) and in inoculated ripe fruits (9.00° Brix) it was lower than uninoculated ripe fruits (10.78° Brix).

Effect on acidity: The level of acidity of both healthy and infected fruits decrease as fruits are stored for longer period. The level of acidity in the ripe (0.32%) and semi-ripe (0.45%) ber fruits inoculated with the *Pestalotiopsis* was significantly reduced than uninoculated ripe (0.58%) and uninoculated semi-ripe (0.77%) fruits.

Effect on ascorbic acid: The ascorbic acid content of both healthy and infected fruits declines as fruits are stored but the reduction in ascorbic acid content is far more pronounced in diseased fruits. The level of ascorbic acid in ripe and semi-ripe fruits infected with *Pestalotiopsis* rot declined significantly over control. The healthy fruits (semi-ripe stage) of ber have much larger amount of ascorbic acid as compared to the diseased fruits. The ascorbic acid content in ripe fruits (63.00 mg/100 gm fruits) and semi-ripe fruits (79.80 mg/100 gm fruits) inoculated with *Pestalotiopsis* decreased than in uninoculated ripe (84.00 mg/100 gm fruit) and uninoculated

semi-ripe fruits (113.40 mg/100 gm fruits).

Effect on phenols: The phenolic compounds are mostly considered as one of the important biochemical parameters for disease resistance and also the accumulation of total phenols is usually higher in semi-ripe fruits as compared to mature or ripe fruits. The level of total phenols was higher in healthy and diseased semi-ripe fruits (0.62 and 0.48 mg/100 gm fruits) as compared to healthy and diseased ripe fruits (0.52 and 0.19 mg/100 gm fruits), respectively.

Effect on sugar contents: The total sugar contents (8.95%) was increased in uninoculated ripe stage of healthy ber fruits compared with inoculated ripe fruits (4.20%) (Table-4). The total sugar content (5.74%) in uninoculated semi-ripe fruits increased significantly than inoculated semi-ripe fruits (2.66%), which was lowest.

The reducing sugar content (5.53%) increased in uninoculated ripe stage of healthy fruits compared with inoculated ripe fruits (1.89%). The reducing sugar content (3.50%) in uninoculated semi-ripe fruits increased significantly than inoculated semi-ripe fruits (1.33%). The lowest reducing sugar content (1.33%) was recorded in semi-ripe fruits inoculated with *Pestalotiopsis*.

The non-reducing sugar content (1.23%) of semi-ripe fruits inoculated with *Pestalotiopsis* decreased than in uninoculated semi-ripe fruits (2.13%). Further, the non-reducing sugar content (2.19%) in ripe fruits inoculated with *Pestalotiopsis* decreased significantly over uninoculated ripe (3.25%) fruits. The present findings indicated that the level of total soluble solids, acidity, ascorbic acid and phenols in healthy ripe and semi-ripe ber fruits was higher as compared to infected ripe and semi-ripe fruits. The present investigations are in conformity with those of Rai (1982) who reported that healthy fruits of ber have much large amounts of vitamin C as compared to the diseases ones. The level of total soluble solids, acidity, ascorbic acid and total sugars content in ripe and semi-ripe stages of guava fruits inoculated with *Pestalotiopsis* were less as compared to healthy fruits (Meena, 2006). Goel and Siddiqui (1999) reported the changes in total soluble solids (TSS), acidity, ascorbic acid, phenols, and total sugars in the ber fruits of different maturity stages. Total soluble solids, acidity and total sugars increased whereas, ascorbic acid and phenolic contents decreased with the ripening process. Similarly, Fourie and Holz (1998) reported the nutrient changes during the advanced development or ripening of the nectarines and plums fruit. A direct relationship was found between the sugar content in nectarines and plums and the late season susceptibility of these fruits to *B. cinerea* infection. The present experiments conducted on these aspects revealed that the total sugar, reducing sugar and non-reducing sugar contents increased in un-inoculated ripe and semi-ripe healthy ber fruits in comparison to *Pestalotiopsis* rot infected fruits.

Phenolic compounds are mostly considered as one of the important biochemical parameters for disease resistance. The accumulation of total phenol is usually higher in resistant

genotypes as compared to susceptible ones. The antifungal properties of phenolic compounds and their derivatives, and the fact that these compounds are frequently found in the young fruit at higher concentrations than in the ripe fruit, led to the hypothesis that these compounds play an important role in the maintenance of latency in the unripe fruit (Barkai-Golan, 2005). Farkas and Kiraly (1962) observed that presence of phenolic compounds in plants or their synthesis in response to infection, have been associated with resistance against fungal pathogens. Similarly, Hudson and Mahgoub (1980) and Takahama (1985) reported that some of the phenolics are known to act as antioxidants and induce resistance. Toxic

phenolic compounds, may be exuded from the lesions and also may exist as normal components of the phylloplane. Analysis of the material that reached into water droplets on necrotic lesions showed the presence of significant levels of phenols within one hour. The phenols released into the water that carries conidia to new infection sites may inhibit conidium germination and germ tube elongation resulting in suppression of disease spread (Nicholson *et al.*, 1989). The results of the present investigations suggests that the level of total phenols was higher in healthy and diseased semi-ripe fruits as compared to healthy and diseased ripe fruits.

Table 1. Incidence and severity of pestalotiopsis rot of ber fruits inoculated at different location.

Site of inoculation	4 th day of inoculation		8 th day of inoculation		12 th day of inoculation	
	Incidence	Severity	Incidence	Severity	Incidence	Severity
Stylar -end	60	6.13 (14.33)*	100	13.56 (21.61)	100	28.75 (32.42)
Epicarp	60	9.56 (18.01)	100	19.06 (25.89)	100	46.88 (43.21)
Stem-end	40	7.69 (16.10)	100	15.31 (23.04)	100	34.38 (35.90)
Control (uninjured inoculated)	20	0.50 (4.05)	25	5.50 (13.56)	40	8.00 (16.43)
Control (uninjured un-inoculated)	00	0.00 (4.05)	00	0.50 (4.05)	00	0.50 (4.05)
SEm ±		0.44		0.51		0.73
CD (P=0.05)		1.34		1.52		2.21

* Figures in parentheses are angular transformed values.

** Fruits were incubated at 25 ± 2°C.

Table 2. Incidence and severity of Pestalotiopsis rot of ber fruits inoculated at different maturity stages of fruits**

Stages of fruit m	4 th day of inoculation		8 th day of inoculation		12 th day of inoculation	
	Incidence	Severity	Incidence	Severity	Incidence	Severity
Unripe fruits	20	7.06 (15.41)*	100	14.38 (22.28)	100	23.13 (28.74)
Semi-ripe fruits	40	8.63 (17.08)	100	16.56 (24.01)	100	26.25 (30.82)
Ripe fruits	60	12.13 (20.38)	100	19.38 (26.11)	100	36.25 (37.02)
SEm ±		0.41		0.48		0.56
CD (P=0.05)		1.30		1.54		1.80

* Figures in parentheses are angular transformed values.

** Fruits were incubated at 25 ± 2°C.

Table 3. Effect of Pestalotiopsis rot on total soluble solids, acidity, ascorbic acid and phenol contents of ber fruits*

Stage of fruit ripeness	Total soluble solids (°Brix)	Acidity (%)	Ascorbic acid (mg/100 g fruit)	Phenols (mg/100 g fruit)
Semi-ripe fruit (Inoculated)	10.00	0.45	79.80	0.48
Ripe fruit (Inoculated)	9.00	0.32	63.00	0.19
Control (Uninoculated semi-ripe fruits)	12.09	0.77	113.40	0.62
Control (Uninoculated ripe fruits)	10.78	0.58	84.00	0.52
SEm ±	0.04	0.03	1.71	0.008
CD (P=0.05)	0.12	0.08	5.28	0.02

*Fruits were incubated at 25 ± 2°C.

Table 4. Effect of Pestalotiopsis rot on sugar contents of ber fruits*

Stage of fruit ripeness	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
Semi-ripe fruit (Inoculated)	2.66	1.33	1.23
Ripe fruit (Inoculated)	4.20	1.89	2.19
Control (Uninoculated semi-ripe fruits)	5.74	3.50	2.13
Control (Uninoculated ripe fruits)	8.95	5.53	3.25
SEm ±	0.10	0.12	0.03
CD (P=0.05)	0.32	0.36	0.10

* Fruits were incubated at 25 ± 2°C.

References

- A.O.A.C. 1990. Official and tentative method of analysis. *Assoc. Agric. Chem.* 18th ed., Washington, D.C.
- Barkai-Golan, R. 2005. Post harvest diseases of fruits and vegetables : Development and control. *Elsevier Science B:V*, Amsterdam.
- Bray, H.G. and Thorpe, W.V. 1954. Analysis of phenolic compounds of metabolism interest. *Meth. Biochem. Anal.*, 1: 27-52.
- Dubois, M., Gilles, K., Hamilton, J.K., Rebers, P.A. and Smith, F. 1951. A colorimetric method for the determination of sugars. *Nature*, 168: 167.
- Farkas, G.L. and Kiraly, Z. 1962. Role of phenolic compounds in the physiology of plant diseases and disease resistance. *Phytopath. Z.*, 44: 105-150.
- Fourie, J.F. and Holz, G. 1998. Initial infection processes by *Botrytis cinerea* and infection of plum and nectarine fruit. *Plant Dis.*, 82: 165-170.
- Goel, A. and Siddiqui, S. 1999. Changes in enzyme activities and physico-chemical characteristics of ber. *Indian J. Agric. Res.*, 33 (3): 209-213.
- Hudson, B.J.F. and Mahgoub, S.E.O. 1980. Naturally occurring antioxidants in leaf lipids. *J. Sci. Food Agric.*, 31: 646: 650.
- Jat, R.G., Agarwal, V.K. and Goyal, S.K. 1997. Studies on post harvest fungal disease of ber fruits. Proceedings of Golden Jubilee International Conference on Integrated Plant Disease Management for Sustainable Agriculture, *Indian Phytopathological Society*, 11-15 Nov, IARI, New Delhi. 313 pp.
- Meena, O.P. 2006. Studies on post harvest fruit rot of guava caused by *Pestalotiopsis palmarum*. M.Sc. (Ag.) Thesis, Rajasthan Agricultural University, Bikaner.
- Nallathambi, P., Umamaheswari, C., Vashistha, B.B. and Nath, Vishal. 2000. Fruit rot (*Alternaria alternata*) and sources of resistance in ber germplasm under arid conditions. *Ann. Arid Zone*, 39 (4): 477-478.
- Nicholson, R.L., Hipskind, J. and Hanau, R.M. 1989. Protection against phenol toxicity by the spore mucilage of *Colletotrichum graminicola*, an aid of secondary spread. *Physiol. Mol. Plant Pathol.*, 35: 243-252.
- Rai, R.N. 1982. Pathological and physiological studies of certain fungi causing fruit rot diseases. D.Phil Thesis, Allahabad Univ., Allahabad, India, 217.
- Somogyi, M. 1952. Aresenomolybdate reagent colour development method of reducing sugar determination. *J. Biol. Chem.*, 200 245.
- Takahama, U. 1985. Inhibition of lipoxygenase- dependent peroxidation by quercetin : Mechanism of antioxidative function. *Photochemistry*, 24: 1443-1446.

Effect of growth regulators on floral malformation in mango (*Mangifera indica* L.) cv. Amrapali

Abhay Bisen^{1*}, R. Dongre² and Shwati U. Pardhi³

¹Assistant Professor (Horticulture), College of Agriculture, Rajnandgaon, IGKV (C.G.)

²Assistant Professor, Department of Forestry, College of Agriculture, JNKVV, Jabalpur (M.P.)

³Ph.D Scholar, Dr. B.S.K.K.V, Dapoli (M.S.)

*Corresponding author's email: abhay_horti@yahoo.co.in

(Received: 15.12.2014; Accepted: 19.01.2016)

Abstract

Mango is a unique species in fruit trees with respect to growth, specific nature and diversity. Like other crops, it is prone to various biotic and abiotic stresses being major obstacle to mango production. Amongst biotic and abiotic problems of mango, Floral malformation has become a crux with yield losses ranging from 60% to 80. A field experiment was conducted to assess the effect of auxin and ethrel on floral malformation in mango. Studies were undertaken on 18 years old mango trees of Amrapali. The selected trees were sprayed "on year" with different concentration of auxin (NAA) viz. 150 ppm, 175 ppm & 200 ppm., ethrel viz. 300 ppm, 400 ppm & 500 ppm and distilled water in the first week of October. The result revealed that PGR particularly NAA @ 200ppm had significantly effect on maximum (65.92) percentage of healthy inflorescences per shoot and (21.46) percentage of hermaphrodite flowers per inflorescence as compared to rest concentrations of PGRs. Similar this PGR spray showed highest 3.42 and 0.63 average number of fruits set and retention per panicles, respectively followed by ethrel @ 500 ppm. While the lowest hermaphrodite flowers, fruits set and retention per panicle was found in control (distilled water spray), but under this treatment maximum percentage (75.96) of male flowers per inflorescence was noted. From the above study, it can be concluded that exogenous spray of NAA @ 200 ppm applied before flower and fruit bud differentiation can reduce the malformed panicles to the extent of about seventeen percent. Perfect flowers (hermaphrodite) can also be increased both in normal as well as malformed panicles which helpful for higher fruits set and retention per panicle.

Key Words: Mango, Auxin, Ethrel, Panicles, Floral malformation and Inflorescence.

Introduction

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae, originated in South Asia. It covers an area of approximately 2.55 million hectares, which is about one third of the total area under fruit production in the country. Through India produces nearly 60 percent of the world mango, i.e. 18.676 million tonnes, is stands fourth in the export of fresh and processed fruits (Anonymous, 2014). Unfortunately, this crop suffers regularly a colossal loss due to floral malformation. The incidence of floral malformation in mango was first reported from Darbhanga in Bihar by Maries. Besides erratic bearing, floral malformation has posed a serious threat to the flourishing industry particularly in Central and Northern part of the Country (Kumar and Reddy, 2006). Due to this disorder, terminal growth of main rachis, secondary and tertiary branches of the panicles get suppressed and thickened forming a compact mass. Mainly male flowers are born in such panicles, which normally do not set fruits resulting into reduction in fruit yield (Shahbaz *et al.*, 2009). The problem aggravated due to non-availability of fully resistant commercial variety to this disorder. (Pandey and Pandey, 2000; Pandey *et al.*, 2002 and Singh *et al.*, 2014). In the present investigation, efforts have been made to bring out the information on the production of malformed panicles,

hermaphrodite flowers, fruits set and fruits retention in response to spray of auxin and ethrel on flower and fruit bud differentiation.

Materials and Methods

The experiment was carried out at Imalia farm, Department of Horticulture, JNKVV, Jabalpur, during the year 2011-2012. The location of the experiment is situated on the Kymore Plateau agro-climatic region in the north western part of Madhya Pradesh at latitude of 23.10°N, longitude 79.58°W and altitude 300 meters above the mean sea level. The climate of this region is semi arid and sub tropical having warm and dry spring summer and cool winter are main characteristics feature. The mean annual maximum and minimum temperatures vary from 42-45°C in May and 5-9°C in January respectively. The average rainfall varies from 500-1200 mm. The main rainfall received during monsoon months i.e. from July to mid September. Mid July to end of August is heaviest rainy period with intermittent dry spell during the rainy period. The trial was conducted on 18 years old. Amrapali mango plants spaced apart from 5X5 m. 21 trees having "on year" were selected and each tree was divided in two sectors. Twenty normal shoots and twenty shoots having scars from each sector of the tree were employed. These shoots were ringed to

prevent translocations of hormone to adjacent shoots. Experiment was consisted of fourteen treatment combinations due to two categories of shoots *i.e* normal and scar. Seven levels of sprays were tried in randomized complete block design (RCBD) with three replication. Seven plants were selected in each replication. The selected trees were sprayed "on year" with different concentration of auxin (NAA) *viz.* 150 ppm, 175 ppm & 200 ppm., ethrel *viz.* 300 ppm, 400 ppm & 500 ppm and distilled water in the first week of October. During spray distilled water used as control treatment. The stock solution of NAA and ethrel along with adhesive agent (Tween-80) was sprayed individually by hand sprayer. Amount of spray solution per plant was determined by spraying water in the plant. Data were recorded for statistical analysis on percentage of healthy inflorescences/shoot, percentage of hermaphrodite flowers/inflorescence, percentage of male flowers/inflorescence, average number of fruits set per panicle and average number of fruits retention per panicle.

Result and Discussions

The data presented in Table 1 & Fig. 1 reveals that spray of auxin and ethrel significantly increased the percentage of healthy inflorescences on scarred shoots. It was observed that the highest (83.73 & 48.11) percentage of healthy inflorescences/shoot was found in normal and scarred shoots, respectively when the plant was sprayed with NAA @ 200 ppm followed by ethrel @ 500 ppm in the first week of October, whereas it was observed minimum 77.16 & 28.61 percentage of healthy panicles in both normal and scarred shoots under distilled water spray. These results were in agreement with Chowdhary and Rahim (2008) who reported that application of 200 ppm NAA during the first week of October was the most effective in reducing the incidence of floral malformation and increased the number of inflorescences on normal and scarred shoots.

Percentage of hermaphrodite flowers per inflorescence varied significantly among the different concentrations of NAA and ethrel. NAA @ 200 ppm spray recorded the highest percentage 29.78 & 13.14 of hermaphrodite flowers per inflorescence, while the control was recorded with the lowest percentage 10.51 and 3.19 in normal and malformed panicles, respectively shown in Table 1 & Fig. 2. These results were close to Chakrabarti and Kumar (2000). They reported that single application of 200 ppm NAA in the first October increased the percentage of perfect flowers, which lead to the increased number of hermaphrodite flowers. The exogenous application of 200 ppm NAA undertaken in the present studies resulted into seventeen percent reduction in floral malformation and two to three times the production of hermaphrodite flowers in both normal and malformed panicles to control. Similar results are also reported by Singh *et al.* (2007) and Pandey and Pandey

(1999).

A perusal of the data presented in Table 1 indicated that the percentage of male flowers per inflorescence was significantly decrease due to the application of different treatments, except control. The highest percentage (71.09 & 80.83) of male flowers per inflorescence was observed under control, while the lower percentage (58.11 & 70.19) was recorded with 200 ppm NAA spray followed by 500 ppm ethrel in normal and malformed panicles, respectively (Fig. 3). Reduction in male flowers per inflorescence have been reported by Pandey and Sant (1995) and Ram and Singh (1998). Thus the results of the present studies are in agreement with the above reports. The external application of NAA might have increased the endogenous levels of auxin and helped in lowering down the suppression of apical dominance, normal growth of main rachis and secondary & tertiary branches of panicles, which resulted in reducing the percentage of male flowers in malformed and normal inflorescences. These results are in accordance with the findings of Singh and Singh (1998).

Analysis of data reveals that average number of fruits set in both normal and malformed panicles significantly increase with spray of either NAA or ethrel (Table 2). The highest (3.42) average number of fruit set per panicle was recorded in the first week of February under 200 ppm NAA followed by 500 ppm ethrel to foliar application. According to Waffa Haggag *et al.* (2011) a delicate balance between the levels of growth regulators and inhibitors exist in nature which decides the production of hermaphrodite flowers. It seems logical that the application of NAA might have helped for attaining the required levels of growth promoters for the production of hermaphrodite flowers which might have increases fruit set. These results also corroborated the findings of Ram and Yadav (1999) who stated that 200 ppm NAA reduced the incidence of malformation and increased the fruits set, whereas minimum (4.61 & 0.87) average number of fruit set per panicle was observed under distilled water spray in normal and malformed panicles, respectively (Fig.4).

The highest (0.63) average number of fruits retention per panicle and per plant was found in NAA @ 200 ppm followed by Ethrel @ 500 ppm both these treatments are significantly ($P = 0.05$) superior to all other treatments (Table 2). The application of either NAA @ 200 ppm or Ethrel @ 500 ppm increased four to five times fruits retention in malformed panicles to control. The results obtained are in accordance with the earlier findings as quoted by Pandey and Pandey (2000) who have reported that higher fruit set and lower fruit drop which also depends upon sufficient production of endogenous levels of flowering substances resulting into increased fruit retention as compared to control. The minimum (0.60 & 0.07) average number of fruit retention was recorded under control in both normal as well as malformed panicles (Fig.5).

Table 1. Effect of growth regulators spray on initiation of healthy inflorescences, male flowers and hermaphrodite flowers.

Treatments	Percentage of healthy inflorescences / shoot			Percentage of male flowers/ inflorescence			Percentage of hermaphrodite flowers/ inflorescence		
	Normal Shoots	Scarred Shoots	Mean	Normal Panicles	Malformed Panicles	Mean	Normal Panicles	Malformed Panicles	Mean
NAA @ 150 ppm	78.11	30.11	54.11	67.11	76.13	71.26	18.13	7.13	12.63
NAA @ 175 ppm	80.24	38.82	59.53	62.17	74.71	68.44	21.43	9.10	15.26
NAA @ 200 ppm	83.73	48.11	65.92	58.11	70.19	64.15	29.78	13.14	21.46
Ethrel @ 300 ppm	79.14	37.14	58.14	65.27	73.24	69.25	23.11	8.77	15.94
Ethrel @ 400 ppm	80.51	40.77	60.64	63.14	72.01	67.57	25.76	10.51	18.13
Ethrel @ 500 ppm	82.19	45.37	63.78	61.11	70.72	65.91	27.51	11.82	19.66
Distilled Water (Control)	77.16	28.61	52.88	71.09	80.83	75.96	10.51	3.19	6.85
Mean	80.15	38.41	-	64.00	73.97	-	22.31	9.09	-
CD at 5%	Spray	Shoot	Interaction	Spray	Panicles	Interaction	Spray	Panicles	Interaction
	1.61	1.32	2.37	1.37	1.21	1.92	1.43	1.18	2.43

Table 2. Effect of growth regulators spray on Fruit set and retention per panicle.

Treatments	Average Number of fruits set per panicle			Average Number of fruits retention per panicle		
	Normal Panicles	Malformed Panicles	Mean	Normal Panicles	Malformed Panicles	Mean
NAA @ 150 ppm	4.21	0.82	2.51	0.73	0.91	0.46
NAA @ 175 ppm	4.73	1.01	2.87	0.82	0.25	0.53
NAA @ 200 ppm	5.33	1.51	3.42	0.91	0.35	0.63
Ethrel @ 300 ppm	4.34	0.91	2.62	0.71	0.14	0.42
Ethrel @ 400 ppm	4.81	1.13	2.97	0.76	0.21	0.48
Ethrel @ 500 ppm	5.01	1.25	3.13	0.85	0.30	0.57
Distilled Water (Control)	3.89	0.73	2.31	0.60	0.07	0.33
Mean	4.61	0.87	-	0.76	0.21	-
CD at 5%	Spray	Panicle	Interaction	Spray	Panicle	Interaction
	0.26	0.31	1.1	0.05	0.04	0.11

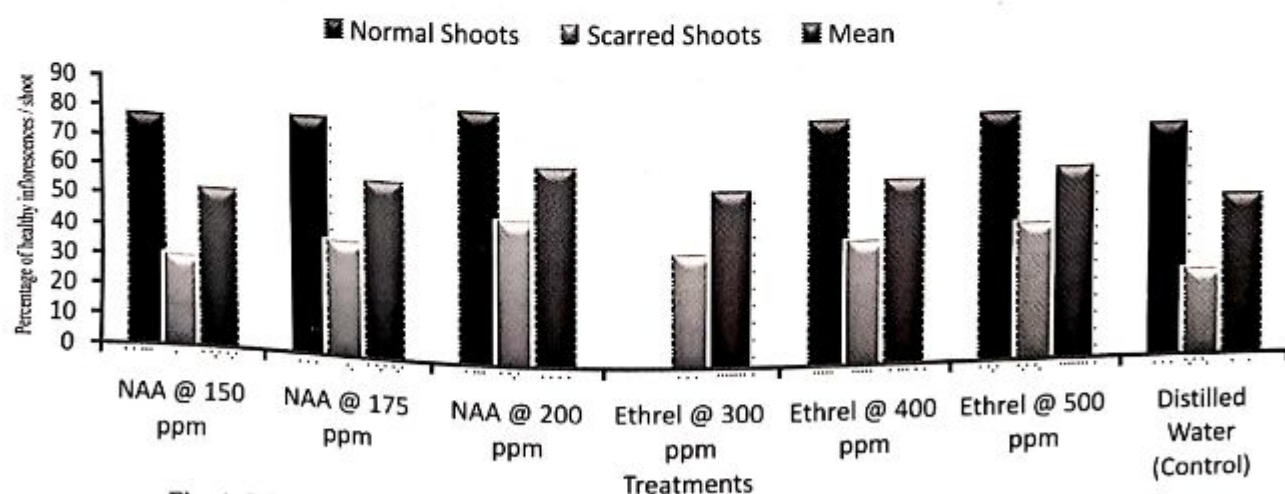


Fig. 1. Effect of growth regulators on initiation of healthy inflorescences/shoot.

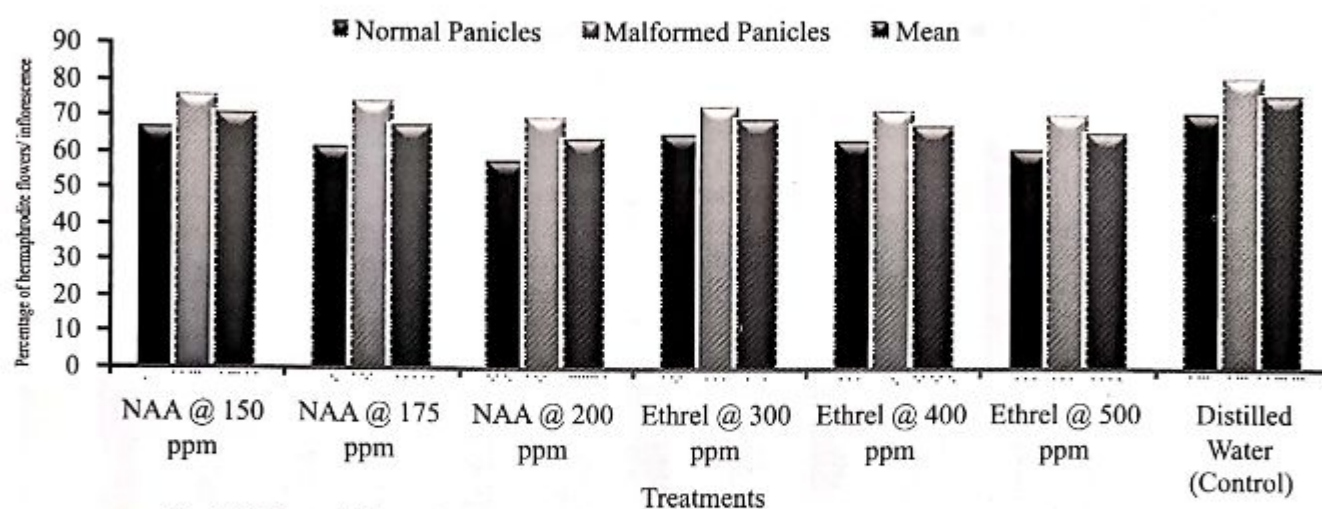


Fig. 2. Effect of Growth regulators on initiation of male flowers/inflorescence.

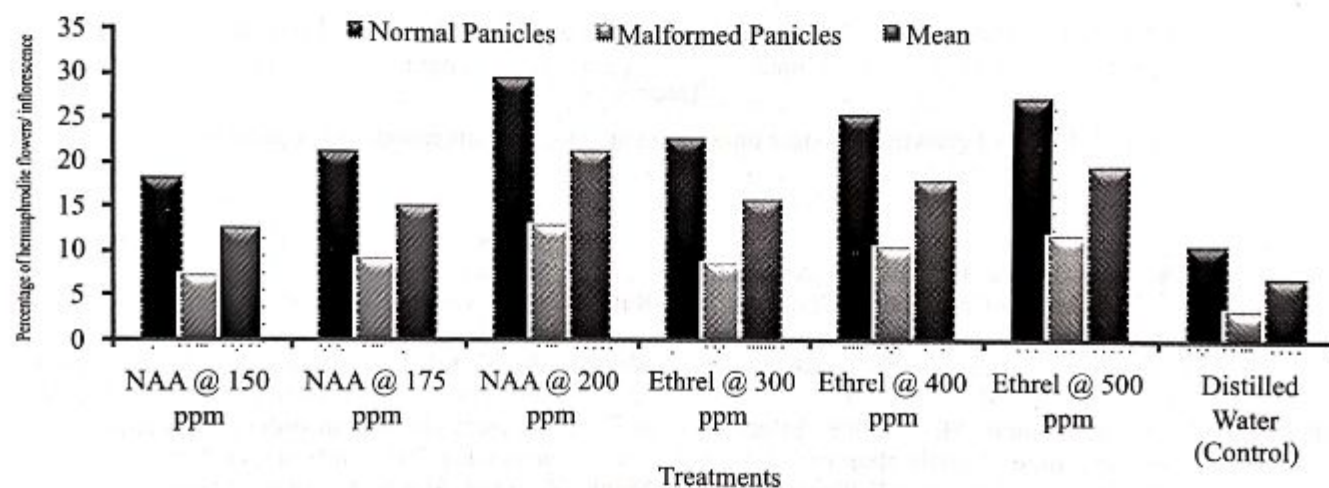


Fig. 3. Effect of growth regulators on initiation of hermaphrodite flowers/inflorescence

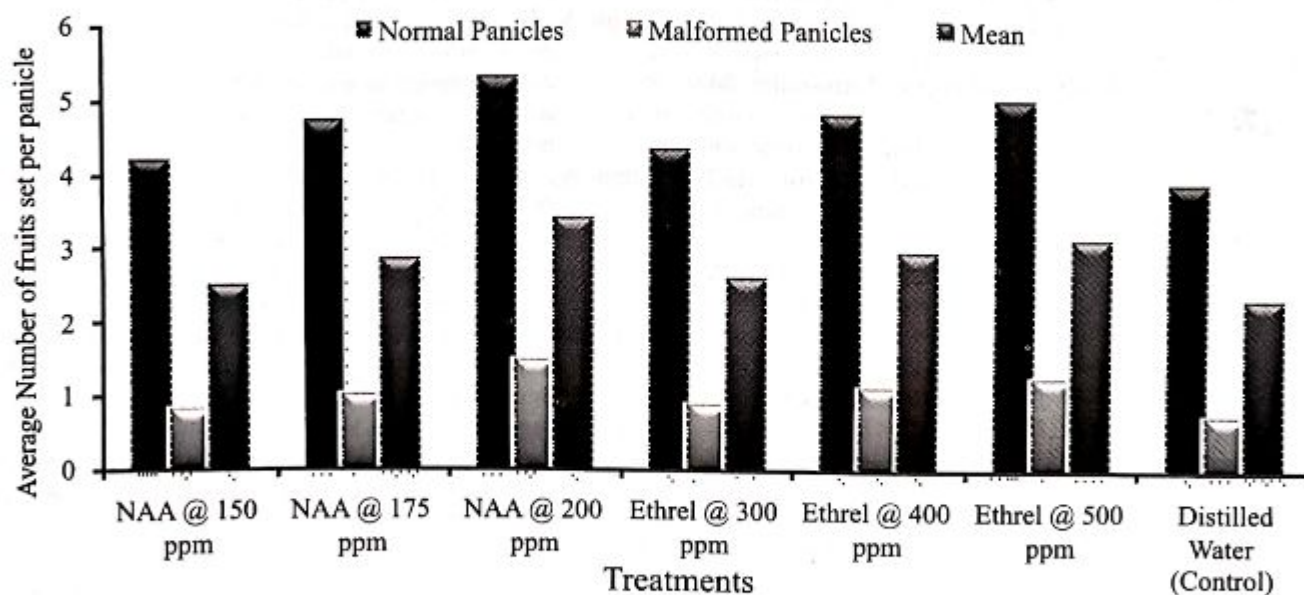


Fig. 4. Effect of growth regulators on average number of fruits set per panicle.

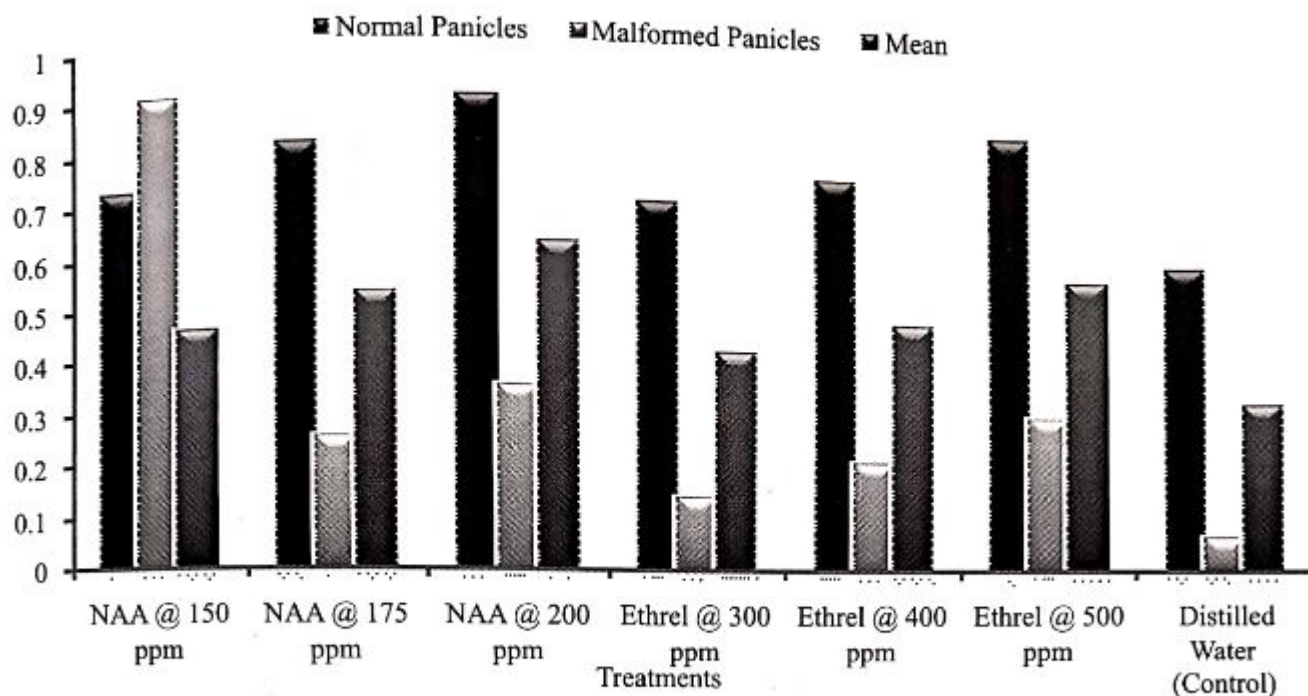


Fig. 5. Effect of growth regulators on average number of fruits retention per panicle.

References:

- Anonymous, 2014. 2nd Advance Estimate of Area and Production of Horticulture Crops, NHB, Gurgaon.
- Chakrabarti, D. K. and Kumar R. 2000. Epidemiological principles of control of mango malformation - A review. *Agric. Rev.*, 21:129-132.
- Chowdhury, M. N. A. and Rahim, M. A. 2008. Effect of concentrations and time of application of NAA on malformation of mango. *J. Agrofor. Environ.*, 2(1):1-6.
- Kumar, M. A. and Reddy, Y. N. (2006). Effect of pruning on sex ratio, fruit set retention of fruits and fruit quality in certain varieties of mango. *Journal of Research Acharya N.G.Ranga Agriculture University*, 34 (2):22-25.
- Pandey, D. and Pandey S. N. 1999. Effect of ethrel spray on the incidence of floral malformation and physiological changes in floral buds of mango. *Progressive Horticulture*, 41(2):171-173.
- Pandey, D. and Pandey S. N. 2000. Effect of growth regulators and zinc sulphate on floral malformation in mango (*Mangifera indica* L.) cv. Amrapali. *Annals of Agricultural Research*, 21 (1):129-32.
- Pandey, G. and Sant, R. 1995. Effect of malformation on changes in endogenous auxins during floral development of mango. *Indian J. Hort.*, 52(2): 92-96.
- Ram, S. and Singh, D. K., 1998. Effect of auxin, gibberellin and cytokinin on floral malformation and productivity in mango. *Recent Horticulture*, 14: 6-9.
- Ram, S. and Yadav, V.K. 1999. Mango malformation-A review. *J. Appl. Hort.*, 1(1): 70-78.
- Shahbaz, M. Z. Iqbal, A. Saleem and M. A. Anjum. 2009. Association of *Lasioidiplodia theobromae* with different decline disorders in Mango (*Mangifera indica* L.). *Pak. J. Bot.*, 41(1): 359-368.
- Singh, Z. and Singh, L. 1998. Micronutrient levels in malformed and healthy organs of mango. *Journal of Plant Nutrition*, 21:2613-2621.
- Singh V. K., Misra A. K., Rajan S. and Ansari M. W. 2007. Protein profile, mangiferin and polyphenol oxidase levels in susceptible and tolerant genotypes of mango against malformation. *Indian J. Hort.*, 64:2224.
- Singh A., Ansari, M. W., Rani, V., Singh, C. P., Shukla, A., Pant, R. C., Tuteja N. and Bains, G. 2014. First evidence of putrescine involvement in mitigating the floral malformation in mangoes: a scanning electron microscope study, *Protoplasma*: 251(5):1255-61.
- Sirohi, S. C., Rana, S. P. and Singh, R. 2005. Response of mango malformation to foliar application of NAA and pesticide. *Indian J. Hort.*, 62 (1): 2224.
- Wafaa Haggag M., Hazza M., Sehab A. and Abd El-Wahab M. 2011. Mango Malformation: I. Toxin Production Associated with *Fusarium* Pathogens. *American Journal of Plant Sciences*, 2:276-281.

Studies on the physico-chemical characteristics of aonla (*Emblica officinalis*) fruits in Chittorgarh district of Rajasthan

R.S. Rathore¹, R.A. Kaushik² and H.K. Jain³

Krishi Vigyan Kendra, Chittorgarh

Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan 313001

¹Krishi Vigyan Kendra, Senth, Chittorgarh

²Professor & Head, Department of Horticulture, RCA, Udaipur

³Associate Professor, Department of Ag. Statistics, RCA, Udaipur

*Correspondence author e mail: drrathore@gmail.com

(Received: 30.04.2015; Accepted: 26.08.2015)

Abstract

The nutritional survey conducted on aonla fruit orchards at different locations in Chittorgarh district of Rajasthan. Variation observed for quality parameters of aonla fruits in different locations. The soil nutrient status influences the quality parameters of the fruits. The average fruit weight of aonla varied from 32.71 to 38.40 g per fruit with the mean value of 35.68 g/fruit. The pooled average fruit length and fruit breadth varied 3.11 to 3.41 cm and 3.79 to 4.15 cm, respectively. The pooled stone weight varied from 1.89 to 2.05 g and pulp to stone ratio ranged from 17.30 to 18.74. The fruit yield per tree ranged from 54.88 to 71.43 kg plant⁻¹. The total soluble solids content ranged from 10.76 to 11.78° Brix and total acidity was recorded between 1.85 to 1.93 per cent. The TSS/acid ratio, ascorbic acid contents, total sugar and reducing sugars varied from 5.58 to 6.35, 411.65 to 581.50 mg/100 g pulp, 4.97 to 6.28 % and 1.71 to 2.10 %, respectively. The quality parameters is found to be directly related to soil nutrient status, hence, better nutrition is likely to improve the quality parameters of aonla fruits.

Key words: Aonla, Physico-chemical, Nutrition status, Yield.

Introduction

Aonla (*Emblica officinalis*) belonging to the family Euphorbiaceae, is a native of Central and Southern India. Aonla is one of the important fruit from Ayurvedic consideration. This fruit has little table value but it is processed in various forms and utilized in large quantities. Its importance in Ayurvedic medicine system can be ascribed to its richness in vitamin-C and some organic acids and phenolic substances. The plant is quite hardy, also grown on alkaline soil, prolific bearer giving high yield; although, it is the most neglected crop. The fruit is small, round and have hard astringent pulp. It is mainly used for making pickles, *murabba*, candy, juice, tophies, powder etc. The major aonla growing districts in Rajasthan are Ajmer, Bhilwara, Chittorgarh, Udaipur, Kota, Bundi, etc. The nutritional status of soil supplemented with regular nutritional management plays an important role in production of quality harvest in any crop. Such basic information on aonla crop in Chittorgarh district of Rajasthan were lacking, where aonla has a great potential. To generate such preliminary information, the present study were undertaken.

Materials and Methods

Studies were conducted on healthy and vigorously growing trees of aonla at farmer's fields during 2009-10 to 2010-11 at Chittorgarh (24° 13' to 25° 13' N latitude and 74° 12' to 75° 53' E latitude). Five orchards of uniform age with same variety (Chakaiya) were selected for investigation. The fruits

were harvested during December. Ten fruits were randomly collected for quality parameters (physico-chemical) analysis. Fruit TSS was measured with "Zeiss" hand refractometer. Total acidity was determined by diluting the known volume of juice and titrating the same against N/10 sodium hydroxide solution, using phenolphthalein as an indicator. It was expressed on percentage basis (A.O.A.C., 1990). TSS/Acidity ratio was estimated by dividing the total soluble solids to total acidity. The ascorbic acid (Vitamin C) content of juice was determined by diluting the known volume of juice with 3 per cent Metaphosphoric acid and titrating it against 2,6-dichlorophenol-indophenol dye solution (A.O.A.C., 1990) until a faint pink colour was obtained. The results are expressed as vitamin C in mg/100 g pulp. Total sugar content was determined using anthrone reagent method (Dubois *et al.*, 1951). To 1 ml of diluted fruit juice (100 times), 5 ml of anthrone reagent was added, then heated for 10 to 15 minutes in a water bath, cooled to room temperature and absorbance was measured at 630 nm on Spectronic-20. Reducing sugar content was measured by following 'Nelson's modification' of 'Somogyi's method' (Somogyi, 1952) using arsenomolybdate colour forming reagent and two copper reagent 'A' and 'B'. The details of fruit orchards and NPK status of soil where the present study was conducted are mentioned in table 1.

Results and Discussion

The data on quality parameters (physico- chemical characteristics) of aonla fruit are presented in table 2 to 5. The

results clearly indicated the extent of variation observed for all the morphological and chemical characteristics of aonla fruit from different orchards. The perusal of pooled data presented in table 2 indicated that average fruit length varied from 3.11 to 3.41 cm with mean value of 3.24 cm. The maximum fruit length (3.41 cm) was recorded at the orchard of Gangrar I while; minimum fruit length (3.11 cm) was recorded at Aonwalheda II. The average fruit breadth varied from 3.79 to 4.15 cm with the mean value of 3.98 cm (Table 2). The highest fruit breadth (4.15 cm) was recorded at Gangrar I while; minimum fruit breadth (3.79 cm) was recorded at Aonwalheda II (Table 2). It is evident that average fruit weight of aonla varied from 32.71 to 38.40 g per fruit with the mean value of 35.68 g/fruit. The maximum fruit weight (38.40 g per fruit) was recorded at Gangrar I while, minimum fruit weight (32.71 g per fruit) was recorded at Aonwalheda II (Table 2). The pooled data revealed that average stone weight of aonla varied from 1.89 to 2.05 g per fruit with the mean value of 1.97 (Table 3). The maximum seed weight (2.05 g per fruit) was recorded of Gangrar I while, minimum stone weight (1.89 g per fruit) was recorded at Aonwalheda II. It is apparent from pooled data (Table 3) that average pulp: stone ratio of aonla fruit varied from 17.30 to 18.74 per fruit with the mean value of 18.10. The maximum pulp: stone ratio (18.74 per fruit) was recorded at the orchard of Gangrar I while, minimum pulp: seed (17.30 per fruit) was recorded at Aonwalheda II. The average yield of aonla fruit varied from 54.88 to 71.43 kg plant⁻¹ with the mean value of 61.20 kg plant⁻¹ (Table 3). The maximum yield (71.43 kg plant⁻¹) was recorded at the orchard of Gangrar I while; minimum yield (54.88 kg plant⁻¹) was recorded at Aonwalheda II. Significant differences were recorded in the physical characteristics among different orchards of study area. Similar variations in these parameters

were reported by Mehta *et al.* (2002) at Hisar and Rohitash (2007) at Bikaner in aonla fruit. Application of adequate quantity of manure and fertilizers and adoption of appropriate management practices might have created the difference in physico chemical characteristics and fruit yield of aonla plants. Proper management of orchards is essential for obtaining quality fruits and yield. Rajan *et al.* (2005) reported that application of nitrogen significantly improved the fruit weight in aonla.

It is obvious from pooled data (Table 4) that average total soluble solids of aonla fruit varied from 10.76° Brix to 11.78° Brix with the mean value of 11.40° Brix. The maximum total soluble solids (11.78° Brix) were recorded at the orchard of Gangrar I while, minimum total soluble solids (10.76° Brix) was recorded at peepalipal. The average total acidity of aonla fruit varied from 1.85 to 1.93 % with the mean value of 1.89 % (Table 4). The minimum total acidity (1.85 %) was recorded at the orchard of Bhiliyakhedi I while; maximum total acidity (1.93) was recorded at Peepalipal. Average TSS/Acidity ratio of aonla fruit varied from 5.58 to 6.35 with the mean value of 6.04. The maximum TSS/Acidity ratio (6.35) was recorded at the orchard of Bhiliyakhedi I while, minimum TSS/Acidity ratio (5.58) was recorded at Peepalipal (Table 4). It is obvious from pooled data (Table 5) that average ascorbic acid of aonla fruit varied from 411.65 to 581.50 mg/100 g pulp with the mean value of 511.59 mg/100 ml pulp. The maximum ascorbic acid (581.50 mg/100 g pulp) were recorded at the orchard of Gangrar I while, minimum ascorbic acid (411.65 mg/100 g pulp) was recorded at Peepalipal. Average reducing sugar of aonla fruit varied from 1.71 to 2.10 % with the mean value of 1.92 %. The maximum reducing sugar (2.10%) was recorded at the orchard of Gangrar I while, minimum reducing sugar (1.71 %) was recorded at Peepalipal (Table 5). It is clear from

Table 1. Soil nutritional status of different orchards location at Chittorgarh district

S.No.	Name of fruit grower	Location	Soil Nutritional Status		
			N (kg/ha)	P (kg/ha)	K (kg/ha)
1.	Sh. Kan Singh Rathore	Gangrar I	409.29	18.93	350.52
2.	Sh. Jagdish Kumar Teli	Aonwalheda I	396.69	17.32	201.09
3.	Sh. Nirmal Kumar Joshi	Samalpura	295.83	18.19	222.51
4.	Smt. Ratan Devi Khavya	Peepalipal	353.46	15.86	270.82
5.	Smt. Usha Sisodia	Bhiliyakhedi I	378.24	19.56	261.34

Table 2. Physical characteristics of aonla fruits cv. Chakaiya at different orchards of Chittorgarh district

Location of the orchard	Fruit length (cm)			Fruit breadth (cm)			Fruit weight (g)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Gangrar I	3.34	3.48	3.41	4.09	4.21	4.15	38.34	38.45	38.40
Aonwalheda II	3.06	3.16	3.11	3.72	3.86	3.79	32.69	32.72	32.71
Samalpura	3.17	3.31	3.24	3.89	4.07	3.98	35.26	36.15	35.71
Peepalipal	3.09	3.23	3.16	3.99	3.85	3.92	34.83	35.12	34.98
Bhiliyakhedi I	3.22	3.36	3.29	3.98	4.14	4.06	36.52	36.72	36.62
Mean	3.18	3.31	3.24	3.93	4.03	3.98	35.53	35.83	35.68
CD at 5 %	0.069	0.074	0.0504	0.082	0.082	0.058	0.561	0.585	0.405
	0.195	0.211	0.142	0.232	0.233	0.162	1.597	1.665	1.138

Table 3. Physical characteristics and yield of aonla fruits cv. Chakaiya at different orchards of Chittorgarh district

Location of the orchard	Stone weight (g)			Pulp : Stone ratio			Yield (Kg ⁻²)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Gangrar I	2.02	2.08	2.05	18.99	18.49	18.74	69.53	73.33	71.43
Aonwalheda II	1.86	1.92	1.89	17.57	17.03	17.30	51.78	57.97	54.88
Samalpura	1.93	1.99	1.96	18.26	18.16	18.21	57.22	61.19	59.21
Peepalpal	1.98	1.90	1.94	17.57	18.47	18.02	56.70	60.26	58.48
Bhiliyakhedi I	1.97	2.05	2.01	18.52	17.90	18.21	60.89	63.11	62.00
Mean	1.95	1.98	1.97	18.18	18.01	18.09	59.22	63.17	61.20
SEm±	0.037	0.023	0.0218	0.263	0.314	0.2048	3.997	2.543	2.369
CD at 5 %	0.106	0.065	0.0612	0.749	0.896	0.5758	11.386	7.244	6.656

Table 4. Chemical characteristics of aonla fruits cv. Chakaiya at different orchards of Chittorgarh district

Location of the orchard	T.S.S (°B)			Total acidity (%)			TSS/Acidity ratio		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Gangrar I	11.87	11.69	11.78	1.88	1.86	1.87	6.31	6.28	6.30
Aonwalheda II	10.87	11.25	11.06	1.93	1.89	1.91	5.63	5.95	5.79
Samalpura	11.57	11.74	11.66	1.90	1.86	1.88	6.09	6.32	6.20
Peepalpal	10.58	10.94	10.76	1.92	1.94	1.93	5.51	5.64	5.58
Bhiliyakhedi I	11.82	11.67	11.75	1.84	1.86	1.85	6.42	6.27	6.35
Mean	11.34	11.46	11.40	1.89	1.88	1.89	5.99	6.09	6.04
	0.172	0.126	0.107	0.021	0.021	0.015	0.089	0.087	0.062
CD at 5 %	0.488	0.359	0.299	0.058	0.058	0.041	0.254	0.248	0.175

Table 5. Chemical characteristics of aonla fruits cv. Chakaiya at different orchards of Chittorgarh district

Location of the orchard	Ascorbic acid (mg/100 ml pulp)			Reducing sugar (%)			Total sugar (%)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Gangrar I	583.42	578.57	580.99	2.05	2.13	2.09	6.25	6.31	6.28
Aonwalheda II	423.17	435.39	429.28	1.77	1.89	1.83	4.90	5.04	4.97
Samalpura	564.63	570.88	567.76	1.86	1.92	1.89	6.04	6.10	6.07
Peepalpal	514.45	526.66	520.55	1.68	1.74	1.71	5.68	5.76	5.72
Bhiliyakhedi I	412.56	410.74	411.65	2.01	2.09	2.05	5.92	6.02	5.97
Mean	499.65	504.45	502.05	1.87	1.95	1.91	5.76	5.85	5.80
	5.897	5.635	4.078	0.062	0.065	0.045	0.078	0.065	0.051
CD at 5 %	16.797	16.051	11.458	0.177	0.186	0.127	0.223	0.184	0.143

pooled data (Table 5) that average total sugar of aonla fruit varied from 4.97 to 6.28 % with the mean value of 5.80 %. The maximum total sugar (6.28 %) was recorded at the orchard of Gangrar I while, minimum total sugar (4.97 %) was recorded at Aonwalheda II. Variability in chemical parameters might be due to the variation in nutrient status of the orchards. These chemical parameters are directly related with nutrients status of plant. Srivastava and Singh (1997) reported that TSS varied from 8 to 14 per cent in germplasm survey of aonla at Faizabad. Rohitash (2007) also reported that PNP TSS varied from 8.50° Brix to 9.50° Brix in fruit from aonla orchards at Bikaner district. Rajan *et al.* (2005) reported that application of nitrogen significantly improve the TSS and ascorbic acid content in fruit of aonla.

References

- A.O.A.C. 1990. Official and tentative methods of analysis. Association of Analytical Chemists. 18th edn. Washington, D.C.
- Dubois M, Gilles K, Hamilton J K, Robers P A and Smith F. 1951. A colorimetric method for determination of sugar. *Nature*, 16: 17.
- Mehta S, Godara R. K, Bhatia, S. K and Kumar S. 2002. Studies on physico-chemical characteristics of various cultivars of aonla under semi-arid conditions. *Haryana Journal of Horticulture Science*, 31 : 17-19.
- Rajan, K., Tarai, K. and Ghosh, S. N. 2005. Effect of nitrogen levels on yield, fruit quality and foliar N, P and K status of aonla grown on laterite soil. *Indian Journal of Horticulture*, 62 : 394-395.
- Rohitash, 2007. Role of soil nutrient status on nutrient content and fruit yield of aonla. M.Sc. thesis, Rajasthan Agricultural University, Bikaner.
- Somogyi, M. 1952. Arsenomolybdate reagent colour development method of reducing sugar determination. *Journal of Biology of Chem.*, 195: 19-23.
- Srivastava, A. K. and Singh, I.S. 1997. Genetic diversity in aonla (*Emblia officinalis* Gaertn.). *Indian Horticulture*, pp: 10

Influence of weather parameters on the seasonal incidence of chilli thrips, *Scirtothrips dorsalis* Hood

A.V. Jadhao, S.K. Patil* and S. R. Kulkarni

Department of Agricultural Entomology,

Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722 (Maharashtra), India

* Corresponding Author email : ksantoshjayu@yahoo.co.in / skpatil.mpkv@gmail.com

(Received: 15.10.2015; Accepted: 11.05.2016)

Abstract

The field experiment was conducted during *Kharif* 2014 on seasonal incidence of chilli thrips (*Scirtothrips dorsalis* Hood) and its natural enemies. The results revealed that the higher population of thrips and coccinellids was recorded in the range of 11.27 to 14.93 thrips per 6 leaves per plant and 0.40 to 0.53 coccinellids per plant, respectively during 2nd week of October to 1st week of November. However, peak activity of thrips (14.93 per 6 leaves per plant) and coccinellids (0.53 per plant) was observed during the 4th week of October (44th MW) and 1st week of November (45th MW). Then gradually declined in population up to last week of December (52nd MW). All the weather parameters i.e. temperatures (maximum and minimum), relative humidity (morning and evening) and rainfall were correlated negatively with the incidence of thrips population and abundance of coccinellids except maximum temperature showed positive correlation with coccinellids.

Keywords: Chilli, *Scirtothrips dorsalis*, seasonal incidence, weather parameters.

Introduction

Chilli (*Capsicum annuum* L.) is an important crop not only because of its economic importance, but also due to nutritional and medicinal value of its fruits. Chilli is the excellent source of colours and antioxidants compounds, a wide spectrum of antioxidant and capsaicinoids are present in chilli fruits. It is used as vegetables, spices, condiments, sauce, pickles and medicines. Among the various factors responsible for low yield of chilli, the insect pests are of prime importance. As many as, 55 insect and non-insect pests have been recorded to infest this crop. Of these, thrips (*Scirtothrips dorsalis* Hood) is considered the most destructive pest in Maharashtra (Day *et al.*, 2001). Both nymph and adult of thrips rasp on terminal auxiliary tender shoots and suck the oozing cell sap from tender leaves, growing shoots, flowers and fruits. Attacked leaves curl upward and exhibit the characteristics of leaf curl symptoms. The economic yield loss was noticed to the extent of 11 to 32 per cent (quantitative) and 88 per cent (qualitative) in chilli. The crop loss caused by thrips (*S. dorsalis*) reported to range from 30 to 50 per cent (Kandyaswamy *et al.*, 1990 and Ahmed *et al.*, 1987). The prevalence and build up of this pest is mostly governed by weather parameters like temperature, relative humidity, rainfall and sunshine hours. For effective pest management of thrips, study on the influence of the various factors responsible for population fluctuation on a particular crop might assist in prediction of its occurrence in a given area. Thus, the

knowledge of the influence of weather parameters on chilli will help to develop a forecasting system and to implement timely plant protection measures. Therefore, the present investigation was undertaken on incidence of thrips on chilli.

Materials and Methods

Field experiment was conducted on incidence of chilli thrips and occurrence of its natural enemies during *Kharif* of 2014 at the Research Farm of Department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722 (Maharashtra state). The seedling of chilli variety "Phule Jyoti" was transplanted after two months in the experimental non-replicated three plots having a size 4.20 m X 3.60 m of each plot with 45 X 60 cm spacing. The crop was raised under normal recommended of practices and left for natural infestation of desired pest. No plant protection measures were taken throughout the crop season. Observations on population of thrips and coccinellids were recorded at weekly interval in the morning hours starting from transplanting on 5 randomly selected plants from each plot. The population of thrips was counted on number of nymphs and adults per 6 leaves per plant (2 leaves from each top, middle and bottom part) and coccinellids was recorded on per plant from each plot. The weather parameters viz., temperature (°C), relative humidity (%) and rainfall (mm) in different standard weeks during the crop season were recorded at meteorological centre, MPKV, Rahuri. The relationship between the thrips and coccinellids with weather parameters was worked out.

Results and Discussion

The data presented in Table 1 and predicted in Fig. 1, revealed that the pest population increased gradually after transplanting of chilli seedling at vegetative and flowering stage of the crop. The average number of thrips population ranged from 0.0 to 14.93 thrips/6 leaves/plant during the period from 32nd to 52nd MW. The minimum number of thrips was recorded in the month of August which may be due to high rainfall. Then the population gradually increased up to the 4th week of October (44th MW) and reached its peak (14.93 thrips/6 leaves/plant). At the time of peak level of infestation of thrips, the maximum and minimum temperature, morning and evening relative humidity and rainfall were recorded 32.0 and 14.0°C, 55.7 and 36.1% and 0.00 mm, respectively. Thereafter the infestation of thrips gradually decreased in 3rd week of November (47th MW) and again increased in the 4th week of November i.e. 48th MW and reached to 12.60 thrips. Then the population declined gradually and remained up to 4.93 thrips in last week of December (52nd MW). These present findings on incidence of thrips, *S. dorsalis* are in close agreement with the results of Raizada (1965) who reported the abundance of *S. dorsalis* on chilli during July to September

was low, but the severe incidence of *S. dorsalis* was observed during October. Similarly, Ningappa (1972) recorded the population of chilli thrips, at its peak during October, and thereafter gradually declined from November onwards reaching the lowest level in May. The infestation of thrips started from 1st week after transplanting i.e. last week of August and remained in field till to the crop maturity (3rd week of February) in the range of 0.50 to 10.54 with an average of 4.37 thrips/twig (Barot *et al.*, 2012). Meena *et al.* (2013) reported infestation of *S. dorsalis* was initiated in the 4th week of July (30th MW) and remained up to 4th week of November (48th MW). The thrips population increased gradually and touched its peak with a mean of 14.5 and 14.7 thrips/3 leaves/plant during 2006-07 and 2007-08 respectively, in the 1st week of October. Thereafter, the population declined gradually and reached up to 7.5 and 7.0 thrips in last week of November (48th MW).

In case of *natural enemies* i.e. coccinellids, the abundance of coccinellid was observed with infestation of thrips after transplanting of the chilli crop in 2nd week of August (33rd MW). Coccinellid population was ranged from 0.0 to 0.53 coccinellid/plant during 32nd to 52nd MW. There was

Table 1. Seasonal incidence of thrips and coccinellids on chilli in relation to weather parameters

Met. Week	Date of observation	No. of thirps per 6 leaves per plant	No. of Coccinellids per plant	Weather parameters				Rainfall (mm)
				Temperature (°C)		Relative Humidity (%)		
				Maximum	Minimum	Morning	Evening	
32	02/08/2014	0.00	0.00	30.5	21.9	72.4	57.0	1.6
33	9/08/2014	1.21	0.07	31.8	21.9	70.6	50.6	34.0
34	16/08/2014	2.46	0.20	32.7	22.6	78.9	51.3	44.4
35	23/08/2014	0.68	0.00	28.6	21.8	81.6	72.4	129.9
36	01/09/2014	1.02	0.13	29.2	22.2	75.0	66.3	15.8
37	08/09/2014	1.40	0.07	30.7	21.0	70.9	56.9	0.0
38	15/09/2014	1.40	0.07	31.9	21.0	71.4	51.6	4.0
39	22/09/2014	3.80	0.27	33.6	20.3	70.4	40.7	0.0
40	29/09/2014	4.14	0.27	34.1	22.2	70.1	40.1	0.0
41	06/10/2014	5.80	0.27	30.0	19.6	64.0	33.0	7.4
42	13/10/2014	12.47	0.46	33.7	21.0	72.1	43.6	13.4
43	20/10/2014	12.27	0.40	29.4	16.1	72.6	57.0	1.0
44	27/10/2014	14.93	0.40	32.0	14.0	55.7	36.1	0.0
45	03/11/2014	11.67	0.53	31.8	15.9	57.6	37.4	0.0
46	10/11/2014	9.06	0.27	29.7	20.1	80.7	63.1	96.2
47	17/11/2014	8.80	0.20	20.1	15.3	69.4	41.0	0.0
48	24/11/2014	12.60	0.20	29.6	12.1	56.9	29.6	0.0
49	01/12/2014	11.20	0.27	29.1	10.9	55.0	32.0	0.0
50	08/12/2014	9.67	0.27	29.2	14.6	67.0	47.0	0.0
51	15/12/2014	7.46	0.13	25.7	17.5	52.0	34.0	0.00
52	22/12/2014	4.93	0.00	27.2	18.2	56.0	37.0	0.00

Table 2. Correlation coefficient (r) of chilli thrips and coccinellids with weather parameters

Weather parameters	Thrips	Coccinellids
Maximum temperature	-0.104	0.29
Minimum temperature	-0.79**	-0.40*
Morning relative humidity	-0.52**	-0.21
Evening relative humidity	-0.54**	-0.37*
Rainfall	-0.27	-0.25

Significant at 5 % level = 0.36*

Significant at 1% level = 0.42**

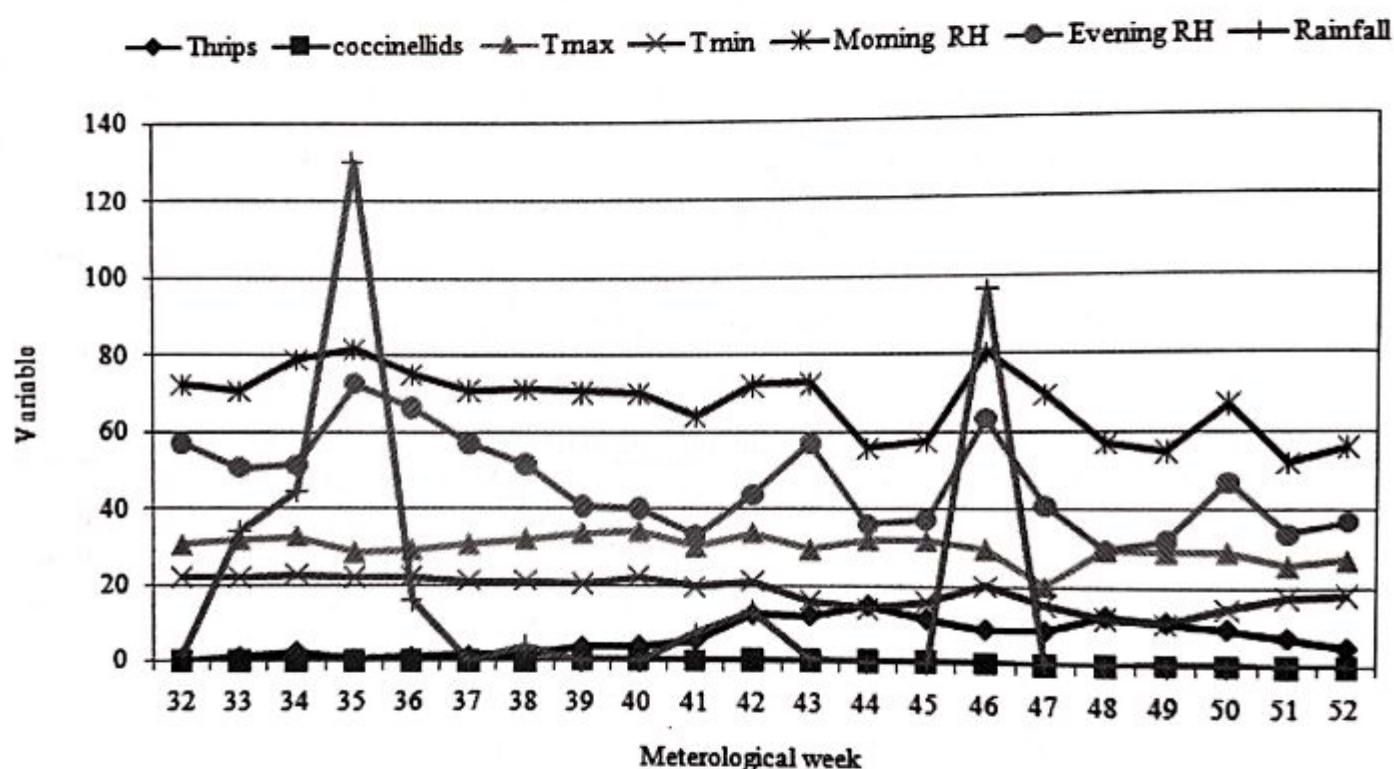


Fig. 1 : Distribution of Thrips and Meteorological data during different weeks

increase in the coccinellid population in 2nd fortnight of September upto 1st week of November. Thereafter, the population gradually declined in till last week of December. The maximum number of coccinellid population (0.53) was recorded in 45th MW i.e. 1st week of November when maximum and minimum temperatures were 31.8 and 15.9°C, relative humidity at morning and evening time were 57.6 and 37.4%, respectively and rainfall recorded 0.0 mm. These present findings are in agreement with the results of Meena and Kanwat (2010) who reported the appearance of coccinellids started from first week of August (1.8 and 1.7 beetles/plant) and reach at maximum in first week of October (6.2 and 6.4 beetles/plant) on okra during *Kharif* 2002 and 2003, respectively.

Correlation of weather parameters with chilli thrips and coccinillids

It is evident from Table 2, that there was negative

correlation between infestation of thrips and all the weather parameters (temperature, relative humidity and rainfall). However, the significant negative correlation was observed with thrips incidence and minimum temperature ($r = -0.79$), morning ($r = -0.51$) and evening relative humidity ($r = -0.54$). Whereas, other parameters viz., maximum temperature ($r = -0.104$) and rainfall (-0.24) were non-significant and negatively correlated with thrips population. The results are in agreement with the findings of Hosamani (2006) who reported minimum temperature, evening RH and rainfall were significantly but negatively correlated with thrips population. Similarly, Barot *et al.* (2012) reported the significant negative correlation with minimum temperature, relative humidity (morning, afternoon and mean) and rainfall. Meena *et al.* (2013) exhibited negative correlation with minimum temperature, morning and evening relative humidity and average rainfall. Thrips population had negative correlation with minimum temperature, morning and evening relative humidity and rainfall (Pathipati *et al.*, 2014).

The current observations in respect of maximum temperature are in contrasts with the findings reported by Bhede *et al.* (2008), Patel *et al.* (2009) and Pathipati *et al.* (2014) who reported the significantly positive relationship between maximum temperature and thrips incidence.

As regards the natural enemies, the activity of coccinellids was recorded during the infestation of thrips on chilli crop. The coccinellids population showed positive correlation with maximum temperature ($r = 0.29$). Whereas, coccinellids showed significant negative correlation with minimum temperature ($r = -0.40$) and evening relative humidity ($r = -0.37$) and non-significantly negative correlation with morning relative humidity and rainfall. The present findings are in agreement with the reports of Meena and Kanwat (2010) who found that the minimum temperature and relative humidity showed significant negative correlation with coccinellids population, whereas maximum temperature had non-significant positive correlation and rainfall had non-significant negative correlation with coccinellids population.

References

- Ahmed, K., Mohamad, M. G. and Murthy, N. S. R. 1987. Yield losses due to various pests in hot pepper. *Capsicum Newsletter*, 6:83-84.
- Barot, B. V., Patel, J. J. and Shaik, A. A. 2012. Population dynamics of chilli thrips, *Scirtothrips dorsalis* Hood in relation to weather parameter. *AGRES- An International e-Journal*, 1(4): 480-485.
- Bhede, B. V., Suryawanshi, D. S. and More, D. G. 2008. The studies on population dynamics and bioefficacy of newer insecticide against chilli thrips, *Scirtothrips dorsalis* (Hood). *Indian Journal of Entomology*, 70 (3): 223- 226.
- Day, P. K., Sarkar, P. K. and Somachoudhary, A. K. 2001. Efficacy of different treatment schedule of profenophos against major pest of chilli. *Pestology*, 25(11):26-29.
- Hosamani, A. 2006. Incidence of thrips and mites in chilli Ph.D. (Agri.) thesis submitted to University of Agriculture Sciences, Dharwad: pp. 45-46.
- Kandaswamy, C., Mohanasundaram, M. and Karuppuchamy, P. 1990. Evaluation of insecticides for the control of the thrips, *Scirtothrips dorsalis* Hood on chillies (*Capsicum annum* L.). *Madras Agricultural Journal*, 77 (3-4): 169-172.
- Meena, R. S., Ameta, O. P. and Meena, B. L. 2013. Population dynamics of sucking pest and their correlation with weather parameters in chilli, *Capsicum annum* L. crop. *The Bioscan*, 8 (1): 177-180.
- Meena, N. K., and Kanwat P. M. 2010. Studies on seasonal incidence and relative safety of pesticides against coccinellid beetles in okra ecosystem. *Journal of Biological Control*, 24 : 116-122.
- Ningappa, M. S. 1972. Studies on the role of *Scirtothrips dorsalis* Hood (Thysanoptera - Thripidae) and *Polyphagotarsonemus latus* (Banks) (Acarina : Tarsonemidae) in causing leaf curl and their control. M.Sc. (Agri.) thesis submitted to University of Agricultural Sciences, Bangalore: p. 64.
- Patel, B. H., Koshiya, D. J. and Korat, D. M. 2009. Population dynamics of chilli thrips, *Scirtothrips dorsalis* Hood in relation to weather parameters. *Karnataka Journal of Agricultural Sciences*, 22 (1): 108-110.
- Pathipati, V. L., Vijayalakshmi, T. and Naramnaidu, L. 2014. Seasonal incidence of major pest of chilli in relation to weather parameters in Andhra Pradesh. *Pest Management in Horticultural Ecosystems*, 20(1): 36-40.
- Raizada, U. 1965. The life history of *Scirtothrips dorsalis* Hood with detail external morphology of its immature stages. *Bulletin of Entomological Research*, 6: 30-49.

Proximate composition of indigenous fruits and vegetables grown in tribal region of Western India

Dashrath Bhati*¹ and Shashi Jain²

Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan

¹Department of Agro-Produce Processing Division, Soybean Processing and Utilization, CIAE, Nabi Bhag, Berasia Road, Bhopal

²Department of Food and Nutrition, College of Home Science,

*Corresponding author's e-mail address: bhati.dashrath.1@gmail.com

(Received: 01.07.2015; Accepted: 12.01.2016)

Abstract: The nutritive value of indigenous fruits (11), green leafy vegetables (12), other vegetables (11) and roots and tubers (8) of western India were analysed in terms of protein, fat, fiber, ash, carbohydrates and energy. *The study concluded that the different indigenous fruits and vegetables consumed in tribal areas are rich source of protein and fat and may be used in daily diet. Hence these indigenous fruits and vegetable may be recommended to achieve sustainable food and nutritional security.*

Key words: Tribal, Indigenous plants, Fruits and Vegetable, Food and Nutritional security

Introduction

The variability in climate, edaphic, and topographic conditions causes diversity of vegetation. "Indigenous" means, a species is defined as native of indigenous to a given region or ecosystem, if it is present in that region is the result of only natural process with no human intervention. Knowledge of such available indigenous plant resources used by man has enabled him to survive in adverse climates. Tribals lives as part of nature and they exploited nature to meet their food/nutritional demands. Tribal instantly collect vegetables from the surrounding at the time of weeding at agriculture farm or grazing their cattle in forest and consume it in either or in cooked form. Analysis of such indigenous fruits and vegetables consumed by the tribal provide an important tool for assessing actual nutrient contribution of these indigenous fruits and vegetables. The present study was therefore undertaken to find out the nutrient composition of forty two indigenous fruits and vegetables consumed by the tribal population of Udaipur District (Rajasthan), located in Western India.

Material and Methods

The field survey was conducted during September 2011 to March 2012, in the five tribal blocks i.e. Jhdol, Kotra, Kherwada, Sarada and Salumber of Udaipur district of Rajasthan (India). The main tribes of the area are *Bheel, Meena, Garasia and Kathodi*. In order to collect relevant information an open end proforma with group discussion were used. In each block a total 50 groups (ten groups from each block) were studied at a time till the receipt of desired information. Total of 450 tribal people were contacted to gather required information. For an effective communication, the help of forest guards and *Van Mitra* were utilized. Plants were collected, photographed, identified and voucher

specimens prepared for the herbarium. Ethnobotanical information about fruits and vegetables was gathered through personal observations and discussions with the villagers. On the basis of consumption by the local population residing in the study area, a total of 42 fruits and vegetables were selected for the study as per the feasibility and availability of samples. All the selected samples were sub divided into four groups i.e. fruits, green leafy vegetables, other vegetables and roots and tubers.

Samples were washed thoroughly in running tap water to remove dust, dirt etc. and tender and edible part were collected. Each sample was dried at $45 \pm 5^\circ\text{C}$ in hot air oven. They were ground to fine powder in a sieve through 1.0 mm mesh and stored in airtight container for analysis.

All samples were analysed for the proximate principle-moisture, protein (N x 6.25), crude fat (ether extraction), ash and crude fiber (NIN, 2003). The carbohydrate, content was calculated by difference, i.e. 100, the sum of the per cent of ash, protein, fat and fiber. Energy value was calculated by multiplying the values obtained for carbohydrate, protein and fat, with 4, 4 and 9 respectively and adding up the values.

Statistical analysis: The data analyses were analysed in triplicate ($n = 3$), and presented as means standard error of deviation.

Result and Discussion

The nutritional composition of indigenous fruits, green leafy vegetables, other vegetables and roots and tubers are presented in Table 1 to Table 4, respectively.

Fruits: *Holoptelea integrifolia* observed to be the fruit with lowest moisture content and *Citrus medica* with the highest (89.13 g/100g). For other fruit species, this value varied

Table 1. Proximate composition of indigenous fruits (g/100g on dry weight basis).

S. No.	Botanical Name	Local name	Moisture	Protein	Fat	Ash	Fiber	CHO	Energy (Kcal)
1	<i>Citrus medica</i>	Bijura	89.13±0.40	9.15±0.73	1.83±0.35	5.17±0.01	12.37±0.37	71.49±0.93	339.03±1.38
2	<i>Cordia gharaf</i>	Gundi	56.29±0.27	8.17±1.01	13.13±0.15	4.62±0.08	5.98±0.25	68.09±0.85	423.25±1.13
3	<i>Diospyros melanoxylon</i>	Timru	62.57±1.55	2.04±0.29	1.90±0.53	3.75±0.06	11.28±0.24	81.02±0.88	349.36±2.71
4	<i>Feronia limonia</i>	Kotambadi	70.34±0.87	8.76±0.77	11.70±0.10	5.20±0.07	7.48±0.11	66.87±0.89	407.80±0.46
5	<i>Ficus benghalensis</i>	Bad	73.00±1.39	4.86±0.17	8.37±0.25	6.06±0.04	32.74±0.38	47.97±0.44	286.62±2.06
6	<i>Ficus recemosa</i>	Gullar	81.32±1.58	4.57±0.34	3.43±0.49	7.38±0.04	14.18±0.06	70.44±0.49	330.94±2.54
7	<i>Holoptelea integrifolia</i>	Bandar Botti	2.18±0.05	21.79±1.61	43.33±0.35	3.76±0.04	4.06±0.07	27.05±1.54	585.38±1.94
8	<i>Manilkara hexandra</i>	Rayna	47.88±1.8	4.28±1.18	8.37±0.12	3.47±0.06	2.20±0.09	81.69±1.23	419.17±0.45
9	<i>Nelumbo nucifera</i>	Kamal Kokari	82.93±1.84	21.11±0.17	3.10±0.2	6.47±0.13	3.94±0.15	65.38±0.24	373.87±0.5
10	<i>Pithecellobium dulce</i>	Jangal Jalebi	84.7±0.35	18.68±0.51	1.40±0.17	5.07±0.11	3.93±0.12	70.92±0.39	371.00±1.01
11	<i>Tribulus terrestris</i>	Gokhru fruit	8.52±0.36	14.98±1.11	7.23±0.32	6.38±0.02	27.10±0.23	44.30±1.12	302.23±2.62

Table 2. Proximate composition of indigenous green leafy vegetables (g/100g on dry weight basis)

S. No.	Botanical Name	Local name	Moisture	Protein	Fat	Ash	Fiber	CHO	Energy (Kcal)
1	<i>Asphodelus tenuifolius</i>	Piyagi	89.21±0.17	20.24±0.34	3.67±0.12	10.1±0.1	12.3±0.16	53.7±0.37	328.74±0.85
2	<i>Cassia tora</i>	Puariya	84.92±0.05	29.38±1.18	5.67±0.06	11.69±0.81	9.52±0.16	43.71±0.78	343.66±3.05
3	<i>Centella asiatica</i>	Brahmi Buti	85.71±0.31	19.17±0.17	2.43±0.21	18.27±0.21	10.63±0.12	49.5±0.34	296.56±1.37
4	<i>Cicer arietinum</i>	Liliya	77.08±0.12	29.77±0.77	3.97±0.06	12.12±0.03	10.85±0.08	43.29±0.73	327.96±0.4
5	<i>Cordia dichotoma</i>	Gunda ku More	78.48±1.35	22.47±0.0	2.5±0.0	13.39±0.09	10.86±0.2	50.78±0.26	315.51±1.04
6	<i>Euphorbia royleana</i>	Thour	93.53±0.64	11.68±0.29	9.47±0.12	14.15±0.05	9.04±0.14	55.67±0.1	354.58±0.36
7	<i>Marsilea minuta</i>	Jhalod Ri Bhaji	70.14±1.82	24.52±0.77	3.17±0.25	8.32±0.13	10.64±0.14	53.29±0.89	340.32±2.39
8	<i>Medicago sativa</i>	Rajka	72.66±0.97	24.23±0.58	2.5±0.0	11.59±0.05	14.58±0.13	47.11±0.63	307.84±0.35
9	<i>Melilotus indica</i>	Pili Sangi	79.57±0.69	30.45±0.61	5.27±0.06	10.58±0.06	7.47±0.41	46.23±0.29	354.13±1.76
10	<i>Polygonum glabrum</i>	Pani vala	84.86±0.83	28.9±0.29	2.37±0.06	12.44±0.54	7.62±0.18	48.68±0.79	331.6±2.39
11	<i>Portulaca oleracea</i>	Lunakiya	90.94±0.26	19.26±0.51	3.37±0.15	26.37±0.51	7.47±0.26	43.52±0.49	281.45±2.07
12	<i>Tribulus terrestris</i>	Gokhru Leaves	82.16±0.36	20.92±0.45	1.63±0.21	16.55±0.33	16.6±0.25	44.24±0.63	275.92±1.65

Table 3. Proximate composition of indigenous other vegetables (g/100g on dry weight basis)

S. No.	Botanical Name	Local name	Moisture	Protein	Fat	Ash	Fiber	CHO	Energy (Kcal)
1	<i>Acacia nilotica</i>	Babul Fali	62.43±0.12	12.36±0.45	2.67±0.12	3.77±0.04	11.57±0.06	69.64±0.35	352.00±0.3
2	<i>Aloe barbadensis</i>	Sinduri	89.52±0.63	11.97±0.51	13.33±0.42	6.2±0.09	9.42±0.35	59.08±0.76	404.2±1.66
3	<i>Averrhoa carambola</i>	Kamrakh	91.96±0.64	6.62±0.17	2.7±0.1	4.35±0.02	7.9±0.11	78.44±0.13	364.52±0.86
4	<i>Bombax ceiba</i>	Samble Dodi	76.9±0.37	10.63±0.29	2.43±0.31	6.76±0.07	12.18±0.13	67.99±0.46	336.41±0.97
5	<i>Carissa congesta</i>	Jangli Karonda	81.58±0.33	6.32±0.17	20.53±0.12	4.75±0.08	6.37±0.25	62.02±0.25	458.17±1.82
6	<i>Cissus quadrangula</i>	Hadjoood	91.87±0.03	9.15±0.45	3.63±0.12	15.13±0.28	11.8±0.28	60.28±0.44	310.41±0.6
7	<i>Crotalaria juncea</i>	San	75.2±0.75	24.13±0.45	2.61±0.1	7.08±0.07	19.77±0.3	46.41±0.64	305.69±0.86
8	<i>Dendrocalamus strictus</i>	Bans/ Karel	91.54±0.29	27.24±0.17	5.1±0.1	12.08±0.15	11.47±0.17	44.11±0.57	331.3±0.99
9	<i>Dioscorea Sp.</i>	Alitha Fruit	72.08±0.9	8.08±0.34	2.07±0.21	3.01±0.01	3.23±0.22	83.61±0.47	385.35±0.24
10	<i>Leptadenia reticulata</i>	Shani Dhodi	88.44±0.4	11.97±0.0	6.6±0.26	5.53±0.08	22.7±0.23	53.2±0.08	320.08±2.15
11	<i>Phoenix sylvestris</i>	Khazoor Root	82.79±0.07	17.61±0.67	9.57±0.21	8.01±0.01	4.84±0.04	59.97±0.58	396.43±0.96

between 8.52 to 84.70 g/100g. Wide variation was recorded for protein content. The lowest protein was recorded in *Diospyros melanoxylon* and the highest in *Holoptelea integrifolia* followed by *Nelumbo nucifera*, *Pithecellobium dulce* and *Tribulus terrestris* (Table 1). Maximum crude fat content was observed for *Holoptelea integrifolia* (43.33

g/100g) followed by *Cordia gharaf* (13.13 g/100g) and *Feronia limonia* (11.70g/100g) while lowest in *Pithecellobium dulce* (1.40g/100g). Highest carbohydrate percentage was recorded in *Manilkara hexandra* and lowest in *Holoptelea integrifolia* (27.05 g/100g).

The protein content of *Holoptelea integrifolia*,

Tribulus terrestris, *Nelumbo nucifera*, *Cordia gharaf*, *Pithecellobium dulce*, *Feronia limonia* and *Manilkara hexandra* was higher than the common conventional fruits. Thus, these fruits may have great potential to combat malnutrition. The fat content of *Holoptelea integrifolia*, was found exceptionally higher (43.33 g/100g) which is more than major oil seeds i.e. groundnut and mustard seeds (Gopalan et al., 2007). Hence, it may be the future alternative source for edible oil/cooking oil.

The fruits of *Holoptelea integrifolia* and *Tribulus terrestris*, were consumed in dried form by the local people of the studied area and this was the reason that the moisture content was low in comparison to the remaining analysed fruits. Fiber, carbohydrates and energy content in all the analysed indigenous fruits were comparable to the conventional fruits.

Green leafy vegetables

Moisture content varies among all the analysed green leafy vegetables ranged from 70.14 per cent in *Marsilea minuta* to 93.53 per cent in *Euphorbia royleana* respectively. *Marsilea minuta* recorded lower moisture in the present study than Gopalan et al., 2007. This might be due to effect of variation in climatic conditions. Highest protein was observed in *Melilotus indica* leaves (30.45 g/100g) followed by *Cicer arietinum*, *Cassia tora* and *Polygonum glabrum* on dry weight basis. Crude fat content ranged from 1.63 to 9.47 g/100g for *Tribulus terrestris* and *Euphorbia royleana*, respectively. The maximum total mineral ash was in *Portulaca oleracea* leaves (26.37g/100g). Crude fiber was maximum in *Tribulus terrestris* (16.6g /100g) followed by *Medicago sativa*, *Cordia dichotoma* and *Cicer arietinum*. Energy was found to be more in *Euphorbia royleana* and *Melilotus indica* contained comparatively low fat content but higher protein content. Proximate composition of all the analysed green leafy vegetables was comparable to the conventional green leafy vegetables (Gopalan et al., 2007). Other workers also reported that wild leafy vegetables contained nutrient comparable to the conventional foods (Gupta et al. 2005, Nazarudeen, 2010 and Bhati and Jain, 2015).

Among all the green leafy vegetables, *Marsilea minuta* was found to be highest protein content followed by *Cicer arietinum*, *Medicago sativa* and *Melilotus indica* in fresh form. Maximum ash and fiber content was recorded in *Tribulus terrestris* (16.6g/100g) leaves.

Other vegetables

The proximate composition of the other vegetables are presented in Table 3. Wide variation was observed in moisture content among all the analysed other vegetables (62.43 to 91.96 per cent). The crude protein maximum (27.24 g/100g) was found in *Dendrocalamus strictus* followed by *Phoenix sylvestris*, *Acacia nilotica*, *Leptadenia reticulata* and *Aloe barbadensis*. This range of protein, however, is relatively higher than the common conventional other vegetables. The mineral ash ranged from 3.01 to 15.13 g/100g being minimum in *Dioscorea* sp. And maximum in *Cissus quadrangula*. The crude fat content in all the other vegetables varied between 2.07 g/100g in *Dioscorea* sp. and 20.53 g/100g in *Carissa congesta*. The results showed the analysed indigenous other vegetables have comparable levels of nutrients to the conventional other vegetables.

Roots and tubers:

The proximate composition of indigenous root and tuber crops are given in Table 4. The maximum moisture content (84.68 per cent) was found in *Dioscorea* sp (*Alitha Kand*), followed by *Dioscorea petaphylla* (82.55 per cent), *Dioscorea hispida* (82.28 per cent) and *Dioscorea esculanta* (81.09 per cent). Protein content ranged from 5.93 g/100g (*Dioscorea esculanta*) to 9.63 g/100g (*Dioscorea petaphylla*).

Protein contents of all the analysed roots and tubers were found to be comparable with the conventional roots and tubers. Crude fat content was ranged from 1.07 to 20.3 g/100g. The maximum ash content was found in *Pueraria tuberosa* (8.55 g/100g) and minimum in *Dioscorea hispida* (3.35 g/100g) among the analysed roots and tubers. Total carbohydrate content ranged from 76.03 g/100g in *Dioscorea petaphylla* to 86.60 g/100g in *Dioscorea esculanta*. Crude

Table 4. Proximate composition of indigenous roots and tubers (g/100g on dry weight basis)

S. No.	Botanical Name	Local name	Moisture	Protein	Fat	Ash	Fiber	CHO	Energy (Kcal)
1	<i>Amorphophallus paeonifolius</i>	Suran	75.78±0.87	6.03±0.17	1.53±0.29	6.75±0.04	3.74±0.18	81.94±0.23	345.43±1.78
2	<i>Dioscorea esculanta</i>	Aamchal	81.09±0.31	5.93±0.34	1.5±0.1	3.73±0.06	2.23±0.15	86.6±0.29	383.64±1.36
3	<i>Dioscorea hispida</i>	Kandu	82.28±1.4	7.39±0.17	1.53±0.15	3.35±0.06	3.66±0.15	84.07±0.16	379.64±0.66
4	<i>Dioscorea petaphylla</i>	Suwart	82.55±0.76	9.63±0.29	2.03±0.06	4.74±0.12	7.56±0.29	76.03±0.49	360.96±0.51
5	<i>Dioscorea tomentosa</i>	Jangli Kanda	75.99±0.25	9.05±0.51	1.97±0.06	3.64±0.01	2.17±0.11	83.17±0.41	386.57±0.45
6	<i>Dioscorea</i> Sp.	Alitha Kand	84.68±0.27	6.52±0.17	1.97±0.06	4.25±0.1	3.51±0.12	83.76±0.13	378.82±1.17
7	<i>Dioscorea</i> Sp.	Amaliya Kand	65.03±0.71	8.27±0.34	1.13±0.06	3.88±0.02	1.93±0.09	84.79±0.31	354.65±0.9
8	<i>Pueraria tuberosa</i>	Modi	80.46±0.03	8.66±0.17	1.07±0.06	8.55±0.2	2.46±0.1	79.27±0.5	332.21±1.43

fiber ranged from 1.93 g/100g to 7.56 g/100g in *Dioscorea* sp. (*Amaliya Kand*) and *Dioscorea petaphylla*, respectively. Energy content was minimum in *Pueraria tuberosa* (332.21 Kcal/ 100g) and maximum in *Dioscorea esculanta* (383.64 Kcal/ 100g). The results showed that analysed roots and tubers contained almost similar amount of protein, crude fat and crude fiber to the conventional roots and tubers which are in common use. However the carbohydrate and energy was found to be lower than common roots and tubers.

Conclusion

These results suggested that indigenous fruits and vegetables should not be ignored. They can be used as alternative source of food and nutrition. This study will help to propagate knowledge on these lesser known indigenous fruits and vegetables to promote their production and utilization as valuable component of a well balanced diet. In spite of using/ consuming the invasive species, it is better to use such indigenous fruits and vegetables as a source of nutrients. Furthermore, forest at *Aravalli* hills possess a rich diversity of tuberous plants and mineral rich containing soil. But due to deforestation, habitat destruction, introduction of exotic species and changes in climatic conditions, many plants which were common in the *Aravalli* hills have become rare and endangered. Thus, there is an urgent need to take a step in the conservation of these fruits and vegetables for nutritional security.

References

- Gopalan, C., Rama Shastri and B.V. Balasubramanian. 2007. Nutritive Value of Indian Foods. NIN. ICMR. Hyderabad.
- Gupta, S., A. J. Lakshmi, M.N. Manjunath and J. Prakash. 2005. Analysis of nutrient anti-nutrient content of underutilized green leafy vegetables. *J. Food. Sci. Tech.*, 38: 339-345.
- Nath, K.K., P. Deka and S. K. Borthakur. 2007. Ethnomedicinal aspects of some weeds from Darrang district of Assam. *Ethnobotany*, 19: 82-87.
- Nazarudeen, A. 2010. Nutritional composition of some lesser-known fruits used by ethnic communities and local folks of Kerala. *Indian. J. Traditional Knowl.*, 9: 398-402.
- Bhati, D. and S. Jain. 2015. *Weeds: An uncommon source of nutrients used by tribal community*. *Indian J. Ecology*, 42(1) pp 86-89.
- NIN. 2003. A Manual of Laboratory Techniques. Edited by Raghuramula, N., Nair, K. and Mand Kalyanasunderam, S. National Institute of Nutrition. ICMR. Hyderabad.

Effect of organic manures and NPK levels on yield and quality of Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

Mukesh Nagar, A.K. Soni, S.K. Bairwa and P.K. Yadav
Department of Horticulture, College of Agriculture
S K Rajasthan Agricultural University, Bikaner
(Received: 25.07.2015; Accepted: 15.01.2016)

Abstract

A field experiment was conducted during *kharif*, season of 2012 to study the effect of organic manures and NPK levels on Bottle gourd. The experiment consisted 16 treatment viz., Four levels of NPK (control, 100:50:50, 80:40:40 and 60:30:30) and organic manures (control, vermicompost, poultry manure and FYM) factorial RBD with three replications. Results indicated that the application of NPK (100:50:50) + vermicompost (5.0 t ha⁻¹) remaining at par with dose of NPK (80:40:40) + vermicompost (5.0 t ha⁻¹), exhibited maximum per cent fruit set, number of fruit per vine, fruit length, fruit weight, total yield per vine, total yield, protein content in fruit and crude fiber content in fruit.

Key Words : Bottle gourd, vermi compost, poultry manure.

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] synonymously called white flower gourd or calabash gourd is a member of Cucurbitaceae family. It is commonly grown in India, Ethiopia, Africa, Central America and other warmer regions of the world. The fruits are consumed as vegetable or for making sweets (*halwa*, *kheer*, *petha* and *burfi*) and pickles. *Kofta* is one of the most popular preparations of tender fruits of bottle gourd. The fruits have cardiatic and diuretic properties and have cooling effect (Choudhary and Bairwa, 2014). It is good for patients suffering from biliousness and indigestion. The dry hard sell of fruits is used for making a wide range of articles like bowls, bottles, ladles, containers and musical instruments. It was named as bottle perhaps the shape of fruits resemble bottle. In addition, the seeds and seed oil are also edible. The fruits contain 0.2% protein, 2.9% carbohydrate, 0.5% fat and 11 mg vitamin C of per 100 g fresh weight. The effects of organic and inorganic fertilizers are complementary to each other in terms of soil fertility improvement and sustainable agriculture. Therefore, it is necessary to make their judicious use in right proportion for harvesting better yield of different crops in cropping sequence and for sustaining soil fertility. The Integrated nutrient management helps in restoring and sustaining soil fertility and crop productivity. It also helps in arresting the emerging deficiencies of macro, secondary and micronutrients favorably by optimizing the physical, chemical and biological environment of soil and achieving economy and efficiency in fertilizer use. Hence, the present study was undertaken to find out the combined effect of organic manures and inorganic fertilizers on the yield and quality of bottle gourd.

Materials and Methods

The experiment was laid out at Horticulture Farm,

College of Agriculture, Bikaner, during *kharif* season 2012. The soil was loamy sandy with pH 8.2 and contained 0.09 % organic carbon, 80.19 kg ha⁻¹ available N, 17.34 kg ha⁻¹ available P, 185.42 kg ha⁻¹ available K. The experiment was laid out in Randomized Block Design (Factorial) with three replications. There were sixteen treatment combinations, which included various combination of NPK (control, 100:50:50, 80:40:40 and 60:30:30) and organic manures (control, vermicompost, poultry manure and FYM). The well rotten farm yard manure (10.0 t ha⁻¹), vermicompost (5.0 t ha⁻¹) and poultry manure (5.0 t ha⁻¹) were applied and spread uniformly in the plots as per treatment. Three seeds per hill were sown manually by dibbling method on 3rd August 2012. The seeds were soaked in cold water overnight before sowing for better germination. The sowing was done in the rows keeping 2.5 m inter-row spacing and 0.80 m plant-to-plant spacing. At each hill and seeds were sown at a depth of 1.5 to 2.0 cm. Germination took place within six days after sowing. One third dose of N, full doses of phosphorus and potassium were applied at the time of sowing. The remaining doses of nitrogen were applied 30 and 60 days into standing crop. The sources of N, P and K were used as urea, single super phosphate and muriate of potash, respectively the recommended dose of NPK was 80:40:40 kg ha⁻¹ (Anonymous, 2010). Data were taken five plants were selected randomly from each plot and tagged.

Results and Discussion

The data presented in Table 1 that organic manures, NPK levels and their combined effect significantly affected per cent fruit set, number of fruits per vine, fruit length, fruit weight, total fruit yield per vine, yield, protein content in fruit and crude fiber on fruit.

Table 1. Effect of organic manure and NPK level and their treatment combinations on yield and quality of Bottle gourd

Treatment	Fruit set %	No. of fruits per vine	Fruit length (cm)	Fruit weight (g)	Total yield per vine (kg)	Yield (q/ha)	Protein content in fruit	Crude fiber content in fruit
Control	41.75	5.6	37.66	537.03	3	134.93	0.193	1.100
Vermicompost	48.61	8	37.82	814.7	6.51	195.11	0.212	1.117
Poultry manure	46.62	7.8	38.17	831.01	6.48	182.96	0.237	1.123
FYM	48.81	7.9	38.22	842.22	6.65	191.32	0.231	1.113
S.E.m±	0.27	0.2	0.17	18.25	0.15	0.27	0.007	0.003
C.D. (P=0.05)	0.79	0.58	0.49	52.72	0.46	0.78	NS	NS
NPK (60:30:30)	45.73	7.5	38.85	844.33	6.33	192.56	0.218	1.137
NPK (80:40:40)	49.16	8.7	38.98	862.31	7.49	193.83	0.237	1.123
NPK (100:50:50)	46.17	8	40.69	875.09	7	231.56	0.268	1.137
S.E.m±	0.27	0.2	0.17	18.25	0.15	0.27	0.007	0.003
C.D. (P=0.05)	0.76	0.58	0.49	52.72	0.46	0.78	0.021	0.009
Vermicompost + NPK (60:30:30)	49.3	8.8	39.18	881.11	7.75	211.33	0.243	1.13
Vermicompost + NPK (80:40:40)	59.23	10.1	42.35	982.96	9.91	265.98	0.281	1.14
Vermicompost + NPK (100:50:50)	65.3	12.2	42.6	1138.45	11.8	298.39	0.331	1.16
Poultry manure + NPK (60:30:30)	49.6	8.9	39.4	888.41	7.9	215.77	0.256	1.127
Poultry manure + NPK (80:40:40)	62.17	11.1	40.79	980.16	10.87	270.57	0.281	1.127
Poultry manure + NPK (100:50:50)	50.79	9.7	39.86	963.41	9.34	231.36	0.262	1.13
FYM+ NPK (60:30:30)	50.59	9.3	39.72	908.37	8.44	228.19	0.256	1.133
FYM+ NPK (80:40:40)	60.95	10.6	42.5	1052.83	11.15	238.44	0.287	1.15
FYM+ NPK (100:50:50)	50.06	9.8	40.26	965.86	9.45	235.09	0.262	1.13
S.E.m±	0.55	0.4	0.34	36.5	0.31	0.54	0.015	0.006
C.D. (P=0.05)	1.59	1.16	0.99	105.44	0.92	1.56	0.043	0.018

Effect of organic manure

The yield and quality attributes of bottle gourd significantly influenced with the use of vermicompost followed by poultry manure (Table 1). The application of vermicompost (5.0 t ha⁻¹) being at par with poultry manure (5.0 t ha⁻¹) recorded maximum per cent fruit set, number of fruits per vine, fruit length, fruit weight, total fruit yield per vine and total yield. The beneficial effect of vermicompost on yield attributes on yield might be due to enhanced supply of micro and macro-nutrients during entire growing season, significant increased yield under the influence of vermicompost was largely function of improve growth and the consequent increase in different yield attributes and yield as mention above. The significant improvement in yield account of vermicompost along with nutrients from soil particularly at later stage of crop growth might have encases the rate of photosynthesis with further increased vegetative growth and provided more site for translocation of photosynthesizes with ultimately increased the yield. The results are in the conformity with the findings of Arancon *et al.*, (2003) in tomato crops, Reddy and Rao (2004) in bitter gourd, Choudhary *et al.*, (2012) in sprouting broccoli.

Effect of inorganic fertilizers

Application of different NPK levels significantly influenced the yield and quality of bottle gourd. The maximum per cent of fruit set, number of fruit per vine, fruit length and total fruit yield per vine were recorded under NPK (80:40:40) fruit weight, total fruit yield, protein content in fruit and crude fiber content in fruit were recorded under NPK (100:50:50) in Table 1. This might be due to the fact that increased NPK levels, helped in the expansion of leaf area and chlorophyll

content which coupled with increased net photosynthetic rates and in turn increased the supply of carbohydrates to plants. The application of NPK favoured the metabolic and auxin activities in plant and ultimately results in increased weight of fruit yield per vine and total yield. However, potassium does not increase the yield of plant but indirectly supported to yield. The results are also in close conformity the findings Singh *et al.*, (2004), Singh and Krishana (2007) and Ouda and Mahadeen (2008).

Interactive effect of organic manures and Inorganic fertilizers

Significant variation in fruit set per cent, number of fruits per vine, fruit length, fruit weight, total fruit yield per vine, total yield, protein content in fruit, crude fiber content in fruit, nitrogen content in fruit, phosphorus content in fruit and potassium content in fruit were observed due to execution of different treatments. The maximum per cent of fruit set was found in treatment vermicompost + NPK (100:50:50) followed by FYM + NPK (80:40:40). The maximum number of fruits per vine was found significant in treatment vermicompost + NPK (100:50:50) followed by Poultry manure + NPK (80:40:40). The fruit length, fruit weight and total yield per vine were significantly influenced by different treatment combinations (Table 1). The longest fruit (42.06), maximum weight (1138.45) and highest total yield per vine (11.80) in treatment vermicompost + NPK (100:50:50) followed by FYM + NPK (80:40:40). The fruit yield per ha of bottle gourd was significantly influenced by organic manure and fertilizers treatment combination. It is generally increased fruit yield from 134.93 to 298.39 q/ha in this experiment. The maximum yield produced by vermicompost + NPK

(100:50:50) treatment was mainly due to cumulative effects of in fruit set per cent, number of fruits per vine, fruit length, fruit weight and total fruit yield per vine. Protein content in fruit and crude fiber content were calculated by multiplying nitrogen per cent in fruit the factor 6.25 as suggested by Gupta *et al.* (1972) and (A.O.A.C., 1960). Table 1 clearly indicated that the combined effect of organic manures and NPK levels significantly influenced the protein content of fruit. Data indicated that the treatment combination vermicompost + NPK (100:50:50) resulted in significantly higher (0.331 %) protein content, whereas the maximum (1.160%) crude fiber content in fruit was observed under vermicompost + NPK (100:50:50) treatment combination. The results have been observed due to availability of adequate amount of NPK at longer period and sustain, maintain and improve the fertility levels of soil. The application of vermicompost + NPK (80:40:40) treatment combination reduces the quantity of inorganic fertilizer for the crops and also reduces the residual effect of these inorganic fertilizers. The vermicompost has nitrogen, phosphorus and other micro-nutrients solubilizing bacteria. They solubilized the nitrogen, phosphorus and other micro-nutrients in soil near the root zone of the crop. They provide nutrients it's in the readily available chelated form to the plants such as nitrate, exchangeable phosphorus, soluble K, Ca and Mg. They also contain biologically active substance such as plant growth regulators. It may be also due to the reason as vermicompost having a material which has high porosity, aeration, drainability and water holding capacity, thus it is capable to improve the physical condition of soil with yield of vegetable crop, when applied in the combination of chemical fertilizers. These finding are agreement with those of Raut *et al.*, (2003) in tomato crops and Singh and Krishana (2007) in point gourd. The combined effect of organic fertilizer and inorganic fertilizer increased the yield attributes and yield. This is due to the fact that application of fertilizers alone have supplied only one or two nutrient but combined use of organic and inorganic fertilizers have provided all the essentials nutrient in proper amount, required by plants for its growth and development. These finding are agreement with those of Kalabandi *et al.*, (2007) in cabbage and Eifediyi and Remison (2010) in cucumber.

References

- A.O.A.C. 1960. Official Method of Analysis, 18th Endn. Association of Official Agricultural Chemists, 1608. Broadnon Drive. Champaign Illinois, USA.
- Arancon, N.Q.; Edwards, C.A.; Bierman, P. and Metzger 2003. Effects of vermicompost on growth and marketable fruit of field grown tomatoes, peppers and strawberries. 7th International Symposium on Earthworm Ecology, Cardiff, Wales, 47 (5-6) : 731-735.
- Anonymous, 2010. Package and Practices of Horticultural

crops in Rajasthan. Directorate of Horticulture, Pant Krishi Bhavan, Government of Rajasthan, Jaipur.

- Choudhary, B.R. and Bairwa, S.K. 2014. Scientific cultivation of Bottle gourd (*Lagenaria siceraria*), Advances of vegetable agronomy, Edited by: Choduary *et.al.*, 2014, Post graduate school, IARI, New Delhi and ICAR, DARE, Ministry of agriculture, GoI, New Delhi:: 116-122.
- Choudhary, S., Soni, A.K. and Jat, N.K. 2012. Effect of organic and inorganic sources of nutrients on growth, yield and quality of sprouting broccoli cv. CBH-1. *Indian J. Hort.*, 69 (4): 550-554.
- Eifediyi, E.K. and Remison, S.U. 2010. Growth and yield of cucumber (*Cucumis sativus*) as influenced by farmyard manure and inorganic fertilizer. *Sciencepub.net/report*, 2 (4).
- Gupta, S.B., Pathak, R.K.; Bhan, S. and Singh, A. 1972. Effect of NPK on yield, nutrient uptake and quality of toria. *Indian J. Agronomy*, 17 (1): 88-91.
- Kalabandi, B.M., Dabhade, R.S. and More, S.S. 2007. Effect of organic and inorganic fertilizer on growth, yield, quality of cabbage (*Brassica oleraceae* var. capitata). *Asian J. Hort.*, 2 (2): 144-147.
- Raut, R.L., Naidu, A.K., Jain, P.K., and Rajwade, V.B. 2003. Influence of organic and chemical sources of nutrients on the yield, fruit quality and storage of tomato in Madhya Pradesh, India. *JNKVV Res. J.*, 37(1): 30-33.
- Reddy, P.K. and Rao, P.V. 2004. Growth and yield of bitter gourd (*Momordica charantia* L.) as influenced by vermicompost and nitrogen management practices. *J. Res. ANGRAU*, 32 : 3, 15-20.
- Samawat, S., Lakzian, A. and Zamirpour, A. 2001. The effect of vermicompost on growth characteristics of tomato. *Agriculture Sciences and Technical.*, 15 (2) : 83-89.
- Sharu, S. R. and Meerabhai M. 2001. Effect of integrated nutrient management on yield and quality in chilli (*Capsicum annum* L.), *Veg. Sci.*, 28 (2): 184-185
- Singh, K.P and Mohan, Krishan 2007. Integrated nutrient management for sustainable production of pointed gourd (*Trichosanthes dioica* Roxb.) under Ganga diara of Bihar. *Asian J. Hort.*, 2 (1): 99-101.
- Singh, Hadip, Srivastava, V.K. and Mangal, J.L. 2004. Effect of different doses of nitrogen and phosphorus on growth, flowering, seed yield and quality of tinda. Department of Vegetable Crops, Haryana Agricultural University, Hissar.
- Ouda, B. A. and Mahadeen, A.Y. 2008. Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea*). *Int. J. Agri. Biol.*, 10: 627-132.

Collar rot disease caused by *Rhizoctonia solani* Kuhn in kagzi lime (*Citrus aurantifolia*, Swingle) a new record from the nurseries of Uttar Pradesh and its management.

Ranvijay Singh¹, Sanjeev Kumar^{1*}, Ramji Singh² and Sachin Kumar Jain²

Department of Plant Pathology

¹N D University of Agriculture & Technology, Kumarganj, Faizabad-224229, U.P., India

²S V P University of Agriculture & Technology, Modipuram, Meerut-250110, U.P., India

*E mail of corresponding author: drsanjeev44@gmail.com

(Received: 21.07.2014; Accepted: 15.10.2015)

Abstract

Collar rot of kagzi lime (*Citrus aurantifolia*, Swing.) is caused by *Rhizoctonia solani* Kuhn. In nursery stage, about 40-55% seedlings of Kagzi lime (*Citrus aurantifolia* Swing) were died due to collar rot. This is the first report of collar rot diseases in Kagzi lime caused by *R. solani* from the nursery of Uttar Pradesh. The efficacy of three *Trichoderma* species viz *T. harzianum*, *T. virens* and *T. viride* against *R. solani* were tested by dual culture technique. *T. virens* and *T. viride* grew very fast before touching the colony of the *R. solani*, thereafter; their growth was significantly slowed down. But *T. harzianum* grew very fast over the colony of *R. solani*, and completely covering it within 8 days. The population of *R. solani* in infested soil could be minimized by treating the soil with *T. harzianum*, *T. virens* and *T. viride*. *T. harzianum* and *T. virens* grew very fast and occupied the space and consumed nutrients in the root rhizosphere, thus, outwitted the pathogen.

Key words: *Citrus aurantifolia*, collar rot, *Rhizoctonia solani* & *Trichoderma* spp.

Introduction

Kagzi lime (*Citrus aurantifolia* Swingle) is an important fruit crop, originated from tropical and subtropical region of South East Asia, particularly India and China. In India citrus crop occupies a prominent place covering an area of about 8.5 L ha with an annual production of 74.64 L tonnes with a productivity of 8.8 t/ha (Anonymous, 2011). Citrus plants and fruits are very susceptible to infestation by fungi, bacteria and viruses (Agrios, 2005 and Singh 2005). From the past two-three years continuously, heavy (42-55%) mortality of seedlings of kagzi lime in the nursery of College of Horticulture, Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad (Uttar Pradesh) has been noticed. In a preliminary survey in many private nurseries in the villages surrounding the university also revealed the occurrence of the similar disease of kagzi lime in nursery beds. The occurrence of such type of disease symptoms on kagzi lime has not been so far reported. Besides, as the disease has reported by Jaganathan (1992) in Tamilnadu and Singh and Andotra (1997) in Jammu and Kashmir. In the field, the disease usually appears in patches. The nursery men attempt to control the disease by treating the seeds usually with PCNB but without success. The maximum percentage germination and survival of kagzi lime seedlings were recorded with benomyl and carbendazim treatment Jaganathan (1992). Singh and Andotra (1997) also reported that soil amendments followed by soil drenching with thiram significantly

controlled seedling mortality in kagzi lime. To control soil borne diseases, the use of fungal bio-agents like species of *Trichoderma* has been recommended by many scientists (Papavizas, 1985; Chet, 1987; Harman and Bjorkman, 1998; Harman, 2006). The management of soil borne diseases with *Trichoderma* formulation is eco-friendly, sustainable and cost effective. The present investigation has been carried out with the etiology of the disease and find out the appropriate *Trichoderma* species against the pathogen.

Materials and Methods

The experiment was conducted at Horticulture Research Centre, Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad (Uttar Pradesh), India during 2010-2011.

Isolation of pathogen

The infected damping off or collar rot region of the seedlings were cut into small pieces and surface sterilized by immersing in 0.1 % (w/v) mercuric chloride (HgCl₂) aqueous solution for one minute followed by rinsing three times with sterilized distilled water. The surface sterilized pieces were placed in petri plates. The excess water over the seedling pieces was wiped out with three folds of sterilized blotting paper and placed on PDA plates. Finally, these were incubated in BOD incubator at 26 ± 2°C.

Identification of the pathogen

The pathogen was identified by the colony characters and morphological features. For confirmation of the identity, the pathogen was sent to the Indian Type Culture Collection, Division of Plant Pathology, I.A.R.I., New Delhi.

Pathogenicity test of *R. solani*

For pathogenicity test of *R. solani*, five earthen pots (6×7 cm.) were filled with a mixture of garden soil and farm yard manure (FYM) at 1:1 ratio. Finally, chopped tender citrus shoots (50 g/kg soil) were then added to the sub-surface soil of the pots and lightly irrigated to maintain moisture necessary for seed germination. Pot surface was covered with brown paper and sterilized in autoclave at 121.6 °C for 20 minutes. Next day after cooling of the soil, the fungal mat grown in Richard's broth media was mixed in aseptic conditions with the sterilized soil (@10g fungal mat for 500 g sterilized soil). Surface of the pots were again covered with brown paper and incubated in BOD incubator (26 ± 2 °C) for three days. Thereafter, surface sterilized mature seeds of citrus variety Kagzi lime were sown in the fungus inoculated pot soil (@ 10 seeds/pot) and incubated in a growth chamber at 26 ± 2°C. High RH (97%) was maintained inside growth chamber. The pots were lightened for 12 h per day. When the typical symptoms appeared, the pathogen was re-isolated from the infected portions and thus pathogenicity of the fungus was confirmed.

Symptomatology

The symptoms were recorded in details both in naturally and artificially infected seedlings with suitable photographs at different growth stages of the seedlings.

Interaction between the pathogen and the antagonists

The efficacy of *T. harzianum*, *T. viride* and *T. virens* against the pathogen *Rhizoctonia solani* (Kuhn) was assessed by using dual culture technique (Morton and Stroube 1955). Five mm disc of each of the antagonists and *R. solani* were cut with the help of sterilized cork borer from the edge of the three days old cultures and were placed over solidified PDA in Petri dishes at 60 mm apart from each other. In control set, only a disc of *R. solani* was placed over the PDA plate. The Petri dishes were incubated in BOD incubator at 26 ± 1 °C. The radial growth of the fungal colonies was recorded every day at 24 h interval till the colonies of *Trichoderma* species mowed the colonies of *R. solani*. Five replications for each treatment were maintained.

Efficacy of the antagonists against the pathogen Soil inoculation with *R. solani*

To a mixture of garden soil and FYM in equal proportion, finely chopped tender citrus shoots (50 gm/kg.) was added lightly irrigated; pot surface was covered with brown paper and sterilized in autoclave keeping for 20 minutes at 121.6 °C. After cooling of the soil, the inoculums (*R. solani*) grown in solid sorghum media was mixed in

aseptic condition with the sterilized soil (@ 50 gm. inoculums for 1.5 kg sterilized soil). Surface of the pots were again covered with the brown paper and incubated BOD incubator (26 ± 2 °C) for five days.

Inoculation of the *R. solani*-infested soil with *Trichoderma* species

When the inoculated pot soil was found to be totally infested with the mycelia growth of the fungus, *R. solani*, as it was evident by the growth of the mycelia over soil surface of the pots, *T. harzianum*, *T. viride* and *T. virens* grown over solid (sorghum) medium for 7 days at 26 ± 2 °C were mixed separately (@ 50 g/pot) with the *R. solani*-infested soil thoroughly.

Population count of *R. solani* and *Trichoderma* species

Population of *R. solani* and *Trichoderma* spp. counted by Soil Plate Dilution technique (Johnson and Curl 1972). After 7 days of inoculation, 200 mg sample from each experimental pot was taken from 10cm depth with sterilized disk cutter. It was put in to 200 ml sterilized distilled water and shaken well, 0.5ml of the suspension was put into sterilized Petri plate into which 30 ml molten and warm PDA and a pinch of Streptomycin were added. The whole mixture was thoroughly mixed and incubated 26 ± 2°C in BOD incubator. To investigate the increase or decrease of population of the *Trichoderma* spp. and *R. solani* with passing time, the experiment was repeated three times at 7 days interval. The colonies of *R. solani* and *Trichoderma* species in each plate were counted by colony counter. For each treatment five replications were maintained.

Results and Discussion

Identification of the pathogen

Colonies grew fast, usually white to brown grown after 5 days of incubation. The colors of the mycelium was white at the beginning, later turn tan brown with ageing and branched near the distal septum of mother hyphal cell at right angles. Sclerotia were dark brown, round to irregular and consisted of brown and barrel shaped (Alexopoulos *et al.* 2002). On the basis of the above mentioned characters the pathogen was identified as *Rhizoctonia solani* (Kuhn). The identification was further confirmed by I.T.C.C. Centre, IARI (New Delhi) and accession number 6528.

Symptomatology

When the seeds were sown in the heavily *R. solani*-infested soil, the seedling suffered both from pre-emergence rotting and post-emergence collar rot diseases. About 30% seedlings died to pre-emergence rotting. Some of the affected seedlings may come out of soil surface but failed to grow further. The collar rot affected seedlings remained alive for some times. But under highly disease conducive condition none of the seedling survived beyond one month. They either toppled over the necrotic zone at the collar region or became necrotic, black and finally died. The similar symptoms

reported on collar rot disease of sunflower caused by *Rhizoctonia solani* by Lakshmidhevi *et al.* (2010).

Pre-emergence rotting

All the seeds in the heavily infected soil were germinated. Usually the seeds germinated by tap roots but sometimes instead of one tap root, 2-3 roots developed from the germinating seeds (Fig. 1. ii, iii, iv and Fig. 2). Tips of the radical underwent rotting (Fig. 1. iii, v) resulting into pre-emergence death of the seedlings. In some seedlings at the junction of the rotten and healthy portion of the radical a knot

was developed (Fig. 1. iv) from where new radical developed and the seedlings managed to emerge out from the soil and remained alive at least for few weeks. In some seedlings tip of the radical underwent necrosis and finally got detached. The upper edge of the cotyledonary leaves turned brown and its dorsal side became black and necrotic (Fig. 1. i). Thus, the partially emerged seedlings finally died due to pre-emergence rooting. The similar symptoms and 74% pre-emergence mortality from infected seedlings of *Pinus caribaea* caused by *Rhizoctonia solani* reported by Narayanappa (1992).

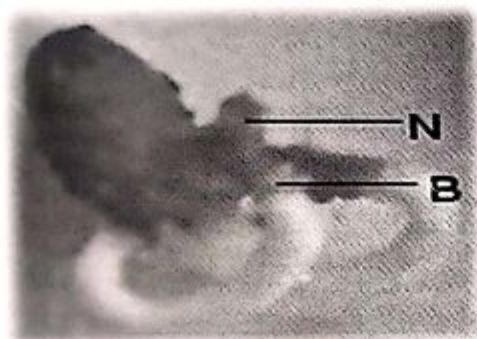


Fig. 1. Pre-emergence infection of citrus seedling by *R. Solani*

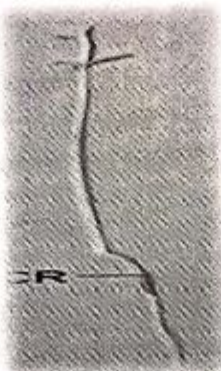


Fig. 2. A citrus seedling infected by *R. solani* at pre-emergence stage (N- necrotic part of the root, B- browning of cells along the upper part of the necrotic zone).

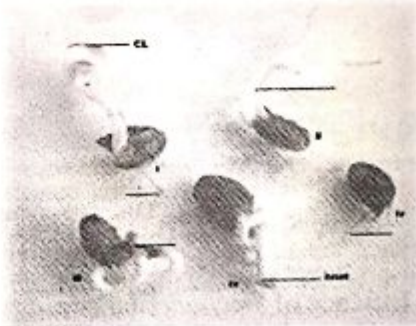


Fig 3. Citrus seedling showing typical symptom

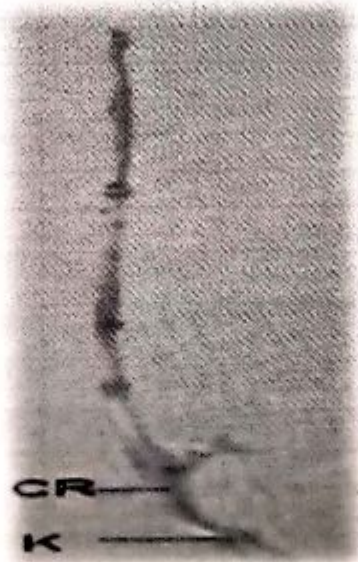


Fig.4. Advance stage of collar rot disease of citrus seedlings. of collar rot disease infected by *R. solani* (CR- collar rot). (L- Living part, D- Dead portion, L- Inner hard tissue of stem, after upper soft tissues underwent necrosis)

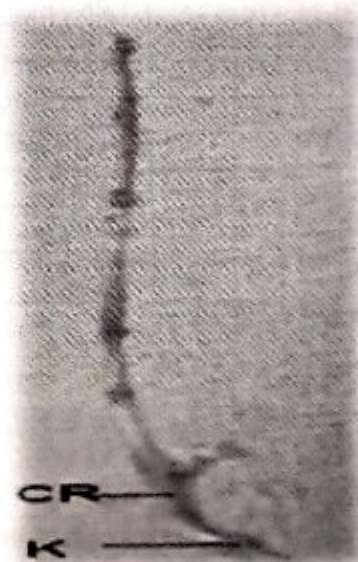


Fig.5. Citrus seedling killed by collar rot disease (CR- collar rot, K- knot)

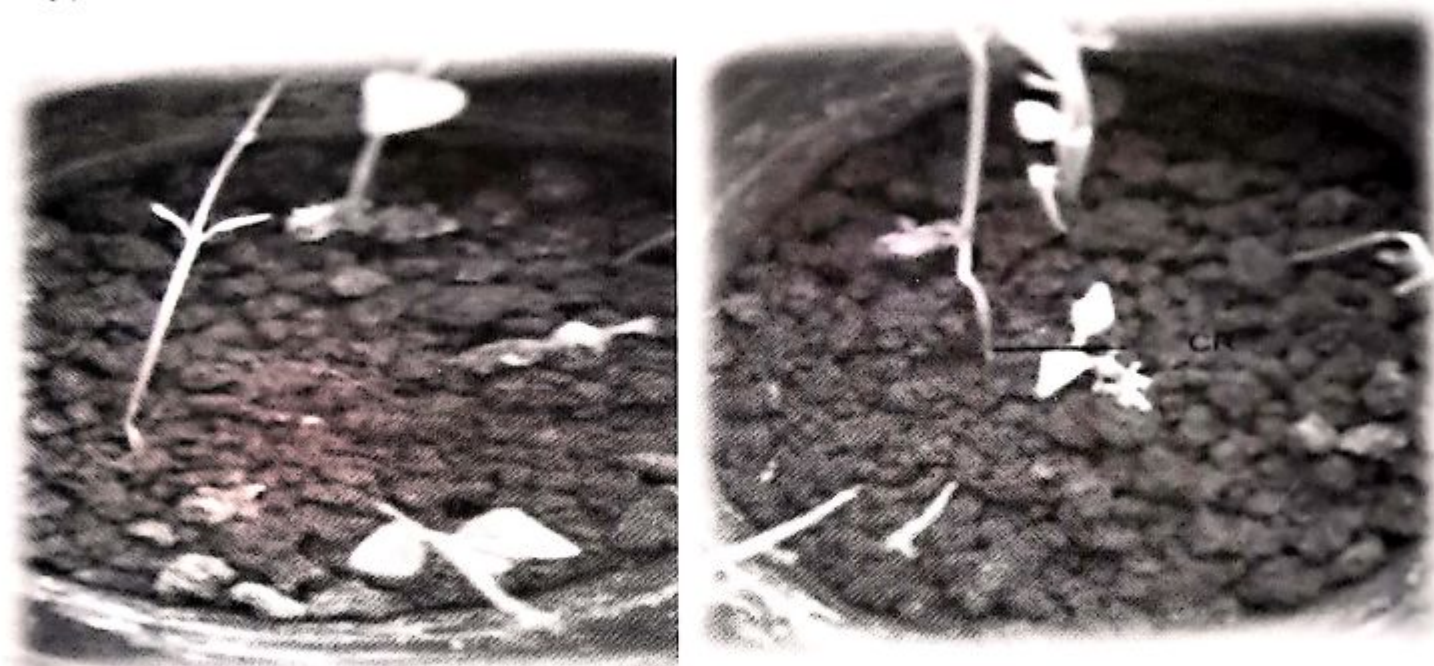


Fig. 6. Diseases symptoms of *R. solani*-infested citrus seedlings

Table 1. Efficacy of *Trichoderma* spp. against *R. solani* (dual culture)

Day of observation (after 24 hour of incubation)	Size of colony (cm) of <i>Trichoderma</i> spp.			% decrease of <i>R. solani</i> colony/day		
	<i>T. viride</i>	<i>T. harzianum</i>	<i>T. virens</i>	In <i>T. viride</i>	In <i>T. harzianum</i>	In <i>T. virens</i>
1st.	1.06	0.96	1.44	-	-	-
2nd.	1.28	1.36	1.78	9.01	15.74	16.50
3rd.	1.38	1.44	1.80	4.50	3.73	1.16
4th.	1.46	1.84	1.86	3.77	19.41	3.52
5th.	1.52	2.56	1.88	2.94	43.37	1.21
6th.	1.54	3.14	1.90	1.01	61.70	1.23
7th.	1.62	3.36	1.92	4.08	61.11	1.25
8th.	1.64	3.5	1.92	1.06	100	00
9th.	1.66	-	1.94	1.07	-	1.26
10th.	2.04	-	2.30	22.82	-	23.07
11th.	2.40	-	2.56	24.65	-	61.66
12th.	2.96	-	3.08	50.90	-	55.31
13th.	3.26	-	3.5	55.55	-	100
14th.	3.5	-	-	100	-	-
CD at 5 %	0.14	0.15	0.18			

Efficacy of *Trichoderma* spp. against *R. solani* (dual culture)

Interaction between *R. solani* and *Trichoderma* spp. *in vitro* in dual culture test, the highest growth after 24 h of

incubation was recorded with *T. virens* (1.44 cm) followed by *T. viride* (1.06 cm) and *T. harzianum* (0.96 cm). During this period, the colonies of *T. species* and *R. solani* did not touch with each other and the *T. species* also did not develop any

pigment. Next day the same trend was also maintained but differences in the size of colonies between *T. harzianum* and *T. viride* were reduced to significant level. After 72 h, the colonies of *Trichoderma* species and *R. solani* covered in between gap and touched each other. The centre portion of all the *Trichoderma* colonies developed their characteristics green color with white spreading mycelia around the green center. By this time the size of the colony of *T. virens* became maximum (1.80 cm) (Table 1). The second big colony size was recorded with *T. harzianum* (1.44 cm) while minimum with *T. viride* (1.28 cm). Up to 5th day, the same trend was maintained although the differences between *T. harzianum* and *T. viride* were reduced to the significant level. However, on the 6th day the highest growth was recorded with *T. harzianum* (2.5 cm) and minimum with *T. viride* (1.52 cm). Up to the 8th day, the same trend was maintained. During this period, *T. harzianum* was found to engulf the entire colony of *R. solani*. Hence, further recording of colony size of *T. harzianum* was stopped. *T. harzianum* controlled the disease caused by *R. solani* due to its fast growth (Sawant *et al.*, 1995). *T. virens* became successful to over grow the colony of *R. solani* on 14th day. *T. viride* took one day more time to completely smoothed the colony of *R. solani*. This finding supports the results of biological control agent *Trichoderma viride* MNT-7 reduced the collar rot disease caused by *R. solani* (Ramesh, 2002).

Interaction between *Trichoderma* species and *R. solani* in soil

The number of colonies of *T. harzianum*, *T. viride*, *T. virens* and *R. solani* both in the treated and control soil have

been presented in the Table 2. The number of colonies of *T. harzianum*, *T. viride* and *T. virens* in the treated soil seven days after the treatment was recorded as 2.7×10^4 , 5.1×10^4 and 5.8×10^4 colonies/g-soil respectively. However in the untreated soil the colonies were counted 1.1×10^6 . Number of *T. harzianum* colonies in the same soil was 6.5×10^4 colonies/gm soil. After days of treatment, there was a reduction in number of colonies of *T. harzianum*. But on twenty-one days after the treatment, the population of *T. harzianum* was again found to be increased. On the other hand, the colonies of *R. solani* in the treated soil showed a gradually decline. In artificially infested soil, *T. harzianum* reduced the population of *R. solani* and protected sugarbeet seedlings from damping-off in three weeks after inoculation (Kok *et al.* 1996). In the *T. viride* treated soil, the population reduction was recorded after fourteen days. But within the next seven days, the population was again built-up and it reached the peak. The population of *R. solani* both in treated and untreated soil recorded a gradual reduction from seven days after treatment up to the end of the experiment. However, rate of reduction of population of *R. solani* in treated soil was considerably higher, but population level was just reverse and the population of *T. virens* from seven days to twenty-one days of the treatment showed a marginal decline while that of *R. solani* in the treated soil reduced significantly. Contrarily, population of *R. solani* in untreated soil was considerably higher than the treated soil. The similar result were reported by Kavitha *et al.* (2006) that *Trichoderma viride* on dry root-rot of *Citrus aurantiifolia* caused by *Fusarium solani* was reduced the disease incidence equally and significantly.

Table 2. Population of *R. solani* and *Trichoderma* spp. in *R. solani*-infested soil (colonies/g soil)

No. of days after treatment	The fungal population in <i>T. harzianum</i> treated soil		The fungal population in <i>T. viride</i> treated soil		The fungal population in <i>T. virens</i> treated soil		Colonies of <i>R. solani</i> in untreated (control) soil
	<i>T. harzianum</i>	<i>R. solani</i>	<i>T. viride</i>	<i>R. solani</i>	<i>T. virens</i>	<i>R. solani</i>	<i>T. harzianum</i>
7	6.5×10^4	2.7×10^4	5.1×10^4	3.3×10^4	5.8×10^4	3.0×10^4	1.1×10^6
14	4.6×10^4	2.2×10^3	4.6×10^4	1.1×10^3	5.6×10^4	2.1×10^3	4.6×10^5
21	6.2×10^4	1.8×10^2	5.9×10^4	1.5×10^2	5.5×10^4	1.7×10^2	6.2×10^5

Table 3. Per cent reduction of *R. solani* colony over the control in *Trichoderma* amended soil

No. of days after treatment	Per cent reduction of <i>R. solani</i> colony over the control		
	<i>T. harzianum</i>	<i>T. viride</i>	<i>T. virens</i>
7	75.22	69.72	72.48
14	66.15	83.08	67.69
21	73.13	77.61	74.63

Efficacy of the *Trichoderma* species in reducing the population of *R. solani*

The per cent reductions in *R. solani* colony over the control after the treatment with the three species of *Trichoderma* are presented in the table 3. With *T. harzianum* the initial reduction was 75.22%. But in the next seven days the per cent reduction was reduced to 66.15%. However at the end of experiment the per cent reduction again increased and attended the level of 73.13%. With *T. viride* the reduction after seven days of treatment was the minimum (69.72%) of all the three treatments. But, within the next seven days, *T. viride* increased its reduction percentage to 83.08%. *T. virens* showed the percent reduction of 72.48%, 67.69% and 74.63% at 7, 14 & 21 days after the treatment respectively. The presence of *T. harzianum* population density of *R. solani* was reduced significantly (Paula and Hau, 2007). Thus, according to the initial efficacy the *Trichoderma* species may be arranged in the following sequence: *T. harzianum* > *T. virens* > *T. viride*. But at the end of the experiment a reverse picture was noticed like this: *T. viride* > *T. virens* > *T. harzianum*.

Conclusion

The infection of *R. solani* in the citrus nursery took heavy loss. The symptoms of *R. solani* were manifested either in the form of pre-emergence rotting or collar rot of young seedlings. The infected seedlings fought back the pathogen by producing more roots or developing mechanical barrier in the form of knot separating the infected zone from the healthy one to stop the progress of the pathogen from infected root tips to the upper part. The population of *R. solani* in infested soil could be minimized by treating the soil with *T. harzianum*, *T. virens* and *T. viride*. *T. harzianum* and *T. virens* grew very fast and occupied the space and consumed nutrients in the root rhizosphere, thus, outwitted the pathogen. On the basis of the results observed in the present experiment, application of *T. viride* and *T. virens* as preventive measures and that of *T. harzianum* as curative one may be suggested.

References

- Agrios, G.N. 2005. Plant Pathology, (5th Ed.) Academic Press, 525 B Street, Suite 1900, San Diego, California 92101-4495, USA, pp-922.
- Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 2002. Introductory Mycology, (4th Ed.) Wiley India (P) Ltd., 4435/7, Ansari Road, Daryaganj, New Delhi 110002, pp-869.
- Anonymous, 2011. National Horticulture Board Database.
- Chet, I. 1987. *Trichoderma*- application, mode of action, and potential as a biocontrol agent of soil-borne plant pathogenic fungi. In: Innovative Approaches to Plant Disease Control (I. Chet, ed.), John Wiley and Sons, New York, NY, USA, 137160.
- Harman, G.E. 2006. Overview of mechanisms and uses of *Trichoderma* spp. *Phytopathol.*, 96, 190194.
- Harman, G.E. and Bjorkman, T. 1998. Potential and existing uses of *Trichoderma* and *Gliocladium* for plant disease control and plant growth enhancement. In: *Trichoderma and Gliocladium Vol. 2. Enzymes, Biological Control and Commercial Applications* (C.P. Kubicek, G.E. Harman, ed.), Taylor and Francis Ltd., London, UK, 229265.
- Jaganathan, R. 1992. Chemical control of damping-off of acid lime. *Madras Agril.*, 79(7):418-420.
- Jhonson, L. F. and Curl, E. A. 1972. *Methods for Research on the Ecology of Soil borne Plant Pathogens*. Burgess Publishing Company, Minneapolis, pp. 247.
- Kavitha, M., Gopal, K., Ahammed, S. K., Sreenivasulu, Y. and Madhusudhan, P. 2006. Biological control of dry root-rot of acid lime (*Citrus aurantiifolia* Swingle) caused by *Fusarium solani* (Mart.) Sacc. of *Biological Control*, 20(1):105-107.
- Kok, C. J., Hageman, P. E. J., Maas, P. W. T., Postma, J., Roozen, N. J. M. and Vuurde, J. W. L. 1996. Processed manure as carrier to introduce *Trichoderma harzianum*: population dynamics and biocontrol effect on *Rhizoctonia solani*. *Biocontrol Science and Tech.*, 6(2):147-161.
- Lakshmidhevi, N., Sudisha, J., Mahadevamurthy, S., Prakash, H. S. and Shetty, H. S. 2010. collar rot disease caused by *Rhizoctonia solani* in sunflower from India. *Australasian Pl. Dis. Notes*, 5(1):11-13.
- Morton, D.T. and Strouble, N.H. 1955. Antagonistic and stimulatory effect of soil micro organisms upon *Sclerotium rolfsii*. *Phytopathol.*, 45 : 417-420.
- Narayanappa, M. 1992. Collar rot - a new disease of *Pinus caribaea*. *Indian Forester*, 118(3):232-233.
- Papavizas G.C. 1985. *Trichoderma* and *Gliocladium*: Biology, ecology and potential for biological control. *Ann. Rev. Phytopathol.*, 23: 2354.
- Paula, T. J. and Hau, B. 2007. Effect of soil moisture on activity and dynamics of *Rhizoctonia solani* and *Trichoderma harzianum*. *J. of Pl. Dis. and Protec.*, 114(3):126-132.
- Ramesh, K. R. 2002. Collar rot disease caused by *Rhizoctonia solani* in Teak (*Tectona grandis* Linn.) - a new record from the nurseries of Tamil Nadu. *Indian J. Forestry*, 25(1/2):87-88.
- Ramesh, K. R. 2002. Studies on the control of collar rot disease caused by *Rhizoctonia solani* in teak (*Tectona grandis*) by seed treatment. *J. of Tropical Forest Sci.*, 14(3):357-363.
- Sawant, I. S., Sawant, S. D. and Ganapathy, M. M. 1995. Collar rot of passion fruit caused by *Rhizoctonia solani* and its control. *Indian Phytopath.*, 48(2):202-205.
- Singh, D. and Andotra, P. S. 1997. Effect of soil amendments for the management of citrus seedling mortality in nursery beds. *J. Mycol. Pl. Pathol.*, 27(1):71-72.
- Singh, R.S. 2005. Plant Diseases, (5th Ed.) Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, pp-720.

Effect of water regime and fertigation on yield and quality of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi in arid zone

Rajendra Kumar Jakhar*, A.K. Singh and Narendra Kumawat

Precision Farming Development Centre, Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner 334 006, Rajasthan, India

*Corresponding author's email: rkjakhar_ss@rediffmail.com

(Received: 11.1.2015; Accepted: 22.02.2016)

Abstract

A field experiment was conducted on sweet orange (*Citrus sinensis*) to study the effect of water regime and fertigation on yield and quality at Precision Farming Development Centre, Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner. The experiment was laid out in split plot design with four replications and consisting twelve treatment combinations, comprised four water regime (0.6, 0.8 and 1.0 volume of water through drip irrigation and another one 1.0 volume of water applied by surface irrigation method) and three levels of recommended dose of NPK (75, 100 and 125%). The results indicated that maximum fruit diameter (7.36 cm), fruit yield (38.17 kg/plant), juice weight (100.4 g), peel weight (47.95 g), reducing sugar (2.33%) and total sugar (8.36%) were recorded in 1.0 volume of water through drip irrigation which was at par with 8.0 volume of water through drip irrigation and significantly superior over 0.6 volume of water. Whereas, maximum acidity (0.76%) was recorded in 0.6 volume of water through drip. Further data showed that among the RDF levels, fertigation with 125% RDF gave maximum fruit diameter (7.20 cm), fruit yield (32.48 kg/plant), juice weight (85.42 g), peel weight (41.59 g), reducing sugar (1.94%) and total sugar (7.63%) which was comparable with 100% RDF and significantly superior over 75% RDF. Whereas, maximum acidity (0.72%) was recorded in 75% RDF followed by 100% RDF and lowest in 125% RDF.

Key words: Water regime, fertigation, fruit yield, reducing sugar, acidity, juice, RDF

Introduction

Citrus (*Citrus sinensis* L.) fruits is one the important fruit crop of the world occupied third position among the sub-tropical and rank third in area and production after banana and mango in India. Andhra Pradesh, Maharashtra, Karnataka, Punjab, Haryana and Rajasthan are main sweet orange growing, stages. In India, sweet orange is commercially adopted in citrus fruit crop with an area of 323 thousand ha with production of 3520 thousand lakh tonnes and productivity 10897 kg/ha (Anonymous, 2013). The production of sweet orange is largely favoured by dry, semi-arid to subtropical conditions. Under warmer conditions, the colour development is poor; however, excellent deep orange colour of the skin develops when grown under subtropical conditions. Quality is also very good under dry semi-arid conditions, while under humid conditions fruits insipid. It has great nutritional role in the daily food requirement, being rich source of vitamin C. (Greory, 1993).

In general, most of the farmers apply the fertilizers in single soil application during dormant season and no fertilizer is applied during vegetative, flowering, and fruit growth stages, thus the effectiveness of the applied fertilizers is reduced considerably. Drip irrigation plays a major role in productivity enhancement (Khan *et al.*, 2012). Drip irrigation proved efficiently in providing irrigation water and nutrients to the roots of plants, while maintaining high yield production. Modern drip irrigation has arguably become the world's most

valued innovation in agriculture since the invention of the impact sprinkler, which replaced flood irrigation. This is because high water application efficiencies are often possible with drip irrigation, since there is reduced surface evaporation, less surface runoff, as well as minimal deep percolation. Moreover, a drip irrigation system can easily be used for fertigation, through which crop nutrient requirements can be met accurately.

Sweet orange respond very well to the application of nutrients either through soil or through fertigation. The efficient use of water and fertilizers to increase the crop yield and fruit quality is important concern in today's citricultural system (Shirgure 2012). Fertigation offers the best and sometimes the only way for ensuring the nutrients enters the root zone especially in areas with inadequate rainfall. The suitable fertilizers, water soluble fertilizers, ready to mix water soluble fertilizers (19-19-19) are more being used by growers. The application of nitrogen, phosphorus and potassium fertilizers through fertigation system during flower initiation to fruit growth and development is latest technology and no literature as well as work is available on sweet orange under arid regions of Rajasthan. Fertigation enables adequate supplies of water and nutrients with precise timing and uniform distribution to meet the crop nutrient demand. Therefore, this study was carried out to investigate the effect water regime and fertigation on yield and quality of sweet orange under arid region of Rajasthan.

Materials and Methods

The field experiment carried out at Precision Farming Development Centre, Agricultural Research Station, S.K. Rajasthan Agricultural University, Bikaner during February 2010 to December 2013 on eight years old sweet orange. The experiment laid out in split plot design with four water regimes (0.6, 0.8, 1.0 volume of water through drip irrigation and another one 1.0 volume of water by surface irrigation method) and three levels of recommended dose of fertilizers of NPK (75, 100 and 125% RDF). RDF was applied as fertigation under drip irrigation and as basal for surface irrigation method with in fifteen and seven days interval, respectively. The RDF was 288 g, 200 g and 240 g/plant, N, P_2O_5 and K_2O , respectively. Physical and chemical properties of the soil for the orchard are presented in Table 1. The data on yield attributes like fruit diameter (cm), juice weight (g), peel weight (g), peel: juice ratio, fruit yield (kg/plant) and fruit quality parameters like reducing sugar (%), total sugar (%) and acidity (%) were recorded at harvest. Fruit diameter measured in centimeter using vernier calipers. At harvest, the fruits were weighed and counted separately for each plant, and then the yield (kg/plant) was calculated in each treatment. Total sugar, reducing sugar and acidity were determined by as per methodology suggested Dubois *et al.* (1951), Nelson's modified of Somogyi method (Somogyi *et al.* 1952) and A.O.A.C (1990), respectively. All plant protection and intercultural operations were done whenever necessary. The statistical analyses of data was done as per the method prescribed by Panse and Sukhatme (1985).

Results and Discussions

Effect of water regime

Data presented in Table 1 showed that yield attributes, yield and quality of sweet orange as influenced by different water regimes. Higher fruit diameter (7.36 cm), juice weight (30.17 g) and peel weight (100.40 g) were recorded with 1.0 volume of water through drip which was comparable to 0.8 volume of water through drip and significantly superior over 0.6 volume of water through drip. However the lower values of these attributes were recorded in 1.0 volume of water through surface. Similarly higher yield (38.17 kg/plant) was also recorded in 1.0 volume of water through drip which was at par with 0.8 volume of water through drip and significantly superior over 0.6 volume of water through drip and 1.0 volume of water through surface. The per cent yield increases of sweet orange by 27.11 and 6.50 higher over 0.6 and 0.8 volume of water through drip, respectively. Peel: juice ratio did not influenced significantly by different volume of drip irrigation. This might be due to more frequent irrigation and maintenance of constant soil moisture under the plant. Patel and Patel (1998) reported that the increase in yield was mainly because of better growth of the plant under optimum amount of nutrients in pomegranate crop. The results are in conformity with the findings of Biswas *et al.* (1999) who obtained higher yields from drip-irrigated plots at an IW: CPE ratio of 0.8 compared with those irrigated using a conventional system in papaya.

Similar findings were also made by Sharma and Mursaleen (2014) in guava.

Quality parameters of sweet orange like reducing sugar (%), total sugar (%) and acidity (%) influenced significantly by various volume of irrigation water through drip (Table 2). High reducing sugar (2.33%) and total sugar (8.36%) were recorded with 1.0 volume of water through drip which was statistically similar to 0.8 volume of water and significantly higher than 0.6 volume of water irrigation. Whereas, the lower values of these parameters were found under 1.0 volume of water through surface. The high acidity (0.78%) was recorded in 1.0 volume of water through surface irrigation which was significantly superior over rest of volume of water. The results are in the confirmation with Prasad *et al.* (2003) found that fruit quality in terms of juice content, acidity and total sugar was better in drip-irrigated pomegranate plants than that in the basin irrigated plants.

Effect of fertigation

The data as regard to yield attributes *viz.*, diameter, juice weight, peel weight, fruit and yield (kg/plant) as influenced significantly by different levels of fertigation (Table 2). Among various level of fertigation, maximum fruit diameter (7.20 cm), juice weight (85.42 g) and peel weight (41.59 g) were recorded in 125% RDF which was statistically similar with 100% RDF and significantly superior over 75% RDF. Among various fertigation levels, higher doses showed better vegetative growth of the plant. It might be due to application of higher dose of fertilizers attributed to better nutritional environment in the root zone as well as in plant system. Nitrogen, phosphorus and potassium are most indispensable of all mineral nutrients for growth and development of the plant as these are the basis of fundamental constituents of all living matter (Ramniwas *et al.*, 2012). Mahalaxmi *et al.* (2001) reported that increase in fruit size and weight with increasing levels of NPK under fertigation. Similarly, maximum fruit yield (32.48 kg/plant) was also found under 125% RDF which was par with 100% RDF and significantly superior to 75% RDF. This might be due to longer activity in fertigation where nutrients were applied to match the nutrient uptake by crop. This enhanced the photosynthesis of fruit development which help in development of fruit marketable size and producing more number of fruits/plant and fruit weight and finally on fruit yield/ha as compared to soil application. The results obtained are in accordance with the earlier findings as quoted by Ramniwas *et al.* (2012) and Kumar *et al.* (2013).

Fruit quality parameters like reducing sugar, total sugar and acidity as influenced significantly by different levels of fertigation (Table 2). High reducing sugar of 1.94% and total sugar of 7.63% were recorded under fertigation with 125% RDF which was comparable to 100% RDF and significantly superior to 75% RDF. Whereas the higher acidity (0.72%) was recorded in fertigation with 75% RDF followed by 100% RDF and lowest was in 125% RDF. These findings are similar to the findings of Ramana *et al.* (2014) in sweet orange.

Interaction effect

The interaction effect of water regime and fertigation was found to be significant on yield of sweet orange. Data from the Table 3 reveals that maximum yield (40.75 kg/plant) was recorded with combination application of 1.0 volume of water through drip along with 100% RDF. This might be due to that the fertigation provided a consistent moisture regime and nutrient in the soil due to which root remain active throughout the season resulting proper translocation of food material and

give opportunity to retain maximum of fruits on the plant. The drip irrigation maintained higher as well as continuous soil moisture along with NPK availability influenced by the water and nutrient uptake resulting into high yields. It is also proved that NPK fertigation is essential for high yields in sweet orange and similar results were also observed by Pavel and Villiers (2004) in mango, Kumar *et al.* (2013) and Ramana *et al.* (2014) in sweet orange.

Table 1. Physical and chemical properties of the orchard soil used in the study (compound soil samples from depths of 0-30 and 31- 60 cm)

S.No.	Particulars	Soil depth
1.	Texture	Loamy sand
2.	pH (1:2 soil water suspension)	8.30
3.	EC dS/m (1:2 soil water suspension)	0.16
4.	Organic carbon (%)	0.09
5.	Available nitrogen (kg/ha)	83.15
6.	Available P ₂ O ₅ (kg/ha)	18.94
7.	Available potash (kg/ha)	189.36
8.	Available Fe (mg/kg)	3.15
9.	Available Zn (mg/kg)	0.38

Table 2. Effect of water regime and fertigation levels on yield attributes, yield and quality of sweet orange

Treatment	Fruit diameter (cm)	Fruit yield/plant (kg/ha)	Juice weight (g)	Peel weight (g)	Peel : Juice	Reducing sugar (%)	Total sugar (%)	Acidity (%)
Water regime								
0.6 V water through drip	6.81	30.03	71.20	36.42	0.51	1.42	6.76	0.76
0.8 V water through drip	7.20	35.84	92.31	45.12	0.49	2.26	8.08	0.66
1.0 V water through drip	7.36	38.17	100.40	47.95	0.48	2.33	8.36	0.60
1.0 V water through surface	6.38	21.86	63.20	31.40	0.50	1.30	6.43	0.78
SEm±	0.06	0.71	1.76	0.97	0.02	0.05	0.16	0.006
CD (P=0.05)	0.18	2.26	5.64	3.11	NS	0.16	0.51	0.020
Fertigation level								
75 % RDF	6.66	29.58	77.16	38.13	0.50	1.66	7.08	0.72
100 % RDF	6.96	32.36	82.75	40.95	0.50	1.88	7.50	0.70
125 % RDF	7.20	32.48	85.42	41.59	0.49	1.94	7.63	0.69
SEm±	0.11	0.43	1.56	0.78	0.01	0.04	0.13	0.008
CD (P=0.05)	0.31	1.26	4.56	2.28	NS	0.11	0.38	0.02

Table 3. Interaction effect of water regime and fertigation levels on fruit yield of sweet orange

Treatment	Fertigation level			Mean
	75% RDF	100 % RDF	125 % RDF	
Water regime				
0.6 V water through drip	27.70	31.14	31.25	30.03
0.8 V water through drip	35.10	36.80	35.62	35.84
1.0 V water through drip	35.75	40.75	38.00	38.17
1.0 V water through surface	19.75	21.25	24.57	21.86
Mean	29.58	32.48	32.36	31.47
SEm±	Water regime 0.71	Fertigation 0.43	W x F 0.86	
CD (P=0.05)	2.26	1.26	2.51	

References

- A.O.A.C. 1990. Official and tentative method of analysis. Assoc. of Agric. Chem. 18th Ed., Washington, D.C.
- Anonymous, 2012. Indian Horticulture Database. National Horticulture Board, Gurgaon. Ministry of Agriculture, Government of India.
- Biswas, R.K., Rana, S.K. and Mallick, S. 1999. Performance of drip irrigation in papaya cultivation in new alluvium agro-climatic zone of West Bengal. *Annals Agric. Res.*, 20:116-117.
- Dubois, M., Giles, K., Hamiltan, J.K., Robers, P.A. and Swim, F. 1951. A colorimetric method for determination of sugars. *Nature*, 168-169.
- Gregory, J.F. 1993. Ascorbic acid bioavailability in food and supplements. *Nutrition Review*, 51: 301-303.
- Khan, I.A., Wani, M.S., Mir, M.A., Ahmed, N., Mushtaq, K. and Hassan, G. I. 2012. Response of almond (*Prunus dulcis*) to different drip irrigation levels vis-à-vis various phonological stages on flowering and yield of almond cv. Shalimar," *Indian Journal of Agricultural Sciences*, 82: 624628.
- Kumar, H., Yadav, P.K., Singh, A.K. and Sharma, S.K. 2013. Evaluation of water regime and fertigation on growth, yield and economics of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi. *The Asia Journal of Horticulture*, 8 (2): 709-713.
- Mahalaxmi, M. Kumar, N., Jeyakumar, P. and Soorrianathasundaram, K. 2001. Fertigation studies in banana under normal system of planting. *South Indian Horticulture*, 49: 80-85.
- Panase, V.G. and Sukhatme, P.V. 1985. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.
- Patel, N.M. and Patel, M.M. 1998. Water requirement of pomegranate (*Punica granatum* L.) cv. Ganesh for better yield under resource limited situations. National seminar on new horizons in production and post-harvest management of tropical and subtropical fruits, Delhi, Dec. 8-9.
- Pavel, E.W. and Villiers, A.J. 2004. Response of mango trees to reduced irrigation regimes. *Acta Horticulture*, 646: 63-68.
- Prasad, R.N., Bankar, G.J., Vashishtha, B.B. 2003. Effect of drip irrigation on growth, yield and quality of pomegranate in arid region. *Indian Journal of Horticulture*, 60:140-142.
- Ramana, K.T.V., Mukunda, L.L., Gopal, K., Sivarama, V.N.P.K., Lakshmi, T.N., Sarada, G. Gopi, V. and Sankar, T.G. 2014. Nitrogen and potassium based fertigation response on plant growth, yield and quality of sweet orange (*Citrus sinensis* Linn. Osbeck) cv. Sathgudi. *Research and Reviews: Journal of Agriculture and Allied Sciences*, 3 (3): 7-10.
- Ramniwas, Kaushik, R.A., Sarolia, D. K., Pareek, S. and Singh, V. 2012. Effect of irrigation and fertigation scheduling on growth and yield of guava (*Psidium guajava* L.) under meadow orcharding. *African Journal of Agricultural Research*, 7(47): 6350-6356.
- Sharma, K. and Mursaleen, N. 2014. Assessment of the Impact of irrigation and fertigation on growth and yield of guava (*Psidium guajava* L.) under meadow orcharding. *International Journal of Irrigation and Water Management*, 2014: 7-14.
- Shirgure, P.S. 2012. Effect of pulse irrigation scheduling with hybrid station controller on fruit yield and quality of Nagpur mandarin (*Citrus reticulata* Blanco). *Science Journal of Crop Sciences*, 1(5): 76-82.
- Somogyi, M. 1952. Aresenomolybdate reagent colour development method of reducing sugar determination. *Journal of Biological Chemistry*, 200-245.

Management of *Hasta bahar* in Acid Lime cv. *Kagzi*

D. K. Sarolia, R. L. Bhardwaj*, Kuldeep Singh, R. A. Kaushik and K. B. Shukla

Department of Horticulture, RCA, Udaipur-3031001, Rajasthan, India

* Krishi Vigyan Kendra, Sirohi-307001, Rajasthan, India

*Corresponding e-mail: rajubhardwaj3@gmail.com

(Received: 18.02.2015; Accepted: 17.08.2015)

Abstract

A field experiment was conducted on acid lime cv. *Kagzi* for management of *Hasta bahar* with 15 treatments comprising of chemicals applied through foliar spray viz., GA₃ (50 and 75 ppm), NAA (400 & 500 ppm, KNO₃ (1 & 1.5%), Cycocel (1000 & 1500 ppm), PP₃₃₃ (1000 & 2000 ppm), applied through soil drenching viz., PP₃₃₃ (2.5 & 5 ml plant⁻¹), cultural practices (Root pruning + exposure and withholding of irrigation water) and control. Cycocel @1000 ppm in the month of September gave early induction of flowering (2, November), maximum number of flowers shoot⁻¹ (60.0), fruit set (19.50%), highest fruit retention (49.0%), maximum number of fruits tree⁻¹ (634), highest yield tree⁻¹ (30.50 kg) and yield ha⁻¹ (8.47 t) and best quality parameters such as high ascorbic acid (39.20 mg 100ml⁻¹ juice), juice per cent (52.78), organoleptic score (8.95) with higher B:C ratio (3.46).

Key Words: *Hasta bahar*, Acid lime, PGRs, Crop regulation.

Introduction

Acid lime (*Citrus aurantifolia* Swingle.) is the third important citrus fruit crop in India next to mandarins and sweet orange (Anonymous, 2013). It is a good source of vitamin C and has good antioxidant properties. It is an appetizer, stomachic, antiscorbutic, antihelminthic and it check biliousness (Basak, 2006). The acid lime tree bears flowers round the year with main season of flowering during January-February (Spring season) and gave fruits during July-August (*ambe bahar*) create glut in the market which result in poor return to growers. The crop from October-November flowering matures fruit during of April-May i.e., *haste bahar* fetch good price. The major constraint faced by the growers of acid lime is the peak and lean production in the same year. The present study was therefore under taken to investigate the effective agro chemical (s) (GA₃, NAA, KNO₃, Cycocel) and cultural practices for better flowering and fruiting on acid lime.

Materials and Methods

An experiment was conducted at Farmer field under KVK, Sirohi and Department of Horticulture, Rajasthan College of Agriculture, Udaipur during the year 2012-13. The experiment was laid out in one way analysis with fifteen treatments replicated thrice with plot size 20 m × 20 m and crop geometry at of 6 m × 6 m consisting of 9 plants each. Eight year old uniform seeded acid lime trees were selected for the experiment. The abiotic factors viz., average minimum and maximum temperatures were 28.0° ± 5.0°C and 38.0° ± 5.0°C, average relative humidity of 58.0 ± 10.0% and 585.0 mm rainfall per annum were recorded during the experimentation. The soil texture of experimental plot was sandy loam with pH 7.5, having organic carbon 0.55%, available P 27.5 ha⁻¹ and K 375.0 kg ha⁻¹. The treatments tried were T₀ (absolute control), T₁ (foliar spray of GA₃ @ 50 ppm in the month of June), T₂

(foliar spray of GA₃ @ 75 ppm in the month of June), T₃ (foliar spray of NAA @ 400 ppm in the month of October), T₄ (foliar spray of NAA @ 500 ppm in the month of October), T₅ (foliar spray of KNO₃ @ 1 per cent in the month of October), T₆ (foliar spray of KNO₃ @ 1.5 per cent in the month of October), T₇ (foliar spray of paclobutrazol @ 1000 ppm in the month of August), T₈ (foliar spray of paclobutrazol @ 2000 ppm in the month of August), T₉ (foliar spray of Cycocel @ 1000 ppm in the month of September), T₁₀ (foliar spray of Cycocel @ 1500 ppm in the month of September), T₁₁ (paclobutrazol soil drenching @ 2.5 ml plant⁻¹ in the month of July), T₁₂ (paclobutrazol soil drenching @ 5 ml plant⁻¹ in the month of July), T₁₃ (with holding irrigation in September-October), T₁₄ (root pruning and exposure in October). Light irrigation was applied uniformly 22-25 days after treatment application. The intercultural operations (weeding, manuring, fertilizer application, mulching, insecticide spray etc.) were done as and when necessary. *Amba bahar* crop has been avoided in all treatment plants. Observation on date to flower initiation, number of flowers shoot⁻¹, per cent fruit set, per cent fruit retention, number of fruits, fruit weight and yield tree⁻¹, yield ha⁻¹ were recorded at appropriate time by standard methods. Acidity (as citric acid) was determined by using standard N/10 NaOH solution in the presence of phenolphthalein as an indicator (AOAC, 1990). The vitamin 'C' (ascorbic acid) content of the juice was estimated by visual titration method with 2, 6-dichlorophenol-indononol dye solution (AOAC, 1990). Organoleptic score (consumer preference) of fruits juice was tested by a panel of five semi-trained judges using 9 point hedonic scale (Amerine *et al.*, 1965). Net financial returns were calculated by subtracting the cost of each treatment from the gross return and the benefit: cost ratio was determined by net income divided by cost of cultivation. The data were subjected to analysis of variance (ANOVA) to

determine significant differences followed by Tukey's test for comparisons of means at significance level of $P \leq 0.05$.

Results and Discussion

Number of days to first flowering is an important factor that governs either delay or earliness of a crop. It is influenced by diverse factors like genetic, environmental, physiological, nutritional, hormonal and cultural. In the present study, the different treatment induced the flowering. The earliest flowering and maximum number of flowers shoot⁻¹ and fruit set were observed in trees sprayed with T₉ (foliar spray of Cycocel @1000 ppm) by nearly 14 days in compare to control. This might be due to Cycocel, a growth retardant acted as an antigibberellin compound and arrested the vegetative bud development, nucleic acid synthesis and protein metabolism by specific anti metabolites, which induce flower formation. Similar results were also reported by Brahmachari *et al.*, (1996) in guava.

The highest fruit retention (57.0%) was noticed in trees sprayed with T₄ (foliar spray of NAA @ 400 ppm) probably due to auxin inhibition activity of the hydrolytic enzyme polygalacturonase and cellulase, which are responsible for the degradation of the cell wall and the middle lamella in the abscission zone (Goren, 1993). The synthetic auxin α -naphthalene acetic acid (NAA) gave positive result in retention of the fruits. Further, treatment T₉ (foliar spray of Cycocel @1000 ppm in the month of September) recorded maximum number of flowers shoot⁻¹ (60.0), highest fruit set (19.50%) and fruit retention (49.0%), with highest fruits tree⁻¹ (634), fruit yield tree⁻¹ (30.50 kg) and yield ha⁻¹ (8.47 t).

However, both Cycocel treatments i.e., T₉ and T₁₀ were at par with these parameters. The increase in yield might be due to more flowers, fruit set and number of fruits per tree. These results are in agreement with the findings of Shrestha (1988), Sadawarte *et al.* (2010) and Mahalle *et al.*, (2010).

A perusal of data presented in table-2 indicated that the acid lime plant received foliar spray of cycocel @ 1000 ppm in the month of September (T₉) exhibited maximum value of juice (52.78%), ascorbic acid (39.20mg 100ml⁻¹ juice) and organoleptic observation (8.95). This may be because of cycocel induced early and uniform flowering and fruiting so accumulate more photosynthates with controlled vegetative growth may enhance organic acid content of fruits in treated plants. Ilango and Vijayalakshmi (2002) observed that application of 1500 ppm CCC has significantly increased the tartaric acid content, ascorbic acid, TSS, protein, carbohydrate, reducing, non-reducing and total sugar content of tamarind pod over control.

As far as relative economics of the treatment is concerned, T₁₀ treatment exhibited highest net return (Rs. 160246.0), whereas the highest B: C ratio (3.46:1) with Rs. 155331.0 net return was observed in T₉ treatment. This might be due to the significantly higher yield and comparatively low cost of cultivation over T₁₀ treatment.

Thus, foliar spray of Cycocel @1000 ppm in the month of September followed by 22-25 days with holding of irrigation gave early induction of flowering and maximum in number of flowers shoot⁻¹, fruit set, number of fruits and higher B: C in Kegzi lime.

Table 1. Effect of crop regulation treatments on flowering and yield parameters of acid lime cv. Kagzi

Treatments	Date of flower initiation	Number of flowers shoot ⁻¹	Fruit set (%)	Fruit retention (%)	Number of fruits tree ⁻¹	Yield per tree (kg)	Estimated yield ha ⁻¹ (t)
T ₀	16 November	35	15.00	37	496	17.33	4.81
T ₁	4 November	38	17.50	45	580	22.13	6.15
T ₂	5 November	40	18.00	49	560	22.71	6.31
T ₃	13 November	42	20.00	55	605	26.98	7.50
T ₄	14 November	44	19.00	57	616	27.78	7.72
T ₅	11 November	50	16.00	39	518	18.86	5.24
T ₆	10 November	48	15.00	43	526	20.06	5.57
T ₇	12 November	44	16.50	45	516	20.00	5.56
T ₈	9 November	42	16.00	47	520	21.13	5.87
T ₉	2 November	60	19.50	49	634	30.50	8.47
T ₁₀	3 November	58	19.00	47	620	28.63	7.95
T ₁₁	12 November	42	16.00	45	566	25.03	6.95
T ₁₂	8 November	44	15.50	43	556	24.00	6.67
T ₁₃	6 November	42	17.50	45	546	22.30	6.19
T ₁₄	7 November	48	17.00	41	534	20.80	5.78
SEm ±	-	1.18	0.45	1.25	14.63	0.86	0.24
CD at 5%	-	3.41	1.31	3.63	42.28	2.50	0.69

Table 2. Effect of crop regulation treatments on quality and economics of acid lime cv. Kagzi

Treatments	Fruit weight (g)	Acidity (%)	Ascorbic acid (mg/100 ml juice)	Juice (%)	Organoleptic score (out of 9)	Total cost ha ⁻¹ (Rs.)	Net return (Rs.)	B:C
T ₀	38.00	4.12	35.50	32.40	7.17	40749	79511	1.95
T ₁	38.16	4.15	36.90	34.24	7.22	43529	109741	2.52
T ₂	40.56	4.20	37.25	36.25	7.25	44919	112373	2.50
T ₃	43.20	4.50	37.45	40.65	7.47	43557	126665	2.91
T ₄	43.00	4.90	37.90	38.50	7.57	44259	128749	2.91
T ₅	36.4	4.25	37.60	42.25	7.65	41583	88989	2.14
T ₆	38.15	4.40	36.50	32.80	7.80	42000	96963	2.31
T ₇	38.76	4.60	37.30	34.65	8.20	44919	93582	2.08
T ₈	40.65	5.00	36.40	36.12	8.60	49089	97292	1.98
T ₉	46.18	5.26	39.20	52.78	8.95	44919	155331	3.46
T ₁₀	47.20	5.72	39.00	50.96	8.82	47004	160246	3.41
T ₁₁	44.24	5.70	37.40	46.46	6.67	42774	130627	3.05
T ₁₂	43.17	5.50	38.20	34.80	6.87	44919	121298	2.70
T ₁₃	40.86	4.75	37.40	32.75	7.20	40749	113745	2.79
T ₁₄	38.96	5.71	38.65	38.60	7.52	41484	102588	2.47
SEm ±	1.25	0.15	0.61	1.02	0.20	-	-	-
CD at 5%	3.62	0.45	1.77	2.94	0.58	-	-	-

Cost of chemicals per 250 g or ml was Rs. 6950 for GA, Rs. 877.5 for NAA, Rs. 521 for CCC, Rs. 104 for KNO₃ and Rs. 1042.5 for Pp333.

References

- A.O.A.C. 1990. In: Official Methods of Analysis. Association of Official Agricultural Chemists. Benjamin Franklin Station, Washington, DC.
- Anonymous. 2013. Indian Horticulture Database-2011-12. Ministry of Agriculture, Government of India, Gurgaon, pp. 5-6.
- Amerine, M.A., Pangborn, R.M. and Rossler, E.A. 1965. Principles of sensory evaluation of food. Academic Press, New York and London.
- Basak, S.L. 2006. Nutritional and medicinal values of plant foods. Naya Udyog, Kolkata pp 135-136.
- Brahmachari, V.S., Mandal, A.K., Kumar, R., Rani, R. and Kumar, R. 1996. Effect of growth substances on flowering and fruiting characters of 'Sardar' guava (*Psidium guajava* L.). *The Horticultural Journal*, 9: 1-7.
- Goren, R. 1993. Anatomical, physiological and hormonal aspects of abscission in citrus. *Horticulture Review*, 15: 145-182.
- Ilango, K. and Vijayalakshmi, S. (2002). Effect of some growth regulators and chemical on yield and quality attributes in tamarind (*Tamarindus indica* L.). *The Orissa Journal of Horticulture*, 30(1): 35-39.
- Mahalle, S. S., Ingle, H. V. and Sable, P. B. 2010. Influence of plant growth regulators and chemicals on yield and quality of *Hasta bahar* in acid lime. *Green Farming*, 1(3): 285-287.
- Sadawarte, A. K., Ghode, P. B. and Jhosi, P. S. 2010. Regulation of flowering in acid lime (*Citrus aurantifolia* Swingle.). National seminar on production technology and marketing of acid lime of India. Souvenir. September, 7-9-2010. Kherva, Dist. Mehsana (GS):15.
- Shrestha, T. N. 1988. Studies on chemical control of flowering and fruiting of acid lime (*Citrus aurantifolia* Swingle). Ph.D. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Standardization of chrysanthemum cv. Mother Teresa to different potting media under *Tarai* field conditions

Deepti Bisht*

Department of Agriculture Sciences and Engineering, IFTM University, Lodhipur.

Moradabad Pin code: 244102 (Uttar Pradesh)

*email- diptibisht.pnt@gmail.com

(Received: 24.11.2014; Accepted: 25.06.2015)

Abstract

A study on response of pot mum cv. Mother Teresa to different potting media under open field conditions was conducted during 2009-10 at GBPUA&T, Pantnagar. In the present investigation, eight growing media were tested. Plants growing in plastic pots containing cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) media exhibited the maximum plant height (36.00 cm), and number of primary and secondary branches (3.67 & 17.67, respectively). Number of flowers per plant (34.0) was recorded maximum in cocopeat + sand + vermicompost (2:1:1). Plants took minimum days for flowering (57.00) when grown in cocopeat + sand + FYM. Flower diameter was observed maximum (5.73 cm) in plants grown in cocopeat + sand + FYM + vermicompost. Maximum duration of flowering (28.13 days) was observed in growing media namely cocopeat + sand + vermicompost. Keeping in view the response of chrysanthemum cv. Mother Teresa to different growing media containing cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) can be recommended for quality pot mum production under open conditions.

Key words: Pot mum, growing media, open field, vegetative and floral traits

Introduction

Chrysanthemum (*Dendranthema grandiflorum* Tzvelev.) commonly called as *guldaudi* or 'Autumn Queen' is one of the major cut flower crop as well as grown for pot mum production globally. It ranks second after rose for cut flower trade and fifth as pot plant in the world floricultural trade. In India, besides, its use as a cut flower and pot plant, flowers are also used for making garlands, *venis*, *gajras* and in religious offerings. It has a wide range of plant shape, size, flower shape and colour which makes it highly suitable for pot culture and bedding purposes.

Growing media is an important component for successful pot mum production. Popular and well-studied growing media which are in use now-a-days are peat, rock wool, vermiculite, perlite and sand. Peat is the most widely used substrate for pot plant production in the nurseries and accounts for a significant portion of the material used to grow potted plants (Ribeiro *et al.*, 2007). In the last few years, cocopeat (coir dust) has been considered as a renewable sphagnum peat substitute for use in horticulture (Yau and Murphy, 2000). Pot mums are more in fashion in western countries and they are even getting importance now-a-days in India due to rise in per capita income as well as awareness and interest among individuals regarding growing of flowers. Moreover, due to shortage of time and space, more and more people prefer to grow plants in pots and in their home gardens. However, not much work has been done to standardize the media composition of chrysanthemum for pot mum production. Keeping in view the current demand for pot mum production, there is an urgency to standardize the most appropriate media for different cultivars under different agro-

climatic conditions. Therefore, the present investigation was undertaken to standardize the most appropriate media composition for pot mum production under *Pantnagar conditions of Uttarakhand*.

Materials and Methods

The experiment was conducted at the Model Floriculture Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during 2009 to 2010. The experiment consisted of eight treatments with three replications. The experiment was plotted according to Completely Randomized Design (CRD). Mother Teresa, a popular spray type cultivar of chrysanthemum was chosen for present investigation. Well rooted plants of uniform size and age were transplanted in plastic pots of 15 cm size. The pots were filled with different media with varying composition of soil + sand + FYM (2:1:1), soil + sand + vermicompost (2:1:1), soil + sand + FYM + vermicompost (2:1:0.5:0.5), cocopeat only, cocopeat + sand + FYM (2:1:1), cocopeat + sand + vermicompost (2:1:1), cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) and soil (control). The observations were recorded on vegetative and flowering traits on five selected plants per treatment in each replication and average value was calculated statistically.

Results and Discussion

The data presented in Table 1 and Table 2 reveal significant variations on growth characters of pot mum under open field conditions. Plant height is an important trait for pot mum production of chrysanthemum. Different media grown plants had varied plant height. Plants grown in cocopeat + sand

+ FYM + vermicompost (2:1:0.5:0.5) media produced plants with maximum height (36.0 cm) closely followed by cocopeat + sand + vermicompost (35.60 cm). Plant height was retarded and was found minimum (23.0 cm) in soil used as control. The cocopeat amended media gave maximum plant height on account of high porosity, nutritional value and good water holding capacity. Similar results were obtained by Noguera *et al.* (2000). Likewise, Singh *et al.* (2009) found that potting media containing sand + FYM (1:1) produces maximum plant height (29.47 cm) in *Begonia*. Plant spread determines the size of the plant in different directions. Maximum plant spread (29.00 cm) was recorded as an average of North-South & East-West in cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) followed by cocopeat + sand + vermicompost (2:1:1) and soil + sand + FYM + vermicompost (2:1:0.5:0.5), which had plant spread of 27.0 and 26.33 cm, respectively. However, minimum plant spread was found in control. Maximum plant spread may be due to increased synthesis of protein as nitrogen is an essential part of nucleic acid which plays vital role in promoting plant growth (Kaur, 1992).

Number of primary and secondary branches differed significantly with respect to different growing media used. Maximum numbers of primary and secondary branches (3.67 and 17.67, respectively) were found in cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) which also produced maximum number of leaves (119.33) per plant followed by cocopeat + sand + vermicompost (2:1:1). Statistically non-significant differences were recorded for number of leaves per plant in media containing soil: sand: FYM: and sand: soil: vermicompost (T_2 and T_3). Like other parameters, minimum number of leaves per plant were observed in control. Superiority of the above media over soil might be due to better growing conditions of the media provided by the presence of cocopeat and vermicompost as these media are rich in nutrients and are also porous in nature. These findings are in conformity with the findings of Kumar and Kumar (2000) who observed that the vegetative characters of gerbera varied in different media owing to the variable production environments. Rani *et al.* (2005) found that among *Lilium* cv. Elite produces more number of leaves per stem (37.37) when grown in a mixture of soil and cocopeat. Singh *et al.* (2010) observed higher number of leaves per plants growing in sand + FYM in the ratio of 1:1 in *Dieffenbachia amoena*. Maximum length of leaf (6.90 cm) was observed in cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) and minimum (4.83 cm) was recorded in control. Ali *et al.* (2011) reported that maximum leaf length (22.76 cm) was produced by the plants grown in silt + mushroom compost, followed by plants grown in silt + leaf mold (20.78 cm) while silt + garden soil + FYM (1:1:1) behaved alike producing minimum leaf length (18.62 cm). However, leaf width was noticed maximum (4.37 cm) in soil + sand + FYM + vermicompost (2:1:0.5:0.5) followed by 4.30 cm in cocopeat + sand + FYM (2:1:1). Surprisingly, minimum (3.27 cm) width of leaf was recorded in cocopeat + sand + vermicompost (2:1:1) as compared to plants grown in soil, i.e., control (3.50 cm). There was a wide range of

variations for number of roots per plant and length of root among the various treatments. Number of roots per plant varied from 248.33 to 390.0 with treatment T_6 and T_1 , exhibiting minimum and maximum roots per plant, respectively. However, different trends of results were observed for length of root of plants, with control producing shortest roots (14.60 cm). These results are in corroboration with the findings of Budiarto *et al.* (2006) who studied that chrysanthemum cuttings planted in the carbonized rice husk produce better rooting capacity compared with those grown on vermiculite.

Maximum number of days taken to bud initiation was (60.50) in T_1 (control) followed by 57.54 days in T_2 i.e., soil + sand + FYM (2:1:1). Bud initiation was earliest (50.0 days) in cocopeat + sand + FYM (2:1:1) which also took minimum days for flowering (57.0 days). Flowering was delayed most in control which took 72.50 days for flowering. These results are in accordance with the findings of Naz *et al.* (2006) who reported that the overall performance of phlox was better in sand + silt + leaf mold. Diameter and total number of flowers per plant are the important floral traits in pot mum which can make or mar the beauty of pot mum production. More the number of flowers and better the growth of plant, better is the media composition. In present experiment, larger flower diameter (5.73 cm) was observed in cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) and plants grown in control produced flowers of smaller diameter (4.40 cm). The influence of growing media on flower diameter was also observed by other workers. Tailin *et al.* (2003) obtained highest flower diameter of dahlia by using leaf manure + sand as media. Similarly, Yasmeen *et al.* (2012) reported that leaf compost + sand (1:1) produce maximum flower diameter (4.94 cm) and farmyard manure produce minimum flower diameter (3.95 cm). Highest number of flowers per plant (34.0) were produced in T_7 i.e. cocopeat + sand + vermicompost. Other treatments which produced appreciable number of flowers were T_6 and T_8 and rest of the treatments were inferior for this very important flowering trait (Table 2). Like most of the traits which were found inferior in control, number of flowers per plant were also found minimum (21.30) in control. The variation in number of flowers/plant may be attributed to the genetic potential of the crop or the physico-chemical properties of the substrates. An increase in number of flowers/plant could be attributed to overall vegetative growth of chrysanthemum plants grown in these substrates. Greater carbohydrate accumulation due to increased photosynthesis might have caused the production of more number of flowers/plant. This in turn might have been caused due to the optimum balance and supply of plant nutrients present in the substrate. Similarly, increased availability of essential elements at critical growth stages could have led to increase in number of flowers. Singh *et al.* (2009) also reported that potting media comprising of saw dust + brick pieces + wooden charcoal + soil + sand + FYM in the ratio of 2:1:1:1:1 produces maximum number of flowers per plant

(6.07) and minimum days to flowering (260.47) in anthurium. Duration of flowering recorded from peak flowering up to the stage till plants remain presentable, was found more (28.13 days) in case of cocopeat + sand + vermicompost (2:1:1). Apart from this media, plants grown in soil + sand + FYM + vermicompost (2:1:0.5:0.5) also remained in good form for considerable extent (28.00 days) and minimum (19.67 days) duration of flowering was recorded in control. Yasmeen *et al.* (2012) depicted that leaf compost + sand (1:1) produce flower

in minimum days than other substrates used. Longevity of flowers varied among various media studied. Plants grown in soil + sand + vermicompost (2:1:1) exhibited maximum flower longevity (15.60 days). Moreover, appreciable flower longevity was observed with various formulations tried for pot mum production and control grown plants. Based on the results obtained in the present investigation, it can be concluded that cocopeat+ sand+ FYM+ vermicompost (2:1:0.5:0.5) is a better growing media for pot mum cv. Mother

Table 1. Effect of growing media on vegetative characters of chrysanthemum cv. Mother Teresa

Treatment	Plant height (cm)	Plant spread (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of leaves per plant	Length of leaf (cm)	Width of leaf (cm)	Number of roots per plant	Length of root (cm)
T ₁ Control	23.00	18.23	1.93	11.63	93.00	4.83	3.50	390.00	14.60
T ₂ Soil + Sand + FYM (2:1:1)	27.00	20.07	2.87	14.00	111.73	5.90	3.83	373.67	19.60
T ₃ Soil + Sand + Vermicompost (2:1:1)	29.67	23.00	2.97	14.43	111.13	6.17	3.43	318.67	19.07
T ₄ Soil + Sand + FYM + Vermicompost (2:1:0.5:0.5)	32.10	26.33	3.47	13.77	112.80	6.47	4.37	289.67	18.07
T ₅ Cocopeat only	31.67	24.67	2.93	15.33	103.77	5.83	3.60	373.33	18.03
T ₆ Cocopeat + Sand + FYM (2:1:1)	31.33	20.43	3.37	15.20	112.23	5.60	4.30	375.00	18.37
T ₇ Cocopeat + Sand + Vermicompost (2:1:1)	35.60	27.00	3.57	16.67	115.67	6.77	3.27	273.00	25.33
T ₈ Cocopeat + Sand + FYM + Vermicompost (2:1:0.5:0.5)	36.00	29.00	3.67	17.67	119.33	6.90	3.63	248.33	24.67
CD at 5%	1.81	1.94	0.35	2.06	5.01	0.92	NS	16.48	2.25

Table 2. Effect of growing media on flowering characters of chrysanthemum cv. Mother Teresa

Treatment	No. of days taken to bud initiation	No. of days taken to flowering	Flower dia. (cm)	Total No. of flowers per plant	Flowering duration (days)	Flower longevity (days)
T ₁ Control	60.50	72.50	4.40	21.30	19.67	10.00
T ₂ Soil + sand + FYM (2:1:1)	57.54	67.54	5.10	24.03	25.60	12.97
T ₃ Soil + sand + vermicompost (2:1:1)	57.00	66.00	5.23	26.27	25.11	15.60
T ₄ Soil + sand + FYM + vermicompost (2:1:0.5:0.5)	52.33	60.54	5.33	27.57	28.00	12.83
T ₅ Cocopeat only	52.66	60.34	5.43	23.00	23.66	15.57
T ₆ Cocopeat + sand + FYM (2:1:1)	50.00	57.00	5.17	30.67	25.60	14.23
T ₇ Cocopeat + sand + vermicompost (2:1:1)	52.33	61.34	5.60	34.00	28.13	14.33
T ₈ Cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5)	56.96	66.94	5.73	29.67	27.27	14.00
CD at 5%	4.51	2.80	NS	2.27	3.31	2.15

References

- Ali, T., Amin, N.U., Khattak, A.M. and Khan, M.A. 2011. Response of Freesia cultivars to different growing media under Peshawar conditions. *Sarhad J. Agric.*, 27: 43-49.
- Budiarto, K., Sulyo, Y., Dwi, E. and Maaswinkel, R.H.M. 2006. Effects of types of media and NPK fertilizer on the rooting capacity of chrysanthemum. *Indonesian J. Agric. Sci.*, 7: 67-70.
- Kaur, K. 1992. Studies on the production of *Gerbera jamesonii* in the sub tropical environment of Punjab. M.Sc. Thesis, Punjab Agricultural University, Ludhiana.
- Kumar, D. and Kumar, R. 2000. Seasonal response on gerbera cultivars. *J. Orn. Hort.*, 3(2): 103-106.
- Naz, I., Baloch, J.U.D. and Waseem, K. 2006. Effect of different growing media on the growth and development of phlox (*Phlox drummondii*). M.Sc. (Hons) Thesis, Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan.
- Noguera, Abad, P.M. and Noguera, V. 2000. Coconut coir waste, a new and viable ecologically-friendly peat substitute. *Acta Hort.*, 517: 279-283.
- Rani, N., Kumar, R. and Dhatt, K.K. 2005. Effect of nitrogen levels and growing media on growth, flowering and bulb production of *Lilium* cultivars. *J. Orn. Hort.*, 8: 36-40.
- Ribeiro, H.M., Romero, A.M. and Pereira, H. 2007. Evaluation of a compost obtained from forestry wastes and solid phase of pig slurry as a substrate for seedling production. *Bioresource Tech.*, 98: 3294-3297.

- Singh, A.K., Gupta, S. and Singh, A.K. 2009. Influence of various potting media on vegetative and root characteristics in Wax begonia. *J. Orn. Hort.*, 12: 111-115.
- Singh, P., Dhaduk, B.K., Chawla, S.L., Singh, A., Aklade, S.A., Desai, J.R. and Yadav, M.K. 2009. Standardization of growing media for anthurium (*Anthurium andreanum* L.) cv. 'Flame' under protected conditions. *J. Orn. Hort.*, 1: 101-105
- Singh, A.K., Gupta, S. and Singh, A. 2010. Study on nutrient levels of various potting media and its effect on vegetative and root characteristics in Dieffenbachia. *J. Orn. Hort.*, 13: 117-121.
- Tailin, Z., Bailin, Q. and Renjuan, J. 2003. Cultivation experiments on several kinds of herbaceous flowers. Zhejiang Forestry College, 20(1): 108-110.
- Yasmeen, S., Younis, A., Rayit, A., Riaz, A. and Shabeer, S. 2012. Effect of different substrates on growth and flowering of *Dianthus caryophyllus* cv. 'Chauband Mixed'. *American Eurasian J. Agric. Env. Sci.*, 12: 249-258.
- Yau, P.Y. and Murphy, R.J. 2000. Biodegraded cocopeat as a horticultural substrate. *Acta Hort.*, 517: 275-278.

Effect of integrated nutrient management on yield parameters and yield of *rabi* onion (*Allium cepa* L.)

Prakash Mahala*, M.R. Choudahry and O.P. Garhwal

Department of Horticulture

SKN College of Agriculture, Jobner

Sri Karan Narendra Agriculture University, Jobner-303329, Rajasthan.

* Corresponding author e-mail:-pmhorti@gmail.com

(Received: 8.10.2015; Accepted: 8.01.2016)

Abstract

The field experiment was conducted to study the "Effect of integrated nutrient management on yield parameters and yield of *rabi* onion (*Allium cepa* L.)" in loamy sandy soils of the Horticulture farm, S.K.N. College of Agriculture, Jobner during *rabi* season of 2013-14 and 2014-15. The experiment comprising of 36 treatment combinations was replicated three times, was laid out in split-plot design having three fertility levels (0, 75 and 100% of recommended dose of NPKS) and three treatments of organic manures (control, FYM @ 20 t ha⁻¹ and poultry manure @ 5 t ha⁻¹) were applied in main plots. Four bio-fertilizers used sub treatments viz. (No inoculation, PSB inoculation, *Azospirillum* inoculation and PSB + *Azospirillum* inoculation) were applied in sub plots. The results of the study envisage showed that application of inorganic fertilizers up to 75% RDF significantly increased yield parameters and yield (neck thickness, number of scales per bulb, fresh weight of bulb and yield of onion). Similarly, application of poultry manure @ 5 t ha⁻¹ significantly increased yield parameters and yield of onion. Application of bio-fertilizers (PSB and *Azospirillum*) alone or in combination significantly influenced yield parameters and yield of onion. Significant maximum values for yield was parameters and yield achieved through combined inoculation with PSB + *Azospirillum*. Application of 75% recommended doses of NPKS along with poultry manure @ 5 t ha⁻¹ was better for realizing enhanced fresh weight of bulb and bulb yield of onion.

Key words: onion, inorganic nutrients, organic manures, bio-fertilizers and yield.

Introduction

Onion (*Allium cepa* L.) is a biennial or perennial herb and belongs to the family Alliaceae. It is one of the most important cash crop vegetable, among the bulb crops and is semi-perishable in nature. It can be transported to a long distance without much transit injury losses. The significance of crop further enhances due to its multiple uses. Onion is rich in protein, calcium, phosphorus and carbohydrates (Bose *et al.*, 1989). The application of different doses of nitrogen increased plant growth and yield of onion (Sharma, 1992). Similarly, phosphorus has its beneficial effect on early root development, plant growth, yield and quality of crop produce (Balai, 2002). Potassium plays an important role in crop productivity by functioning as an activator of numerous enzymes like pyruvic kinase, cytoplasmic enzymes and therefore, cause pervasive effect on metabolic events. The application of different doses of sulphur improves plant height, number of leaves, bulb diameter, bulb weight and yield of onion (Jana *et al.*, 1990). The application of organic manures like FYM and poultry manure alone and in combination with NPK have been reported to decrease the bulk density, improve the soil porosity and increase water holding capacity (Maheswarappa *et al.*, 1999). Further, inoculation biofertilizers mobilize nutrient elements from unavailable to available form through biological processes. These are biologically active strains or products containing active form of microorganisms. **Phosphate Solubilizing Bacteria** (PSB) when inoculated, secrete anti-biotic

substances and solubilise the otherwise unavailable insoluble soil phosphorus and then make it available to the plant. The inoculation of PSB bio-fertilizer increases the yield of crops by 10 to 30 per cent (Tilak and Annapurna, 1993). *Azospirillum* inoculation helps the plants to attain better vegetative growth and also in saving inputs of nitrogenous fertilizers by 20-30 per cent. Application of *Azospirillum* had significant effect on nutrient uptake, which may be helpful for increasing the crop production by way of enhancing the soil fertility (Subbian, 1994). Use of biofertilizers not only supplement the nutrients but also improve the efficiency of applied nutrients (Somani *et al.*, 1990). Studies have also showed that integrated use of chemical fertilizers, organic residues like FYM, compost etc. and biofertilizers resulted in reduced losses of nutrients and environmental pollution (Ange, 1993).

Materials and Methods

The present investigation was carried out at the Horticulture farm, S.K.N. College of Agriculture, Jobner during *rabi* season of 2013-14 and 2014-15, to find out the influence of inorganic fertilizer, organic manure and bio-fertilizers on yield parameters and yield of onion. The soil of the experimental site was loamy sand having 131.7 kg ha⁻¹ available nitrogen, 14.8 kg ha⁻¹ available phosphorous, 149.0 kg ha⁻¹ available potassium and 9.88 kg ha⁻¹ available sulphur. The study was carried out at three fertility levels (0, 75 and 100% of recommended dose of NPKS) through urea, SSP, MOP and elemental sulphur and three treatments of organic

manures (control, FYM @ 20 t ha⁻¹ and poultry manure @ 5 t ha⁻¹) were applied in main plots. Four treatments of bio-fertilizers (No inoculation, PSB inoculation, *Azospirillum* inoculation and PSB + *Azospirillum* inoculation) were applied in sub plots. Experiment was laid out in split plot design, the plot size measuring 2.0m x 1.5m (3 m), having three replications. The onion seedling was transplanted at 20 cm row to row and 10 cm plant to plant spacing using 10 kg seed per hectare. Healthy crop of onion was raised following standard agronomic practices. Observations on yield parameters and yield of onion were recorded periodically with respect to influence of inorganic fertilizers, organic manures and bio-fertilizers and their interaction effects. The data were statistically analyzed as per the method suggested by Panse and Sukhatme (1985).

Results and Discussion

Effect of inorganic fertilizers

The result of present study clearly indicate that neck thickness, number of scales per bulb, fresh weight of bulb and bulb yield (Table-1) increased significantly on application of 100% RDF. However, application of 75% RDF and 100% RDF failed to show any significant differences. The increase in these parameter due to nitrogen application may be explained on the basis that nitrogen fed to plants might have made their rapid growth and acquired healthy green colour due to increased synthesis of chlorophyll content which in turn resulted in enhanced net assimilation rate due to increased photosynthetic activities. Thus, it also lead to thickening of scales. Moreover, the nitrogen application might have influenced the availability of other nutrients including phosphorus and sulphur and thus better nutrition, ultimately leading to increased yield parameters. The bulb yield, being a function primarily of the cumulative effect of yield attributing parameters, increased significantly with the application of nitrogen fertilization upto 75% RDF. The observed significant increase in bulb yield of onion with increased application of N might be due to low initial available N status (131.70 kg ha⁻¹) of the experimental soil. The plant adequately supplied with N had more number of functional leaves and photosynthesizing area which consequently contributed to better growth and development of individual plant (Biswas *et al.*, 1995). This in turn resulted in production of more yield. These results are in conformity to the reports of Singh (2000). The beneficial influence of phosphorus in early stage of growth may be explained by early stimulation of scanty root system through efficient translocation to the roots of certain growth stimulating compounds formed on account of protoplasmic activity of tops in phosphorus fed plants, which enhanced absorption of nitrogen and other nutrients and their utilization. The increase in yield parameters and yield may also be attributed to functional role of potassium resulting in higher net photosynthetic activity and denser rooting system (Sharma *et al.*, 1994). The low initial available sulphur content in experimental soil and better development and thickening of xylem and collenchyma fibers because of higher rate of protein synthesis and enhanced photosynthetic activity of the plant with increased chlorophyll synthesis reflects the utility of sulphur in such crops (Biswas *et al.* 1995). Further, sulphur being an integral constituent of certain amino acids of which nitrogen is also an essential constituent, might have helped in increasing net assimilation rate of nitrogen and other nutrients.

Thus, it might have resulted in increased yield attributes. These results are in agreement to the findings of Yadav *et al.* (2008) and Sharma (2014).

Effect of organic manures

Data presented in table-1 revealed that the neck thickness, number of scales per bulb, fresh weight of bulb and bulb yield increased significantly with the application of poultry manure @ 5 t ha⁻¹. However, it was statistically at par to FYM @ 20 t ha⁻¹ only in number of scales and yield of residual crop. Poultry manure and FYM having a material contains better levels of available nutrients, enhanced water holding capacity and leads to slow but steady release of macro and micro nutrients during the course of microbial decomposition (Singh and Ram, 1982). Organic matter is also a source of energy for soil micro flora which brings the transformation of soil inorganic nutrients in the form that is readily utilized by growing plants and improves the physical properties of the soil (Singh and Singh, 1974). The beneficial response of Poultry manure and FYM to yield might also be attributed due to the availability of sufficient amount of plant nutrients throughout the growth period of crop, resulting in improved plant vigour and yield (Brar and Pastricha, 1998). The increased yield and yield parameters with poultry manure might be because of rapid availability and utilization of nitrogen for various internal plant processes for carbohydrates production. Later on, these carbohydrates underwent hydrolysis and got converted into reproductive sugars which ultimately helped in increasing yield. The carbohydrate content due to application of poultry manure might be attributed to balanced C: N ratio and increased metabolic activity of plant (Zarate *et al.*, 1997). These results are in close conformity with the findings of Choudhary *et al.* (2013), Damse *et al.* (2014), Meena *et al.* (2014) and Meena *et al.* (2015).

Effect of bio-fertilizers

The result of present study (Table-1) clearly indicates that neck thickness, number of scales per bulb, fresh weight of bulb and bulb yield increased significantly due to combined inoculation of PSB + *Azospirillum*. The reason is due to the fact that *Azospirillum* is known to produce antifungal, antibiotic substances that inhibit a range soil borne fungal pathogens. It can also synthesise thiamine, riboflavin, pyridoxine, cyanocobal amine, nicotinic acid, pantothenic acid, indole acetic acid and gibberellins or gibberellins like substances resulting in vigorous plant growth and dry matter production which in turn resulted in better, bulb development and ultimately higher yield. Further, *Azospirillum* inoculation might have helped in increasing nitrogen availability because it is a micro acrophillic nitrogen fixer. It colonizes the root mass, fixes nitrogen in loose association with plants and these bacteria induce the plant root to secrete mucilage which creates low oxygen involvement and help in fixing atmospheric nitrogen which reflected in the better yield parameters. Increased activity of plant growth substances like gibberellic acid, indole acetic acid, and dihydrozeatin in *Azospirillum* inoculated plant, greatly improved the yield. The solubilization effect of PSB is generally due to the production of organic acids by this organism. They are also known to produce amino acids, vitamins, growth promoting substance like indole acetic acid and gibberellic acid which helps in better growth of crop and ultimately yield attributes and yields.

Biological nitrogen fixation depends appreciably on the available form of phosphorus. So the combined inoculation of nitrogen fixer and PSB may benefit the plant better (by proving both nitrogen as well as phosphorus) than either group of inoculants alone. Such mutually beneficial synergistic effects have also been reported by Yadav *et al.* (2008), Sharma (2014) and Meena *et al.* (2015).

Interaction effect

Interaction effect of different levels of fertility and organic manures were found to be significant for fresh weight of bulb and bulb yield. Maximum fresh weight of bulb and bulb yield (Table-2 and 3) were obtained with 100% RDF combined with poultry manure @ 5 t ha⁻¹. However, this combination was recorded statistically at par with 75% RDF + poultry manure @ 5 t ha⁻¹. The use of poultry manure in the absence of chemical fertilizer has remarkable effect in improving the fresh weight of bulb and bulb yield of onion. However, it was decreased with increasing levels of fertilizers. It is also apparent that a saving of 25% nutrients in use of fertilizer could be made by applying poultry manure along with chemical fertilizers. Besides improving soil physical properties, poultry manure is a good source of major and micro plant nutrients. The beneficial response of poultry manure to

yield might also be attributed to the better availability of plant nutrients throughout the growth period (Singh and Mishra, 1986). The incorporation of organic manure in soil and its successive decomposition enabled the onion to ensure on almost continuous supply of nutrients efficiently synchronizing with crop requirements. The considerable mineralization of NPKS as a consequence of organic manure application may be attributed to any of the following reasons.

1. The organic acids and CO₂ (formed during the decomposition of organic matter of the soil as well as added organic materials) has solubilization effect on iron, aluminium, magnesium and calcium phosphate.
2. The NPKS contained in the organic matter of the soil or the one added from external sources is liberated upon decomposition.
3. Organic anions and hydroxy ions, such as tartaric, citric, malic and malic acids liberated during decomposition of organic matter or organic manures may complex or chelate iron, aluminium and prevent them from reacting with NPK ions specially phosphate ions or prevent reversion to unavailable forms.

Similar results were reported by Bagali *et al.* (2012), Choudhary *et al.* (2013), Damsc *et al.* (2014) and Kumar *et al.* (2014).

Table 1. Effect of inorganic fertilizers, organic manures and bio-fertilizers on neck thickness, number of scales per bulb, fresh weight of bulb and bulb yield

Treatments	Neck thickness (cm)	Number of scales per bulb	Fresh weight of bulb (g)	Bulb yield (q ha ⁻¹)
Inorganic fertilizers				
F ₀ (0% RD of NPKS)	0.85	6.64	40.20	186.10
F ₁ (75% RD of NPKS)	1.00	7.34	64.84	300.18
F ₂ (100% RD of NPKS)	1.03	7.47	65.88	305.00
SEm±	0.01	0.07	0.76	3.12
CD (P=0.05)	0.03	0.19	2.19	8.96
Organic manures				
M ₀ (Control)	0.75	6.63	43.02	199.17
M ₁ (FYM 20 t ha ⁻¹)	1.04	7.32	62.00	287.03
M ₂ (Poultry Manure 5 t ha ⁻¹)	1.08	7.49	65.90	305.08
SEm±	0.01	0.07	0.76	3.12
CD (P=0.05)	0.03	0.19	2.19	8.96
Bio-fertilizers				
B ₀ (No-inoculation)	0.89	6.62	43.64	202.05
B ₁ (PSB inoculation)	0.96	7.26	59.93	277.47
B ₂ (<i>Azospirillum</i> inoculation)	0.97	7.27	60.44	279.81
B ₃ (PSB + <i>Azospirillum</i> inoculation)	1.02	7.46	63.87	295.71
SEm±	0.01	0.07	0.73	3.51
CD (P=0.05)	0.04	0.18	2.04	9.81

Table 2. Interactive effects of inorganic fertilizers and organic manures on fresh weight of bulb (g)

Treatments	M ₀ (Control)	M ₁ (FYM 20 t ha ⁻¹)	M ₂ (Poultry Manure 5 t ha ⁻¹)	Mean
F ₀ (0% RD of NPKS)	30.34	43.75	46.50	40.20
F ₁ (75% RD of NPKS)	48.96	70.56	75.00	64.84
F ₂ (100% RD of NPKS)	49.76	71.69	76.19	65.88
Mean	43.02	62.00	65.90	
SEm±	1.32			
CD (P=0.05)	3.79			

Table 3. Interactive effects of inorganic fertilizers and organic manures on bulb yield (q ha⁻¹)

Treatments	M ₀ (Control)	M ₁ (FYM 20 t ha ⁻¹)	M ₂ (Poultry Manure 5 t ha ⁻¹)	Mean
F ₀ (0% RD of NPKS)	140.46	202.54	215.30	186.10
F ₁ (75% RD of NPKS)	226.67	326.67	347.21	300.18
F ₂ (100% RD of NPKS)	230.37	331.88	352.74	305.00
Mean	199.17	287.03	305.08	
SEm±	5.41			
CD (P=0.05)	15.52			

References

- Ange, A. 1993. Integrated plant nutrition system on farm and soil fertility management The major concepts. Regional office for Asia and Pacific (RAPA), Bangkok publication, 13: 47-76.
- Bagali, A.N., Patil, H.B., Chimmad, V.P., Patil, P.L. and Patil, R.V. 2012. Effect of inorganics and organics on growth and yield of onion (*Allium cepa* L.). *Karnataka Journal of Agricultural Sciences*, 25(1): 112-115.
- Balai, R.P. 2002. Response of mungbean [*Vigna radiata* (L.) Wilzeck] to phosphorus and bacterial culture in loamy sand. M.Sc. (Ag.) Thesis, RAU, Bikaner.
- Biswas, D.R., Ali, S.A. and Khera, M.S. 1995. Response of gobhi sarson (*Brassica napus* L., ISN-706) to N and S. *J. of the Ind. Soc. of Soil Sci.*, 43: 220-223.
- Bose, T.K., Som, M.G. and Kabir, J. 1989. Bulb crops. In: Vegetable crops of India. Naya Prakash, Calcutta, 10: 545-579.
- Brar, B.S. and Pastricha, M.S. 1998. Long term studies on integrated use of organic and inorganic fertilizer in soil of Punjab. In Long Term Soil Fertilizer Management Through Integrated Plant Nutrient Supply System, IIS-Bhopal, pp-168.
- Choudhary, B.S., Soni, A.K. and Khaswan, S.L. 2013. Growth, yield and quality of garlic (*Allium sativum* L.) as influenced by different nutrient management practices. *Annals of Agricultural Research*, 34(3): 210-213.
- Damse, D.N., Bhalekar, M.N. and Pawar, P.K. 2014. Effect of integrated nutrient management on growth and yield of garlic. *The Bioscan*, 9(4): 1557-1560.
- Jana, B.K., Jahangir, K. and Kabir, J. 1990. Effect of sulphur on growth and yield of onion cv. Nasik Red. *Crop Research*, 3(2): 241-243.
- Kumar, A., Singh, B., Kumar, D., Kumar, P., Kumar, T., Kumar, S. and Goswami, A. 2014. Effect of balanced fertilizer and planting techniques on growth and yield of garlic (*Allium sativum* L.). *Annals of Horticulture*, 7(2): 123-128.
- Maheswarappa, N.P., Nan, H.V. and Hegde, M.R. 1999. Influence of organic on yield of arrow root, soil physical, chemical and biological properties when grown as inter crop in coconut garden. *Annals of Agricultural Research*, 20: 318-323.
- Meena, A.K., Paliwal, R., Meena, K.K. and Singh, S.P. 2015. Effect of organic manures and bio-fertilizers on yield attributes and economics of kharif onion (*Allium cepa* L.) in semi-arid region. *Ind. Res. J. Genet. and Biotech.*, 7(2): 259-261.
- Meena, R.N., Verma, V.K. and Singh, K. 2014. Effect of organic nitrogen management on yield, quality, economics and nutrient uptake of onion (*Allium cepa* L.). *Int. J. of Innov. Res. in Sci. Eng. & Tech.*, 3(12): 18323-18331.
- Panse, V.G. and Sukhatme, P.V. 1985. Statistical methods for agricultural workers. Fourth Enlarged Edition, ICAR publication, New Delhi.
- Sharma, O.L., Katole, N.S. and Gautam, K.M. 1994. Effect of

- irrigation schedules and nitrogen levels on bulb yield and water use by onion (*Allium cepa* L.). *Agri. Sci. Dig., Karnal*, 14: 15-18.
- Sharma, R.P. 1992. Effect of planting material, nitrogen and potash on bulb yield of rainy season onion (*Allium cepa* L.). *Ind. J. of Agro.*, 37(4): 868-869.
- Sharma, S. 2014. Effect of Integrated Nutrient Management on growth, yield and quality of *kharif* onion (*Allium cepa* L.). M.Sc. (Ag.) Thesis, SKRAU, Bikaner.
- Singh, A.K. 2000. Effect of nitrogen and potash on bulb yield of onion. *National Symposium on onion garlic production and post harvest management. Challenges and Strategies*. NHRDF Nasik Nov., 19-21st, 2000. pp-200.
- Singh, H. and Mishra, B. 1986. Kinetics of pyrite oxidation in relation to solubilization of rock phosphate in neutral soil. *J. Ind. Soc. Soil Sci.*, 34: 52-55.
- Singh, R.S. and Ram, H. 1982. Effect of organic matter on the transformation of inorganic phosphorus in soils. *J. Ind. Soc. Soil Sci.*, 30: 185-189.
- Singh, V. and Singh, R.M. 1974. Changes in physico-chemical properties of soil as affected by organic manures. *J. Agri. & Sci. Res.*, 16: 22-27.
- Somani, L.L., Bhandari, S.C., Sexena, S.N. and Gulati, I.J. 1990. Phospho microorganism In: *Bio-fertilizers*. Eds. Somani, L.L., Bhandari, S.C., Sexena, S.N. and Vyas, K.K. 271-290.
- Subbian, K. 1994. Effect of N, P and bio-fertilizers on yield and nutrient uptake in chilli and bellary onion. *Madras Agricultural Journal*, 81: 277-279.
- Tilak, K. V.B.R. and Annapurna, K. 1993. Bacterial fertilizers. *Proc. Ind. Nat. Acad. Sci.*, B-59 (3&4): 315-324.
- Yadav, D.K., Paliwal, R. and Yadav, B.L. 2008. Effect of inorganic, organic fertilizers and bio-fertilizers on yield and yield attributes of *rabi* onion (*Allium cepa* L.). *Haryana J. Hort. Sci.*, 37(1&2): 128-129.
- Zarate, N.A.H., Vieira, M., Doc. and Cahecas, J.O. 1997. Lettuce yield as affected by rates and method of application of semi decomposed poultry manure. *Horticulture Btassilarians*, 15: 65-67.

Effect of age of seedlings and plant hormones on quality and bolting in onion (*Allium cepa* L.)

Desh Raj Choudhary*, Satesh Kumar and Sonam Spaldon
Division of Vegetable Science and Floriculture, SKUAST, Jammu-180 009 (J&K)

*Corresponding Author's e-mail : desraj1992@gmail.com

(Received: 17.09.2015; Accepted: 14.12.2015)

Abstract

In the present investigation the response of 6, 8 and 10 week old seedlings of onion cv. N-53 was studied along with foliar application of Cycocel (500 & 1000ppm), Ethephon (2000 & 2500ppm) and Paclobutrazol (1000 & 2000ppm) in factorial RBD replicated thrice during Rabi season of 2014-2015 at Division of Vegetable Science and Floriculture, SKUAST, Jammu. The results showed maximum equatorial diameter of bulbs (6.11cm) and TSS (9.63°B) in 8 week old seedlings. Minimum bolting was recorded in 8 week old seedlings (16.99%) which was statistically superior to 10 and 6 week old seedlings. Significantly higher days to first bolt was observed in 8 week old seedlings (99.71 days) over 10 and 6 week old seedlings (96.19 and 77.76 days), respectively. It is evident from the results; application of Paclobutrazol 2000ppm recorded the maximum equatorial diameter of bulbs (5.79cm) and TSS (9.49°B) along with lowest bolting (35.99%) up to 97.22 days after transplanting. Interactive results between seedling age and plant hormones showed maximum equatorial diameter of bulbs (6.80cm), TSS (11.50°B) and lowest bolting (9.64%) in the treatment having 8 week old seedlings with Paclobutrazol 2000 ppm (A_2P_2). Seedlings of 8 week old attained A* (5.70%) and A grade (15.00%) bulbs recovered along with other marketable grades like B (45.00%) and C (28.00%). While the seedlings aged 6 and 10 week old could not attain bulbs of A* and A grade bulbs. The storage studies also pointed out minimum rotting (72.20%) and total weight loss (70.00%) in this treatment.

Key words: Onion, Seedling age, Plant hormones, Total soluble solids (TSS), Bolting.

Introduction

Onion (*Allium cepa* L.) $2n=2x=16$, is an important bulb crop and belongs to Alliaceae family. In recent years it has gained the importance of a cash crop because of its very high export potential. Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Bihar, Gujarat, Haryana, Rajasthan, Uttar Pradesh, Tamil Nadu and Odisha are the major onion growing states of the country. Its cultivation is highly technical and depends on environmental conditions such as photoperiod and temperature (Steer, 1980). The factors like improper nitrogen fertilization, seedling age at the time of transplanting, hormonal imbalance of the plant, etc. also affect the yield of onion. During early growth and development, onion requires cool temperature (6-20°C), but during bulb initiation and development, warmer temperature (25-27°C) is required (Ansari, 2007).

Pre-initiation of inflorescence axis prior to bulb development referred as bolting, is one of the serious problem challenging onion cultivation round the world. The hollow stalk represents a single internode, elongating out of the innermost leaf base. Flower initiation however occurs only after the emergence of certain number of leaves, depending on cultivar followed by exposure of the plant to extreme temperature (Brewster, 1985). Plant hormones play an interesting role in modern agriculture to improve and accelerate physiological processes of plants (Ashraf *et al.*, 2010). Relatively slow growth and early cessation of cell

elongation are the characteristics that can be directly linked to scape formation. Their role as anti-gibberellins (Ouzounidou *et al.*, 2010) can be utilized in various growth process in onion such as bulbing (Levy *et al.*, 1973), bolting (Izquierdo and Corgan, 1980) and senescence (Levy *et al.*, 1972). Keeping in view the economic importance of bolting in onion, the present investigation was intended to determine the relationship of seedling age and exogenous application of plant hormones (growth inhibitors) on quality and floral initiation (bolting).

Materials and Methods

The present study was conducted at Vegetable Research Farm, Division of Vegetable Science and Floriculture, SKUAST, Chatha, Jammu (J&K) situated at 33°55'N latitude and 74°58' East longitude with altitude of 296 meter above mean sea level during Rabi season of 2014-2015. The experiment was laid out in factorial randomized block design (RBD) with three replications comprising of three seedling age (6, 8 and 10 week old) and seven plant hormonal treatments viz., Cycocel 500 ppm (C_1), Cycocel 1000 ppm (C_2), Ethephon 2000 ppm (E_1), Ethephon 2500 ppm (E_2), Paclobutrazol 1000 ppm (P_1), Paclobutrazol 2000 ppm (P_2) and Control-distilled water spray (C_0). Transplanting was done at a spacing of 15cm between rows and 10cm between plants in 2.25x2.0m sized plots accommodating 300 plants per plot. Fertilization, other cultural practices and need based plant protection measures were followed as recommended for

commercial production. Three consecutive spray of each plant hormone was made in the morning hours at critical phases of onion i.e. 30 days after transplanting (at thermo phase), 60 days after transplanting (at competition phase) and 90 days after transplanting (at completion phase).

The data were recorded on ten randomly selected bulbs from each replication for equatorial diameter (cm), bulb grade by equatorial diameter (%) and TSS ($^{\circ}$ Brix). Equatorial diameter of bulbs was measured with the help of digital vernier calliper and calculated on the basis of the bulb grade (%) and equatorial diameter. Bulbs were graded in five grades based on equatorial diameter viz., A* (>6.5cm), A (5.5-6.5cm), B (4.5-5.5cm), C (3.5-4.5cm) and D (<3.5cm). The bulbs of D grade were regarded as unmarketable including diseased and rotten bulbs. The TSS of extracted juice was determined by a hand refractometer (RHB-62 Model). After proper curing of bulbs, 1.0kg bulbs of each treatment were kept in plastic bags under room conditions ($27\pm5^{\circ}\text{C}$) for 25 days after harvest (DAH). After every two weeks, bulbs were noticed for rotting, sprouting and physiological loss in weight and subsequently removed. The readings for shelf life of bulbs continued for eight weeks till the bags showed >80% physiological losses of weight (PLW) and rotting of the bulbs. Total number of plants per plot showing emergence of flower stalk were counted and divided by the number of established plants in each plot and the percentage bolting was calculated. The date on which 50% of the plants showed bolting was recorded and the days were calculated from the date of transplanting to find out days to 1st bolt. The recorded data were averaged and statistically analysed (Steel and Torrie, 1981) using the statistical programme developed by O.P. Sheoran.

Results and Discussion

The influence of seedling age, plant hormones and their interaction on different attributes has been given in Table 1. Maximum equatorial diameter of bulbs was recorded in 8 week old seedlings (6.11cm) which was statistically superior to 10 and 6 week old seedlings (5.30 and 3.42cm). Likewise, the maximum TSS was observed in 8 week old seedlings (9.63°B) which was significantly higher over 10 and 6 week old seedlings (8.22°B and 6.90°B), respectively. Seedling age showed a varied trend which statistically differed for bolting phenomenon in onion. Maximum bolting was recorded in 6 week old transplants (85.05%) which were statistically higher to the percentage recorded in 8 and 10 week old transplants. Minimum bolting was however recorded in 8 week old seedlings (16.99%) which was statistically superior to other respective ages i.e. 10 and 6 week old seedlings. Significantly higher days to first bolt was observed in 8 week old seedlings (99.71 days) over 10 and 6 week old seedlings (96.19 and 77.76 days), respectively. Probable reason of high bolting in 6 week old seedlings might be that in the thermo-phase stage the plants were exposed to temperature ranging between $17-29^{\circ}\text{C}$ which inhibit all the category of seedlings to show transition i.e., from vegetative to generative stage. As the diurnal temperature decreased 7 to 3°C during night and 3 to 4°C

during day, marked transition was recorded in those seedlings that observed short juvenile phase as in 6 week old seedling (119 days from sowing date to 1st bolt) with leaf number varying from 6 to 8. Therefore, it can be inferred that the factor responsible for bolting is the length of the juvenile phase and the corresponding optimum temperature. Similar findings have also been reported by Singh and Chaure (1999).

Exogenous application of plant hormones at various concentrations also significantly influenced the quality traits of onion. Application of Paclobutrazol at both 1000ppm and 2000ppm was found statistically superior in comparison to Ethephon treatments. Maximum equatorial diameter of bulbs was recorded with Paclobutrazol 2000ppm (5.79cm) which was statistically higher than rest of the treatments. Reduction in equatorial diameter of bulb due to exogenous application of growth inhibitors might be due to restricted growth and less nutrient conception that might have resulted in low carbohydrate synthesis by the plant (Deore and Bharud, 1990 and Hye *et al.*, 2002). Application of Paclobutrazol at 1000ppm and 2000ppm has significant effect on TSS of bulbs whereas other hormonal treatments either increased or decreased it non-significantly over the control. Maximum TSS (9.49°B) was recorded with Paclobutrazol 2000ppm which was statistically higher than rest of the treatments but at par with its lower concentration i.e. 1000ppm. Increase in TSS content due to Paclobutrazol might be due to the efficiency of this chemical to control bolting percentage of the bulbs and accumulate higher initial food reserve in the bulbs leading to higher soluble content (Arvin and Banakar, 2002).

As evident from table 1 that application of Paclobutrazol 2000 ppm recorded lowest bolting (35.99%) which was found statistically superior to rest of the treatments including control except Paclobutrazol 1000 ppm and Ethephon 2500 ppm. The treatments involving application of Cycocel at 500 ppm as well as 1000 ppm increased bolting in the plants (47.61% and 52.41%) as compared to control (46.12%). Further, the application of Paclobutrazol 2000ppm was found statistically superior to inhibit bolting upto 97.22 days after transplanting which was found at par with its lower concentration i.e. 1000ppm (94.33 days) and Ethephon 2500ppm (95.44 days). Application of Cycocel at both the concentrations (500 ppm and 1000 ppm), recorded 1st bolt at an earlier date i.e., 87.89 and 82.67 days after transplanting as compared to rest of the treatments and control (89.56 days). The reason for such response of growth retardants might be due to the active movement of these inhibitors from the leaves into the bulb tissues at the time of bulb maturity thereby lowering down GA₁ levels, responsible for transition from vegetative to reproductive stage (Kielak and Bielinska-Czarnecka, 1987).

Seedling age and various concentrations of plant hormones revealed significant interaction for equatorial diameter of bulbs. Maximum equatorial bulb diameter (6.80cm) was recorded with Paclobutrazol 2000ppm on 8 week old seedlings (A₂P₂) which was at par with Cycocel 500ppm (A₂C₁), Cycocel 1000ppm (A₂C₂) and Paclobutrazol

Table 1. Effect of different seedling age and plant hormones on quality and bolting of onion

Treatments	Equatorial diameter (cm)	TSS (°B)	Bolting (%) [*]	Days to 1 st bolt ^{**}
Seedling age (in weeks)				
A ₁ (6 week old)				
A ₂ (8 week old)	3.42	6.90	85.05 (67.60)	77.76 (8.87)
A ₃ (10 week old)	6.11	9.63	16.99 (23.82)	99.71 (10.03)
SEm ⁺	5.30	8.22	27.77 (31.60)	96.19 (9.85)
CD (P=0.05)	0.09	0.20	1.10	1.20
Plant hormones (ppm)	0.25	0.58	3.16	3.43
C ₁ (Cycocel 500ppm)				
C ₂ (Cycocel 1000ppm)	4.88	8.25	47.61 (44.12)	87.89 (9.41)
E ₁ (Ethephon 2000ppm)	5.17	8.53	52.41 (47.93)	82.67 (9.13)
E ₂ (Ethephon 2500ppm)	4.52	7.61	42.53 (40.59)	91.44 (9.60)
P ₁ (Paclobutrazol 1000ppm)	4.38	7.20	39.98 (38.59)	95.44 (9.80)
P ₂ (Paclobutrazol 2000ppm)	5.34	9.00	38.26 (37.29)	94.33 (9.74)
C ₀ (Control-Distilled water spray)	5.79	9.49	35.99 (35.42)	97.22 (9.88)
SEm ⁺	4.50	7.69	46.12 (43.10)	89.56 (9.50)
CD (P=0.05)	0.13	0.31	1.69	1.83
Interaction	0.37	0.89	4.82	5.24
A ₁ C ₁				
A ₁ C ₂	3.24	7.47	86.33 (70.00)	76.33 (8.79)
A ₁ E ₁	3.96	7.67	94.33 (76.28)	71.67 (8.52)
A ₁ E ₂	3.10	6.47	85.33 (67.47)	79.67 (8.98)
A ₁ P ₁	2.97	5.95	81.67 (64.71)	81.00 (9.05)
A ₁ P ₂	3.43	7.07	80.67 (63.97)	78.00 (8.88)
A ₁ C ₀	3.98	7.40	79.00 (62.70)	80.00 (8.98)
A ₂ C ₁	3.27	6.27	86.00 (68.06)	77.67 (8.87)
A ₂ C ₂	6.23	9.26	21.76 (27.50)	97.33 (9.91)
A ₂ E ₁	6.30	9.34	25.32 (29.74)	90.67 (9.57)
A ₂ E ₂	5.83	8.80	16.64 (23.92)	98.33 (9.97)
A ₂ P ₁	5.73	8.53	14.12 (21.72)	105.00 (10.29)
A ₂ P ₂	6.53	11.17	11.20 (19.48)	105.33 (10.31)
A ₂ C ₀	6.80	11.50	9.64 (17.61)	109.00 (10.50)
A ₃ C ₁	5.33	8.83	20.27 (26.74)	92.33 (9.66)
A ₃ C ₂	5.17	8.02	32.73 (34.84)	90.00 (9.53)
A ₃ E ₁	5.25	8.58	37.57 (37.75)	85.67 (9.31)
A ₃ E ₂	4.63	7.56	25.63 (30.38)	96.33 (9.86)
A ₃ P ₁	4.44	7.11	24.15 (29.33)	100.33 (10.06)
A ₃ P ₂	6.07	8.77	22.90 (28.43)	99.67 (10.03)
A ₃ C ₀	6.60	9.97	19.33 (25.95)	102.67 (10.18)
SEm ⁺	4.91	7.97	32.10 (34.49)	98.67 (9.98)
CD (0.05)	0.23	0.54	2.92	3.17
CV (%)	0.65	NS	NS	NS
	7.90	10.80	11.70	6.0

^{*}Figures given in the parenthesis denote the angular transformed values.

^{**}Figures given in the parenthesis denote the square root transformed values.

Table 2. Effect of seedling age and plant hormones on bulb grade (%) by equatorial diameter of onion

Treatment	A ⁺ (>6.5cm)	A (5.5-6.5cm)	B (4.5-5.5cm)	C (3.5-4.5cm)	D (<3.5cm)*
			24.3	65.4	10.3
A ₁ C ₁	-	-	13.3	54.0	32.7
A ₁ C ₂	-	-	26.7	48.7	24.6
A ₁ E ₁	-	-	22.0	58.0	20.0
A ₁ E ₂	-	-	19.5	70.5	10.0
A ₁ P ₁	-	-	40.0	47.3	12.7
A ₁ P ₂	-	-	33.7	41.0	25.3
A ₁ C ₀	-	-	23.04	56.30	20.66
Mean	-	-	50.0	30.0	5.0
A ₂ C ₁	-	15.0	57.0	25.0	6.0
A ₂ C ₂	-	12.0	50.0	27.0	5.0
A ₂ E ₁	-	18.0	50.0	12.2	3.5
A ₂ E ₂	11.0	23.3	50.0	20.7	4.0
A ₂ P ₁	12.0	13.3	36.7	15.0	3.0
A ₂ P ₂	15.3	30.0	32.3	20.0	17.7
A ₂ C ₀	6.7	23.3	45.0	28.0	6.31
Mean	5.7	15.0	53.0	35.7	11.3
A ₃ C ₁	-	-	54.7	25.3	20.0
A ₃ C ₂	-	-	58.4	24.3	17.3
A ₃ E ₁	-	-	53.3	31.4	15.3
A ₃ E ₂	-	-	57.7	32.7	9.6
A ₃ P ₁	-	-	53.4	38.3	8.3
A ₃ P ₂	-	-	65.3	10.0	24.7
A ₃ C ₀	-	-	61.8	23.0	15.2
Mean	-	-			

*Unmarketable bulbs including diseased and rotten bulbs.

Table 3. Effect of seedling age and plant hormones on shelf life of bulbs (days)

Treatments	No. of bulbs stored at 25 DAH	40 DAH		55 DAH		70 DAH		85 DAH		Total loss (%)	
		Rotting (No.)	PLW (g)	Rotting (No.)	PLW (g)	Rotting (No.)	PLW (g)	Rotting (No.)	PLW (g)	Rotting	PL W
A ₁ C ₁	33	10	300	5	150	7	210	11	340	100	100
A ₁ C ₂	27	8	240	9	270	4	120	6	370	100	100
A ₁ E ₁	34	9	270	7	250	13	350	5	130	100	100
A ₁ E ₂	33	11	330	7	210	12	360	3	100	100	100
A ₁ P ₁	32	12	360	2	60	6	180	12	400	100	100
A ₁ P ₂	27	8	240	4	120	5	210	10	430	100	100
A ₁ C ₀	32	14	420	2	60	8	300	8	220	100	100
Mean	31.14	10.29	308.57	5.14	160.00	7.86	247.10	7.86	284.30	100	100
A ₂ C ₁	15	4	280	2	140	2	140	4	184	80	74.4
A ₂ C ₂	16	5	315	3	189	2	126	4	112	87.5	74.2
A ₂ E ₁	13	3	237	3	237	4	296	2	178	92.3	94.8
A ₂ E ₂	13	4	320	3	240	4	320	2	80	100	96
A ₂ P ₁	15	5	335	3	201	2	134	3	134	73.3	80.4
A ₂ P ₂	11	3	210	2	140	1	70	2	280	72.2	70
A ₂ C ₀	12	4	320	6	160	3	240	1	80	83.3	80

Mean	13.57	4	288.14	3.14	186.70	2.57	189.40	2.57	149.70	84.1	81.4
A ₃ C ₁	17	5	305	2	122	3	183	5	305	88.2	91.5
A ₃ C ₂	13	3	225	3	255	5	345	1	75	92.3	90
A ₃ E ₁	17	5	375	2	150	2	150	6	265	88.2	94
A ₃ E ₂	16	6	480	4	320	2	100	3	80	93.8	98
A ₃ P ₁	15	2	136	4	272	2	136	5	340	86.7	88.4
A ₃ P ₂	14	2	146	2	146	5	365	3	219	85.7	87.6
A ₃ C ₀	16	3	189	3	189	4	252	4	252	87.5	88.2
Mean	15.42	3.71	265.14	2.86	207.70	3.29	218.70	3.86	219.40	88.9	90.7

DAH-Days After Harvest; PLW-Physiological Losses in weight (g).

1000ppm (A₃P₁). However, the interaction effect between seedling age and plant hormones showed non-significant results for TSS, bolting and days to 1st bolt.

Data presented in Table 2 revealed that 6 and 10 week old seedlings could not attain A⁺ and A grade bulbs, while in 8 week old seedlings, bulbs of A⁺ grade (5.70%) and A grade (15.00%) were recovered along with other marketable grades like B (45.00%) and C (28.00%). The least unmarketable yield (D grade) of 6.31% was also recovered from 8 week old seedlings. Minimum percentage (3.00%) of unmarketable bulbs (D grade) was recorded in 8 week old seedling sprayed with Paclobutrazol 2000ppm with maximum A⁺ grade (15.30%) and A grade (23.30%). However, maximum percentage (32.70%) of unmarketable bulbs (D grade) was recorded in 6 week old seedlings sprayed with Cycocel 1000ppm with no A and A⁺ grades.

Shelf life of bulbs as influenced by various plant hormones and age of the seedling (Table 3) showed maximum shelf life in 8 week old seedlings where 81.4% physiological loss in (PLW) weight alongwith 84.1% rotting of the bulbs under ambient storage for eight weeks (April to June) was recorded. Among various treatment combinations, the maximum shelf life with respect to rotting and physiological loss in weight (72.2% rotting and 70% PLW) was observed in 8 week old seedlings applied with Paclobutrazol 2000ppm (A₃P₂) as compared to control (83.3% rotting and 80% PLW). The probable reason of increased shelf life in Paclobutrazol treatments can be attributed to enhance bulb proteins and sugars as reported by Arvin and Banakar (2002).

References

- Ansari, N.A. 2007. Effect of density, cultivars and sowing date on onion sets production. *Asian Journal of Plant Science*, 6: 1147-1150.
- Arvin, M. J. and Banakar, M. H. 2002. Effects of plant growth regulators on bolting and several traits of onion (*Allium cepa* L.) cv. Texas Early Grano. *Journal of Science and Technology of Agriculture and Natural Resources*, 6(1): 59-70.
- Ashraf, M., Akram, N.A., Arteca, R.N. and Foolad M.R. 2010. The physiological, biochemical and molecular roles of brassinosteroids and salicylic acid in plant processes and salt tolerance. *Critical Reviews in Plant Sciences*, 29(3): 162-190.
- Brewster, J.L. 1985. The influence of seedling size and carbohydrate status and of photon flux density during vernalization on inflorescence initiation in onion (*Allium cepa* L.). *Annals of Botany*, 55:403-414.
- Deore, B.P. and Bharud, R.W. 1990. Growth yield and storability of fenugreek as influenced by foliar spray of growth substances. *Journal of Maharashtra Agriculture University*, 15:208-210.
- Hye, A. Md., Haque, S. Md and Karim, A. Md. 2002. Influence of growth regulators and their time of application on yield of onion. *Pakistan Journal of Biological Sciences*, 5(10):1021- 1023.
- Izquierdo, J. and Corgan, J.N. 1980. Onion plant size and timing for ethephon induced inhibition of bolting. *Journal of the American Society for Horticultural Science*, 105(1): 66-67.
- Kielak, E. and Bielinska-Czarnecka, M. 1987. Effects of length of drying on hormone activity in onion (*Allium cepa* L.) during storage. *Proceedings of the IV International Symposium of Plant Growth Regulators*, 1:155-159.
- Levy, D., Kedar, N. and Karacine, R. 1973. Effect of ethephon on bulbing of onion under noninductive photoperiod. *Hort Science*, 8: 228-229.
- Levy, D., Ventura, J. and Kedar, N. 1972. Effect of ethephon on seedstalk growth and seed yield of onion. *Hort Science*, 7: 470-471.
- Ouzounidou, G., Papadopoulou, P., Giannakoula, A. and Ilias, I. 2010. Comparative study on the effects of various plant growth regulators on growth, quality and physiology of *Capsicum annuum* L. *Pakistan Journal of Botany*, 42: 805-814.
- Singh, J. and Chaur, N.K. 1999. Effect of age of seedlings and nitrogen levels on growth and yield of onion (*Allium cepa* L.). *Advances in Horticulture and Forestry*, 6:73-77.
- Steel, G.D. and Torrie, J.H. 1981. Principle and Procedure of Statistics: A Biochemical Approach. Auckland, McGrawhill. pp. 32-36.
- Steer, B.T. 1980. The bulbing response to day length and temperature of some Australasian cultivars of onion (*Allium cepa* L.). *Australian Journal of Agricultural Research*, 31: 511-518.

Management of *Alternaria* leaf blight of *Mateera* (watermelon) by fungicides, bio-agents and botanical

S. K. Maheshwari*, B. R. Choudhary, D. Singh, B. D. Sharma and S. K. Sharma
ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner 334 006 (Rajasthan)

*Corresponding author e-mail: maheshwariskciah@gmail.com

(Received: 11.09.2015; Accepted: 4.02.2016)

Abstract

The field trials were conducted for management of *Alternaria* leaf blight (*Alternaria cucumerina* var. *P. watermelon*) in *mateera* (watermelon) by fungicides, bio-agents and botanical during summer season of 2013 and 2014 at Plant Pathology Block of ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan). Three fungicides (copper oxychloride, carbendazim and mancozeb), four bio-agents (*Aspergillus niger*, *Pseudomonas fluorescens* CIAH-196, *Trichoderma viride* CIAH-240 and *Trichoderma viride* Non-Resistant) and one botanical such as onion leaf extract were taken for the study. Disease incidence and disease severity of *Alternaria* leaf blight in *mateera* ranged from 10.0 to 34.17% and 8.88 to 29.01%, respectively. Among nine treatments, one foliar spray of mancozeb (0.25%) proved the most effective fungicide for the management of this disease in *mateera* under field conditions with the minimum disease incidence (10.0%) and disease severity (8.88%) and the maximum disease control (69.39%). Further, next best treatment was *Trichoderma viride* CIAH-240 (5%). However, the maximum disease incidence (34.17%) and disease severity (29.01%) were observed in control followed by onion leaf extract (5%) with disease incidence (27.85%), disease severity (24.34%) and the minimum disease reduction (16.09%).

Key words: *Alternaria* leaf blight, *mateera* (watermelon), bio-agents, botanical, fungicides, management

Introduction

Watermelon [*Citrullus lanatus* (Thunb) Mansf.] is a popular desert crop throughout the tropics and the Mediterranean regions of the world. Presently, it is not only a summer season fruit but also becoming an everyday fruit like apples and bananas. The fruits are rich source of B-carotene, vitamin B, C and E, minerals (K, Mg, Ca and Fe), citrulline amino acid and phenolics. Watermelon is also known as *Tarbooj* in some parts of India and *Mateera*, particularly in Rajasthan. *Mateera* is drought hardy landraces crop (Anon., 2003). It is an indigenous type of watermelon and is extensively grown with mixed cropping on sand-dunes landscape in Thar desert. *Mateera* fruits are attributed to sweet and refreshing edible flesh (pulp) and consumed fresh and have juicy properties.

Mateera is subjected to attack of a number of bacterial, viral and fungal diseases, which inflict heavy damage to the crop every year. Among the fungal diseases, *Alternaria* leaf blight incited by *Alternaria cucumerina* (Ell. & Ev.) Elliot is an important disease in Rajasthan as well as major watermelon growing states of India. In India, the disease was first reported by Khandelwal and Prasada (1970) on watermelon from Jobner (Rajasthan), where it occurs almost every year. This disease is found to cause serious losses in watermelon production throughout the Rajasthan (Prasada *et al.*, 1973). Yield losses due to the leaf necrosis and foliage loss are variable according to the type of cucurbitous crop and its susceptibility, reaching at 80% on pumpkins and 88% on watermelons in India (Bhargava and Singh, 1985). Characteristic disease symptoms first appear on foliage as

small circular spots. These spots expand to form large reddish brown spots with a concentric ring. This disease needs regular monitoring for evolving effective management strategies. Attempts have been made to manage *Alternaria* leaf blight of *mateera* through application of fungicides, bio-agents and botanical as foliar spray. Keeping in view, the above facts, the present investigation was undertaken to study the efficacy of fungicides, bio-agents and botanical for management of this disease under hot arid conditions of Rajasthan.

Materials and Methods

The field trials were conducted in Randomized Block Design using *mateera* variety 'Thar Manak' with three replications at Plant Pathology Block of ICAR-Central Institute for Arid Horticulture, Bikaner (Rajasthan) in the last week of February of 2013 and 2014. The row to row and plant to plant distance were maintained 2.0 m x 0.50 m. Infected leaves of *mateera* were collected from Plant Pathology Block of this Institute. Small bits with typical disease symptoms along with healthy tissues were cut with the help of sterile blade, surface sterilized with 0.1% mercuric chloride for 30 seconds followed by three washing with sterilized water and plated aseptically in the petri plates containing Potato Dextrose Agar (PDA) medium and incubated at $25 \pm 2^\circ\text{C}$ in BOD incubator for seven days. Fungus was isolated and culture was purified by single spore technique as *Alternaria cucumerina* and further maintained on PDA medium. Pathogenicity was done on *mateera* plants by isolating *Alternaria cucumerina* from infected leaves of *mateera*. After 30 days, the plants were artificially inoculated by spraying

spore-cum-mycelial suspension, prepared in sterile water. Leaves were used for inoculation purpose. The inoculated plants were covered with polythene bags for 48 hours to provide sufficient humidity for infection. Disease symptoms were produced in the plant leaves. The reisolation of the pathogen was done. The recommended packages of practices for this crop were adopted.

Three fungicides such as copper oxychloride (0.25%), carbendazim (0.1%) and mancozeb (0.25%), four bio-agents such as *Aspergillus niger*, *Pseudomonas fluorescens* CIAH-196, *Trichoderma viride* CIAH-240 and *Trichoderma viride* Non-Resistant (5% of each bio-agent) and one botanical such as onion leaf extract (5%) were used for management of *Alternaria* leaf blight. One foliar spray of each treatment was given separately on the crop at appearance of the first disease symptoms.

Data on disease incidence and disease severity were recorded on maturity stage of this crop. Disease severity was recorded into rating scale (0- 4) on the basis of leaf area covered by spots (Prasada *et al.* 1973), where 0= Healthy, 1= Trace (1-10% of the leaf area covered by spots), 2= Moderate ((11-20% of the leaf area covered by spots), 3= Severe ((21-30% of the leaf area covered by spots) and 4= Very severe (31% and above of the leaf area covered by spots). Disease incidence was calculated on the basis of per cent plants infected. Total number of plants and number of infected plants by this disease were counted. Disease incidence and disease control were calculated by following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

$$\text{Per cent disease control} = \frac{\text{Disease severity in control} - \text{Disease severity in treatment}}{\text{Disease severity in control}} \times 100$$

The percentage data of 2013 and 2014 for disease incidence and disease severity were converted into angular transformation and pooled data were subjected for statistical analysis (Table 1 & 2).

Results and Discussion

Pooled data of 2013 and 2014 on disease incidence and disease severity were given in the results and all the treatments including fungicides, bio-agents and botanical tested under field conditions reduced the disease incidence as well as disease severity and gave better disease control as compared to control. Disease incidence and disease severity of *Alternaria* leaf blight in *mateera* were found with ranging from 10.0 to 34.17% and 8.88 to 29.01%, respectively (Table 1 & 2). Out of which, one foliar spray of mancozeb (0.25%) was found most effective for the management of *Alternaria* leaf blight of *mateera* *in vivo* with the minimum disease incidence (10.0%), followed by *Trichoderma viride* CIAH-240 (5%) which was differed statistically in case of disease incidence (16.30%) with mancozeb. However, the maximum disease incidence (34.17%) was observed in case of untreated control. The least effective treatment was onion leaf extract (5%) with disease incidence (27.85%), followed by *Pseudomonas fluorescens* CIAH-196 (5%) having 23.60% disease incidence, which was not statistically at par in case of disease incidence with each other against *Alternaria* leaf blight of *mateera* (Table 1).

Pooled data revealed that one foliar spray of mancozeb (0.25%) was also found the most efficient fungicide against *Alternaria* leaf blight of *mateera* with the minimum disease severity (8.88%) and maximum disease control (69.39%), followed by *Trichoderma viride* CIAH-240 (5%)

Table 1. Field efficacy of fungicides, bio-agents and botanical on disease incidence of *Alternaria* leaf blight of *mateera* (pooled data of 2013 and 2014)

S. No.	Treatments	Disease incidence (%) (2013)	Disease incidence (%) (2014)	Pooled data
1.	Copper oxychloride (0.25%)	25.0 (30.00)*	20.0 (26.57)*	22.50 (28.32)*
2.	Carbendazim (0.1%)	20.0 (26.57)	15.0 (22.79)	17.50 (24.73)
3.	Mancozeb (0.25%)	10.0 (18.43)	10.0 (18.43)	10.0 (18.43)
4.	<i>Aspergillus niger</i> (5%)	22.20 (28.11)	23.50 (29.00)	22.85 (28.56)
5.	<i>Pseudomonas fluorescens</i> CIAH-196 (5%)	25.0 (30.00)	22.20 (28.11)	23.60 (29.06)
6.	<i>Trichoderma viride</i> CIAH-240 (5%)	15.0 (22.79)	17.60 (24.80)	16.30 (23.81)
7.	<i>Trichoderma viride</i> CIAH-NR (5%)	17.60 (24.80)	21.10 (27.35)	19.35 (26.10)
8.	Onion leaf extract (5%)	26.30 (30.85)	29.40 (32.83)	27.85 (31.85)
9.	Control	33.33 (35.26)	35.00 (36.27)	34.17 (35.77)
	SE(m)	1.85	2.10	1.42
	CD (p= 0.05)	5.53	6.28	4.08

*Figures in parentheses are angular transformed values for analysis

Table 2. Field efficacy of fungicides, bio-agents and botanical on disease severity of *Alternaria* leaf blight of *mateera* (pooled data of 2013 and 2014)

S. No.	Treatments	Disease severity (%) (2013)	Disease severity (%) (2014)	Pooled data	Disease control (%)
1.	Copper oxychloride (0.25%)	20.70 *(27.06)	22.50 (28.32)*	21.60 (27.69)*	25.54
2.	Carbendazim (0.1%)	17.52 (24.74)	15.70 (23.34)	16.61 (24.05)	42.74
3.	Mancozeb (0.25%)	8.25 (16.69)	9.50 (17.95)	8.88 (17.34)	69.39
4.	<i>Aspergillus niger</i> (5%)	18.77 (25.67)	20.35 (26.81)	19.56 (26.25)	32.57
5.	<i>Pseudomonas fluorescens</i> CIAH-196 (5%)	21.90 (27.90)	24.77 (29.85)	23.34 (28.89)	19.54
6.	<i>Trichoderma viride</i> CIAH-240 (5%)	12.77 (20.94)	11.80 (20.09)	12.29 (20.52)	57.63
7.	<i>Trichoderma viride</i> CIAH-NR (5%)	14.27 (22.19)	14.10 (22.06)	14.19 (22.13)	51.08
8.	Onion leaf extract (5%)	22.77 (28.50)	25.90 (30.59)	24.34 (29.56)	16.09
9.	Control	26.77 (31.16)	31.25 (33.99)	29.01 (32.59)	-
	SE(m)	1.42	0.95	0.87	
	CD (p= 0.05)	4.25	2.86	2.49	

*Figures in parentheses are angular transformed values for analysis

which was not statistically at par in case of disease severity (12.29%) with mancozeb. The bio-agent (*Trichoderma viride* CIAH-240) gave 57.63% disease control. However, the maximum disease severity (29.01%) was appeared in case of control without treatment. The least effective treatment was onion leaf extract (5%) with disease severity (24.34%) and disease control (16.09%), followed by *Pseudomonas fluorescens* CIAH-196 (5%) with 23.34% disease severity and disease control (19.54%), which was found statistically at par against this disease (Table 2).

Prasada *et al.* (1973) reported that *Alternaria* blight caused by *Alternaria cucumerina* in watermelon crop can be effectively controlled with dithane Z-78, followed by dithane M-45 under field conditions. Batta (2003) found that difenoconazole (0.35%) completely inhibited disease-lesion of *Alternaria* leaf spot (*Alternaria cucumerina*) on treated cucumber leaf-discs. Mancozeb (0.2%) was found effective against purple blotch of onion caused by *Alternaria porri* and *Alternaria* spp. causing blights in other crops as reported by several workers (Deshmukh *et al.*, 2007; Pandey *et al.*, 2008; Ilhe *et al.*, 2008). Dushyant *et al.* (2014) found that the minimum disease intensity of early blight of tomato caused by *Alternaria solani* was observed by carbendazim + mancozeb (0.2%), followed by mancozeb (0.2%) in the field. Mane *et al.* (2014) revealed that mancozeb (0.2%) was the most effective fungicide against early blight (*Alternaria solani*) of potato.

Conclusion

However keeping in mind the huge losses caused by *Alternaria* leaf blight, it is advisable to reduce the disease severity in *mateera*/watermelon through foliar spray of

mancozeb (0.25%) under hot arid conditions of Rajasthan. This disease may attain an alarming status and may wreak havoc in *mateera* growing areas if not taken care well in time.

References

- Anonymous, 2003. Annual Report (2002-03), Central Institute for Arid Horticulture, Bikaner (Rajasthan).
- Batta, Y. 2003. *Alternaria* leaf spot disease on cucumber: susceptibility and control using leaf disk assay. *An-Najah University Journal of Research*, 17(2): 269-279.
- Bhargava, A. K. and Singh, R. D. 1985. Comparative study of *Alternaria* blight, losses and causal organisms of cucurbits in Rajasthan. *Indian J. of Mycol. Pl. Pathol.*, 15: 150-154.
- Deshmukh, V. S., Dhruj, I. U. and Chanvan, T. V. 2007. Chemical control of purple blotch (*Alternaria porri*) of onion. *Plant Disease Research*, 22: 34-36.
- Dushyant, Khatri, N. K., Prasad, J. and Maheshwari, S. K. 2014. Efficacy of fungicides against early blight of tomato caused by *Alternaria solani*. *Ann. Pl. Protec. Sci.*, 22 (1): 148-151.
- Ilhe, B. M., Shinde, H. N., Bhalekar, M. N. and Kshirsagar, D. B. 2008. Management of fungal disease complex of tomato. *Journal of Plant Disease Science*, 3 (2): 173-175.
- Khandelwal, G. L. and Prasada, R. 1970. Taxonomy, physiology and control of *Alternaria* leaf spot of watermelon (*Citrullus lanatus*). *Indian Phytopathology*, 23: 32-36.

- Mane, M. M., Lal, A., Zghair, Q.N. and Simon, S. 2014. Efficacy of certain bio-agents and fungicides against early blight of potato (*Solanum tuberosum* L.). *International Journal of Plant Protection*, 7 (2): 433-436.
- Pandey, N. K., Purushottam, Gupta, R. C. and Mishra, R. K. 2008. Management of foliar diseases of onion. Annual Report (2008). National Horticultural

Research and Development Foundation, Nashik (Maharashtra), India.

- Prasada, R., Khandelwal, G. L. and Jain, J. P. 1973. Epidemiology, forecasting and control of *Alternaria* blight of cucurbits. *Proceedings of Indian National Science Academy*, 37: 301-308.

Effect of transplanting dates and crop geometry on growth, quality, yield and profitability of papaya (*Carica papaya* L.) cv. Red Lady-786

R. L. Bhardwaj*, D.K.Sarolia and M.M.Sundaria

*Krishi Vigyan Kendra, Sirohi, Agriculture University, Jodhpur-342304 (Rajasthan) India

*Corresponding author e-mail: rajubhardwaj3@gmail.com

(Received: 30.09.2014; Accepted: 5.06.2015)

Abstract

Field experiments were conducted at four adjoining farmer's field in district Sirohi of Rajasthan during 2012-13 and 2013-14. The experiments comprised of three transplanting dates i.e. first week of March (Temp. 30°C, RH 42%), first week of July (Temp. 35°C, RH 60%), first week of September (Temp. 32°C, RH 70%) and three crop geometries followed were 3m x 3m (1111 plants ha⁻¹), 2m x 2m (2500 plants ha⁻¹), 2.5m x 1.6m (2500 plants ha⁻¹). The experiments were replicated four times in a Randomized Block Design. Results revealed that the maximum seedling survival per cent at 20 DAT (89.30%) and 30 DAT (81.45%) was recorded in T₃ treatment (1st September + 2.5m x 1.6m). The combination of crop geometry of 3m x 3m and transplanting date in first week of March (T₁) resulted maximum plant height (289.61 cm), stem girth (50.76 cm), number of leaves (42.45), number of fruits plant⁻¹ (82.46), highest average fruit weight (1.98 kg) and fruit yield plants⁻¹ (163.28 kg). However, maximum fruit set (57.70 %), fruit retention (75.50 %), yield ha⁻¹ (2372.47 q in two year of experimentation) and quality parameters viz., TSS (11.80°Brix), ascorbic acid (58.35 mg 100g⁻¹ fruit pulp), pulp thickness (3.20 cm), overall quality score of fruit (8.36) and low acidity (1.30%) with highest net return (10.689 lakh ha⁻¹ in two years of experimentation) and benefit: cost ratio (4.54) was found in the combination of crop geometry of 2.5m x 1.6m and transplanting date in first week of March (T₁). This led to lower virus incidence (leaf curl & ring spot virus), sun scald and frost injury symptoms.

Key word: Papaya ring spot virus, Days After Transplanting, crop geometry, diurnal fluctuation, Dates of transplanting

Introduction

Papaya (*Carica papaya* L.) is an important quick growing delicious and nutritious fruit crop. It is not only needed as a fresh fruit but also used for processing of fruits and as vegetable for cooking. It contains high amount of vitamin A, vitamin C and iron (Rashid *et al* 1987). Papaya is available round the year and grown easily in the homesteads as well as large scale farms in India (Bhardwaj *et al* 2013). India leads the world in papaya production with an annual output of about 4.1 million tones. Rajasthan state occupied 9,000 ha area with production 16,010 tones, Sirohi is leading districts in papaya cultivation (Anonymous, 2013). Among gynodiocious varieties, Red Lady is a choicest variety which fetches high price in the market for good shape, size, delicious taste and long self life. Though South Western Rajasthan is naturally blessed with suitable condition for growing papaya, yet the average yield of papaya is not satisfactory compared to many other states in India due to lack of systematic management practices especially adequate spacing on proper plant population per unit area and date of transplanting. However, the availability of cultivable land is decreasing day by day, the solution lies in resorting to maintain proper crop geometry and it not only provides economic use of land but also helps in efficient utilization of resources or inputs (solar energy, water,

fertilizer, pesticides etc.) for higher yield. Because Red Lady variety is a new plant type, as imported hermaphrodite short duration hybrid (F₁) there is an urgent need to find out suitable transplanting dates and crop geometry for higher production, induce mechanization for reduction of labour cost. Optimum crop geometry is one of the important factors for higher production, by efficient utilization of underground resources (plant nutrient and water) and converges maximum solar radiation and in turn better photosynthate formation (Bhardwaj and Agrawal, 2014). Ideal crop geometry was also minimizing the effect of unfavorable climatic condition (Sun scald and frost) and disease incidence on crop. According to bench mark survey report of Sirohi district for papaya cultivation reported that significant increase in papaya fruit yield with cost minimizing by increase row to row spacing upto 2.5 meter for initial weeding by tractor operated cultivator and reduce plant spacing next to 1.6 meter for maintained maximum plant population upto 2500 ha⁻¹ (Bhardwaj *et al* 2013).

Appropriate time of seedling transplanting not only increases the productivity and quality of fruit but also helps in synchronized, uniform growth and development (flowering and fruiting) of plants, reduce weed and disease infection (leaf curl virus and papaya ring spot virus). Enhancing better

growth in plant by providing optimum growing period through manipulation of planting time may offer the most promising approach for increasing production and reducing the virus incidence in papaya (Singh and Singh, 1998). Leaf curl and ring spot virus disease plays havoc in papaya production and there being no effective control measures, the only alternative approach in the absence of virus resistant varieties is to escape the infestation through cultural manipulation, i.e. to avoid the infestation by checking the vector population at its active stage or planting at such a time when vectors are not active (Chadha, 1992).

Information on seedling transplanting dates and crop geometry for production of papaya cv. Red Lady in Rajasthan is lacking and it is desirable to obtain precise information in this aspect. Hence, keeping this in view the present study was undertaken to find out the best time for transplanting and crop geometry for higher yield, quality of fruits and economic returns from papaya cultivation.

Materials and Methods

The effect of transplanting dates and crop geometry on the growth, yield and quality of papaya cv. Red Lady-786 was investigated at four adjoining fields of farmers during two consecutive years i.e., 2012-13 and 2013-14 in district Sirohi (Rajasthan). The abiotic factors viz., average minimum and maximum temperatures were $28.0^{\circ}\text{C} \pm 5.0^{\circ}\text{C}$ and $38.0^{\circ}\text{C} \pm 5.0^{\circ}\text{C}$, relative humidity of 58.0 ± 25.0 per cent and total rainfall 585.0 mm per annum were recorded during the experimentation (24 months). Treatment comprised of nine combinations consisting by three transplanting dates and three crop geometry viz., (T₁) Transplanted in first week of March + 3m x 3m (1111 plants ha⁻¹), (T₂) Transplanted in first week of March + 2m x 2m (2500 plants ha⁻¹), (T₃) Transplanted in first week of March + 2.5m x 1.6m (2500 plants ha⁻¹), (T₄) Transplanted in first week of July + 3m x 3m (1111 plants ha⁻¹), (T₅) Transplanted in first week of July + 2m x 2m (2500 plants ha⁻¹), (T₆) Transplanted in first week of July + 2.5m x 1.6m (2500 plants ha⁻¹), (T₇) Transplanted in first week of September + 3m x 3m (1111 plants ha⁻¹), (T₈) Transplanted in first week of September + 2m x 2m (2500 plants ha⁻¹) and (T₉) Transplanted in first week of September + 2.5m x 1.6m (2500 plants ha⁻¹). The experiment was laid out in Randomized Block Design with four replications in 10m x 10m plot size and accommodated plants at 3m x 3m (9 plants), 2m x 2m (25 plants) and 2.5m x 1.6 m (25 plants) per plot⁻¹ for each replication. The beds were prepared and pits measuring 50 x 50 x 50 cm were dug 15 days prior to transplanting. The 45 days old disease free seedlings were transplanted in the main plot as per treatments. First half recommended dosage of organic matter and fertilizer (10 kg Farm Yard Manure + 150 g nitrogen + 150 g phosphorus + 250 g potash) were applied at the time of transplanting in pits and remaining half quantity of organic matter and fertilizer was applied in four splits dosage i.e. 3 month, 6 month, 9 month and 12 month after transplanting by ring method near root zone. The intercultural

operations (weeding, irrigation, mulching, insecticide spray etc.) were followed as and when required.

All the observations were taken from randomly selected five plants of each replication throughout the investigation period at appropriate time by adopting standard methodology. Seedling survival per cent (after transplanting in main field recorded at 10, 20 and 30 DAT) was recorded by following formula:

$$\text{Survival per cent} = \frac{\text{Survival plants}}{\text{Total transplanted plants}} \times 100$$

The plant height was measured three-monthly starting after third months of planting upto 24 months (at last harvesting). Plant height was measured from the ground level to the highest point of plant in centimeters (at 3, 6, 9, 12, 15, 18, 21 & 24 months after transplanting). Stem girth was determined 15 cm above ground by a vernier caliper in centimeters. Number of functional leaves was counted which were green and photosynthetically active at the time of observations. While leaf area was determined by tracing the leaves on a graph paper and calculating the areas covered and expressed in square meter. Days taken to first flower initiation, number of flowers plant⁻¹ number of fruits plant⁻¹ and days taken fruit setting to harvesting was calculated by simple counting method. Fruit set and retention were recorded from randomly selected five tagged plants by using following formulae:

$$\text{Fruit set (\%)} = \frac{\text{Total number of fruit set plant}^{-1}}{\text{Total number of flowers plant}^{-1}} \times 100$$

$$\text{Fruit retention (\%)} = \frac{\text{Total number of fruit gets maturity plant}^{-1}}{\text{Total number of fruit set plant}^{-1}} \times 100$$

Fruit yield and fruit weight was recorded after 10 months from the date of planting to 24 months age of plants, which was a first spell of complete fruiting and expressed in kg fruit⁻¹. The total fruit yield plant⁻¹ and hectare⁻¹ were calculated by weighing total marketable fruits during successive harvesting obtained from each plant, per plot and per hectare estimated by multiplied yield per plant to planting density and expressed in kg and quintal, respectively. Further, the net return was calculated by subtracting cost of each treatment from gross return. The gross return was calculated from yield multiplied by average market rate during the period of investigation. The benefit cost ratio was calculated by dividing net return to total cost of cultivation.

Total soluble solids (TSS) of the fruit pulps was determined by Zeiss Hand Juice Brix Refractometer, values corrected to 20°C and expressed as °Brix. Acidity (as citric acid) was determined by using standard N/10 NaOH solution in the presence of phenolphthalein as an indicator, AOAC (1984). Total sugar in the pulp was determined by the Anthrone reagent method AOAC, (1984). The ascorbic acid (vitamin C) content of the pulp was estimated by titration

method with 2, 6-dichlorophenol-indononol dye solution (AOAC, 1984). The pulp thickness was measured from cavity surface to outer surface of fruit by scale and expressed in centimeter. The over all quality (pulp colour, cavity size, seed content, skin colour, size and shape of papaya fruits) and consumer preference of fruits was done by a panel of five semi-trained judges using 10 point hedonic scale (Amerine et al 1965). Chlorophyll content of leaves was estimated by the method of Arnon (1949) at 6 and 24 month after transplanting. Incidence or occurrence of leaf curl and ring spot virus as well as sun scald and frost injury symptoms were recorded visually on leaves and fruits, respectively and expressed in percentage in relation to the total sample by the panel of five members at 6, 12 and 18 months after transplanting.

All data were subjected to analysis of variance (ANOVA) to determine significant differences followed by Tukey's test for comparisons of means at significance level of $P \leq 0.05$.

Results and Discussion

Vegetative growth parameters

It appears from the figure-1 that the maximum seedling survivality was recorded at 20 DAT (89.30%) closely followed by at 30 DAT (81.45%) in T_3 treatment (1st week of September + 2.5m x 1.6m), which was significantly superior to other treatment combinations but at par with T_4 treatment (1st September + 2m x 2m). The maximum survival per cent of seedling in T_4 treatment might be due to more favorable environmental condition (Temp. 32°C and RH 70%) in the month of September for seedling transplanting and re-establishment of the seedling than other. The results of present investigation were also supported by Bhardwaj et al (2013) in papaya. Data presented in Table 1, 2 and 3 the vegetative parameters i.e., plant height (77.83 cm), leaf area (2.40 m²) and number of leaves (12.22) was recorded maximum in treatment T_4 (1st week of July + 3m x 3 m), whereas stem girth (8.99 cm) was in T_1 (1st week of March + 3m x 3 m) at 3 months after transplanting. At the end of crop season i.e., at 24th month after transplanting maximum plant height (289.61 cm), stem diameter (50.76cm), leaf area (3.84 m²) and number of leaves (42.45) were recorded in treatment T_1 (1st week of March + 3m x 3 m). Whereas, respective vegetative parameters were recorded minimum in T_4 treatment (1st week of September + 2m x 2m).

The seedling transplanted in 1st week of March favour higher vegetative growth than later dates of transplanting of papaya seedling due to better establishment of seedlings prior to onset of monsoon and that plants use maximum rain water and soluble nutrients for initial growth and development. The warmer and intermediate temperature with wider diurnal fluctuation in environment gave congenial conditions for good mean growth rate in papaya plant, accumulation of reserves in more quantity and fairly large sweet fruit (Allan et al 1987). Similarly better plant growth due to higher temperature (36°C/28°C) in the present study confirms the

observations of Singh and Singh (1998) in papaya.

Vigorous vegetative growth (plant height, stem girth, number of leaves and leaf area) and root volume in wider line spacing (3m x 3m) planting, might be due to reduction in crop competition for nutrients, water, light and spacing than the closer space planting (T_2 & T_3), eventually enhanced photosynthesis and contributed to produce higher dry matter. This was also enunciated by Chattopadhyay et al (1985), Reynolds and Robinson (1985), Chaudhuri and Baruah (2010) in banana and Bhardwaj et al (2013) in papaya, lending ample support to the present study.

Yield and yield attributes

The yield among different months was strongly influenced by transplanting dates and crop geometry. Transplanting of seedling in month of March with 2.5m x 1.6 m crop geometry was more productive over the other months of transplanting and crop geometry. However, highest number of fruits plant⁻¹ (82.46), fruit weight (1.98 kg), fruit yield plant⁻¹ (163.28 kg) was recorded in treatment T_1 (1st week of March + 3m x 3m), whereas the minimum number of fruit plant⁻¹ (50.78), lowest fruit weight (1.15 kg) and fruit yield plant⁻¹ (58.39 kg) was recorded in T_4 treatment (1st week of September + 2m x 2m). Reduction in number of fruits, fruit weight and fruit yield plant⁻¹ with increasing plant density may be due to excessive interception of light by the enhanced canopy and higher crop competition for nutrients and water under high density planting. When the plant population was low, more leaf surface was exposed to sunlight and indirectly greater amount of assimilates accumulated in the various organs of the plant leading to increased number of fruits plant⁻¹, fruit weight and fruit yield plant⁻¹. Interestingly, computation the marketable yield from fruit weight, the present study showed a tremendous increase in yield per unit area with increasing plant population (T_3 and T_4). Similar results were also reported by Bhardwaj et al (2013) in papaya.

Minimum days required in flower initiation (154.40 days) and least days taken from fruit set to harvest (112.12 days), maximum fruit set (57.70 %), fruit retention (75.50%), fruit yield ha⁻¹ (2372.47 q in 24 month of cropping duration), net return (Rs.10.689 lakh) and benefit: cost ratio (4.54:1) was observed in T_3 treatment (1st week of March + 2.5m x 1.6m) which was significantly different from all other treatments. Maximum number of flowers plant⁻¹ (285.33 in 24 month of cropping duration) was reported in T_3 treatment. Minimum days required in flower initiation and least days taken from fruit setting to harvesting in T_3 treatment might be due to more total leaf surfaces exposed to light due to wider spacing between rows, which increased the metabolism of the plant causing early physiological maturity and flowering. The enhanced yield components might be due to the fact that wider space availability between the rows and closer space between plants is favourable for more sun light penetrates within the crop canopy leading to increased photosynthesis area (total leaf area), thus higher photosynthetic rate and accumulation of

more assimilates which in turn increased the sink size and finally increased yield and quality of fruits. Higher yield attributes of papaya under wider row space planting due to better availability of resources was also noted by Bhardwaj et al (2013) in papaya. Mehta et al (2012) they were reported that the proper crop geometry significantly increases yield, quality of seed, profitability and productivity of dill. The present study gets ample support from the work of Singh and Singh (1998), Kudada and Prasad (1999) in papaya.

Seedling transplanting dates also play a significant role on quality and yield of fruit in papaya. The seedling transplanted in the month of March the fruiting cycle of papaya was started in the month of August - September (154 DAT), which was coincide with suitable climatic condition (Temp. 28-32°C with 50-60% RH) for maximum flowering, fruit setting, fruit retention and development of fruit and harvesting of fruits in month of March-April before on-set of sever hot season, these conditions congenial for enhancing yield and quality of fruits. Bhardwaj et al (2013) also observed that the transplanting of papaya seedling in the month of March significantly increase number of flower, fruits, fruit set per cent and yield due to coincide with favorable climatic condition for first flowering and fruiting. Similar results were also in conformity with the finding of Muthukrishnan and Irulappan (1990), Singh and Singh (1998) in papaya plants.

Quality parameters

The maximum leaf chlorophyll content (3.38 μm 100g⁻¹ leaf) was observed in T₁ treatment, which was at par with T₄ (3.36 μm 100g⁻¹ leaf) and minimum in treatment T₃. Higher chlorophyll content in wider space planting might be due to high light penetration at lower leafy portion of the plants and availability of nutrient and water also higher than other crop geometry. Similar result was also reported by

Bhardwaj et al (2013) in papaya and Bhardwaj and Agrawal (2014) in fennel.

It was interesting to know that the seedling transplanting dates and crop geometry exhibited a significant effect on the fruit quality parameter viz., TSS, acidity, total sugar, ascorbic acid, pulp thickness and overall quality score of fruits (pulp colour, cavity size, seed content, skin colour, size and shape of papaya fruits) (Table 5). In the present investigation, the plant raised under high density (2500 plant ha⁻¹) with wider line spacing exhibited superior fruit quality and extended harvesting period. The sweetness of papaya, mainly assessed by TSS (total soluble solids) content and maximum TSS (11.80°Brix) was reported in T₁ treatment which was statistically similar to T₁ (11.78°Brix) and T₂ (11.75°Brix), and rest of the treatments was significantly different and lowest TSS (11.17°Brix) was in T₄. Lower acidity in papaya fruit increase public choice and market value of the fruits. The minimum acidity (1.30%) was observed in T₁ treatment, which was at par with T₁ (1.32%) and T₂ (1.31%), and rest of the treatments was significantly different and highest acidity (1.45%) was in T₄ treatment. Maximum total sugar (7.97%), highest ascorbic acid (58.35 mg 100g⁻¹ of fruit pulp), pulp thickness (3.20 cm) and maximum overall fruit quality score (8.36) was also observed in T₁ treatment. This probably due to the fact that papaya planted in wider line space and closer plant space (2.5m x 1.6m), there is no significant change in plant population per hectare and high light penetration at lower leafy portion of the plants due to wider line spacing which is positive for increased rate of photosynthesis and accumulate more dry matter in fruits which ultimately resulted in higher quality of the fruits. Higher acidity in higher plant population (2m x 2m) may be due to shade effect where sugar conversion from organic acid is hampered due to lack of sufficient light. Moreover, lower

Table 1. Effect of transplanting dates and crop geometry on plant height of papaya cv. Red Lady

Treatments	Plant height (cm)							
	3 MAT	6 MAT	9 MAT	12 MAT	15 MAT	18 MAT	21 MAT	24 MAT
T ₁	61.90	153.05	201.68	236.84	267.10	271.92	284.87	289.61
T ₂	54.12	129.30	173.68	212.88	240.50	245.87	251.77	254.56
T ₃	49.47	125.28	166.68	201.92	223.45	228.82	235.87	239.96
T ₄	77.83	162.65	191.62	212.01	220.28	234.34	241.99	246.58
T ₅	69.87	145.90	175.62	197.02	204.33	219.34	235.09	237.83
T ₆	62.91	136.64	168.62	191.00	200.33	214.34	226.29	229.44
T ₇	71.17	143.04	170.38	185.52	190.37	201.25	207.69	209.20
T ₈	61.30	128.00	157.38	175.50	178.37	182.25	188.29	185.78
T ₉	56.25	122.25	152.38	165.47	167.57	179.55	184.30	191.58
S. Em ±	6.43	1.859	4.011	5.862	6.102	5.054	5.433	6.513
CD at 5%	2.17	5.579	12.033	17.586	18.308	15.162	16.299	19.540

* All data in table are pooled of 2011-12 & 2013-14. MAT= months after transplanting

Table 2. Effect of transplanting dates and crop geometry on stem girth of papaya cv. Red Lady

Treatments	Stem girth (cm)							
	3 MAT	6 MAT	9 MAT	12 MAT	15 MAT	18 MAT	21 MAT	24 MAT
T ₁	8.99	18.80	27.40	34.70	40.16	44.60	48.20	50.76
T ₂	7.18	15.47	22.45	28.37	32.32	35.27	37.22	38.50
T ₃	7.92	17.13	25.01	31.89	36.77	40.65	42.20	43.56
T ₄	8.09	16.07	23.05	29.03	33.01	36.11	37.88	43.15
T ₅	6.41	14.32	21.25	27.18	31.11	33.95	35.88	37.30
T ₆	6.70	15.07	22.45	29.25	33.63	37.01	39.05	39.97
T ₇	7.24	15.53	22.83	29.07	33.83	37.00	39.28	39.87
T ₈	5.57	12.95	19.36	24.77	28.18	30.98	32.38	33.23
T ₉	5.59	13.35	20.08	25.83	29.56	32.68	34.43	35.48
S. Em ±	0.250	0.636	0.636	0.636	0.938	1.450	1.450	1.450
CD at 5%	0.751	1.908	1.908	1.908	2.814	4.352	4.352	4.352

Table 3. Effect of transplanting dates and crop geometry on leaf area and total number of leaves per plant of papaya cv. Red Lady

Treatments	Leaf area (m ²)			Number of total leaves, months after transplanting							
	3 MAT	12 MAT	24 MAT	3 MAT	6 MAT	9 MAT	12 MAT	15 MAT	18 MAT	21 MAT	24 MAT
T ₁	1.80	6.25	3.84	9.30	17.55	25.17	31.55	36.55	39.55	41.55	42.45
T ₂	1.57	5.17	3.00	8.20	15.25	21.30	26.65	29.45	31.45	34.95	34.25
T ₃	1.62	5.73	3.20	8.25	16.30	23.55	29.45	33.45	36.35	38.45	39.45
T ₄	2.40	6.14	3.50	12.22	19.47	29.00	33.00	34.10	36.10	27.00	38.05
T ₅	2.10	4.48	3.04	10.26	15.56	21.30	24.10	26.10	28.30	29.50	30.50
T ₆	2.20	5.13	3.43	11.31	17.51	24.10	28.00	30.90	33.10	34.00	34.10
T ₇	2.01	5.08	3.23	10.10	16.10	21.47	25.27	28.87	30.17	33.47	35.37
T ₈	1.84	4.03	2.61	9.25	13.60	17.47	20.07	22.37	24.47	25.57	25.87
T ₉	1.63	4.52	2.71	8.50	13.10	19.47	22.47	24.97	26.37	27.17	28.67
SEm ±	0.092	0.159	0.102	0.487	0.487	1.162	1.162	1.162	1.162	1.162	1.162
CD at 5%	0.278	0.478	0.307	1.463	1.463	3.487	3.487	3.487	3.487	3.487	3.487

* All data in table are pooled of 2011-12 & 2013-14. MAT= months after transplanting

Table 4. Effect of transplanting dates and crop geometry on yield attributes and economics of papaya cv. Red Lady

Treatments	Days taken to first flower initiation	Number of flowers plant ⁻¹	Fruit set (%)	Fruit retention (%)	Number of fruit plant ⁻¹	Days taken fruit set to harvest	Fruit weight (kg)	Fruit yield plant ⁻¹ (kg)	Fruit yield ha ⁻¹ (q)	Net return (Rs.in lakh)	B:C ratio
T ₁	165.65	263.70	45.25	69.11	82.46	126.32	1.98	163.28	1814.05	7.617	3.24
T ₂	157.50	173.65	51.33	71.40	63.64	120.27	1.28	81.46	2036.55	8.841	3.76
T ₃	154.40	155.60	57.70	75.50	67.78	112.12	1.40	94.90	2372.47	10.689	4.54
T ₄	169.14	278.79	42.17	66.87	78.61	132.39	1.91	150.14	1668.03	7.007	2.88
T ₅	166.19	179.14	47.84	69.17	59.27	123.34	1.25	74.09	1852.25	8.021	3.31
T ₆	163.39	159.39	53.79	72.92	62.51	125.39	1.32	82.52	2062.89	9.179	3.80
T ₇	169.38	285.33	37.73	64.73	69.69	131.58	1.75	121.96	1355.03	5.093	2.39
T ₈	165.33	193.38	42.53	61.73	50.78	123.38	1.15	58.39	1459.80	5.669	2.64
T ₉	161.08	175.13	48.83	65.73	56.22	125.38	1.28	71.96	1798.90	7.534	3.43
S Em ±	1.603	6.259	1.570	1.570	1.952	1.472	0.044	3.932	45.137	0.111	0.066
CD at 5%	4.809	18.778	4.712	4.712	5.857	4.418	0.134	11.796	135.413	0.335	0.200

Table 5. Effect of transplanting dates on quality of papaya cv. Red Lady.

Treatments	TSS of fruit pulp (°B)	Acidity (%)	Total sugar (%)	Ascorbic acid (mg/100g pulp)	Pulp thickness (cm)	Overall organoleptic score (out of 10 marks)	Leaf chlorophyll content (mg/g leaf)	
							6 MAT	24 MAT
T ₁	11.78	1.31	7.92	57.20	3.10	7.82	3.43	3.38
T ₂	11.75	1.32	7.78	58.15	3.15	7.46	3.38	3.32
T ₃	11.80	1.30	7.97	58.35	3.20	8.36	3.39	3.34
T ₄	11.50	1.40	7.90	56.52	2.70	7.30	3.41	3.36
T ₅	11.45	1.43	7.75	57.05	2.75	6.90	3.37	3.30
T ₆	11.52	1.42	7.82	57.94	2.80	7.95	3.38	3.33
T ₇	11.26	1.43	7.84	55.08	2.45	7.15	3.40	3.35
T ₈	11.17	1.45	7.72	55.63	2.53	6.75	3.32	3.29
T ₉	11.21	1.44	7.75	56.81	2.58	7.50	3.36	3.31
SEm ±	0.576	0.016	0.078	1.570	0.008	0.162	0.008	0.008
CD at 5%	0.172	0.048	0.235	4.712	0.026	0.486	0.026	0.026

* All data in table are pooled of 2011-12 & 2013-14. MAT= months after transplanting

total sugar in late transplanted (September) and 2m x 2m crop geometry plants may be due to less conversion of sugar from starch. The present study support from the work of Reddy (1991), Chaudhuri and Baruah (2010) in Banana.

Occurrence of abiotic stresses

Occurrence of papaya leaf curl and ring spot virus was observed throughout the investigation period. Least in viral infection was observed with transplanting in first week of March with 2.5 m x 1.6 m crop geometry (Fig.2 and Fig.3) The minimum incidence of leaf curl virus (27.52 %) and papaya ringspot virus (26.30 %) was observed in T₁ treatment (1st week of March + 2.5m x 1.6m), whereas maximum incidence of leaf curl virus (42.57%) and papaya ring spot virus (30.45%) at 18 month after transplanting was reported in T₄ treatment (1st week of September + 2m x 2m). The papaya leaf curl virus was transmitted by white fly and its infestation is higher in weed infested field. Change in crop geometry (wider line spacing and closer plant spacing) for weed management by tractor operated machine, which was significantly reduces weed infestation as well as white fly population in initial stage of the plants. However, March transplanting was found to be safer in respect to virus infestation because at that time the weed and vector population was very low due to high temperature and low relative humidity upto month of July. Mora-Aguilera et al (1996) reported the usefulness of transplanting dates in controlling papaya ringspot virus in Mexico. Occurrence of virus infestation influenced by different planting months was also reported by Singh and Singh (1998), Ray et al (1999), Kudada and Prasad (1999) in papaya. Similarly Bhardwaj and Agrawal (2014) was also observed that minimum infestation

of disease in fennel, when crop was planted in higher line spacing and low plant spacing method then other crop geometry.

The minimum sun scald and frost injury (32.25%) was observed in T₁ treatment whereas highest incidence (89.10%) was reported in T₄ treatment (Fig. 4). The possible explanation of minimum incidence of abiotic stress (sun scald and frost) in the later transplanting dates (First week of July) and close planting (2m x 2m) due to favorable environmental condition and high density planting reduce effect of sun scald and frost by shading effect on each other. Similar results are also reported by Bhardwaj et al (2013) in papaya crop.

Conclusion

The papaya seedling transplanted in first week of March in 3m x 3m crop geometry gave better vegetative growth rates and development compared to other treatments. On the same date of transplanting with 2.5m x 1.6 m (2500 plants ha⁻¹) crop geometry recorded maximum fruit set, retention, yield ha⁻¹ and better quality attributes of fruits and highest net return and benefit: cost ratio along with minimum days to first flower initiation and fruit set to harvest. In addition to this, this transplanting date (1st week of March) and crop geometry (2.5 x 1.6 m) also reduce the severity of leaf curl and papaya ring spot virus including comparatively less incidence of sun scald and frost injury. Thus, March transplanting with 2.5 m x 1.6 m crop geometry treatment combination (T₁) is much suitable for higher yield with better fruit quality under agro-climatic conditions of South- West Rajasthan.

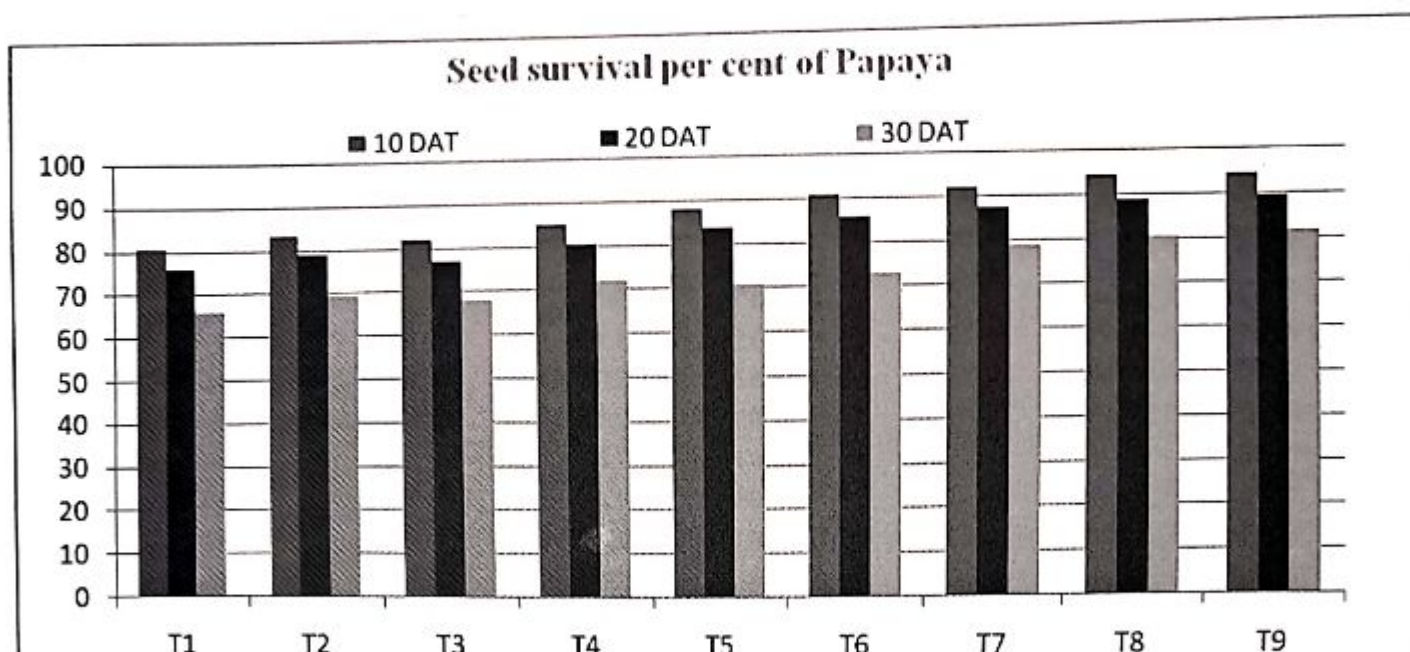


Figure 1. Effect of transplanting dates and crop geometry on field survival of seedlings of papaya.

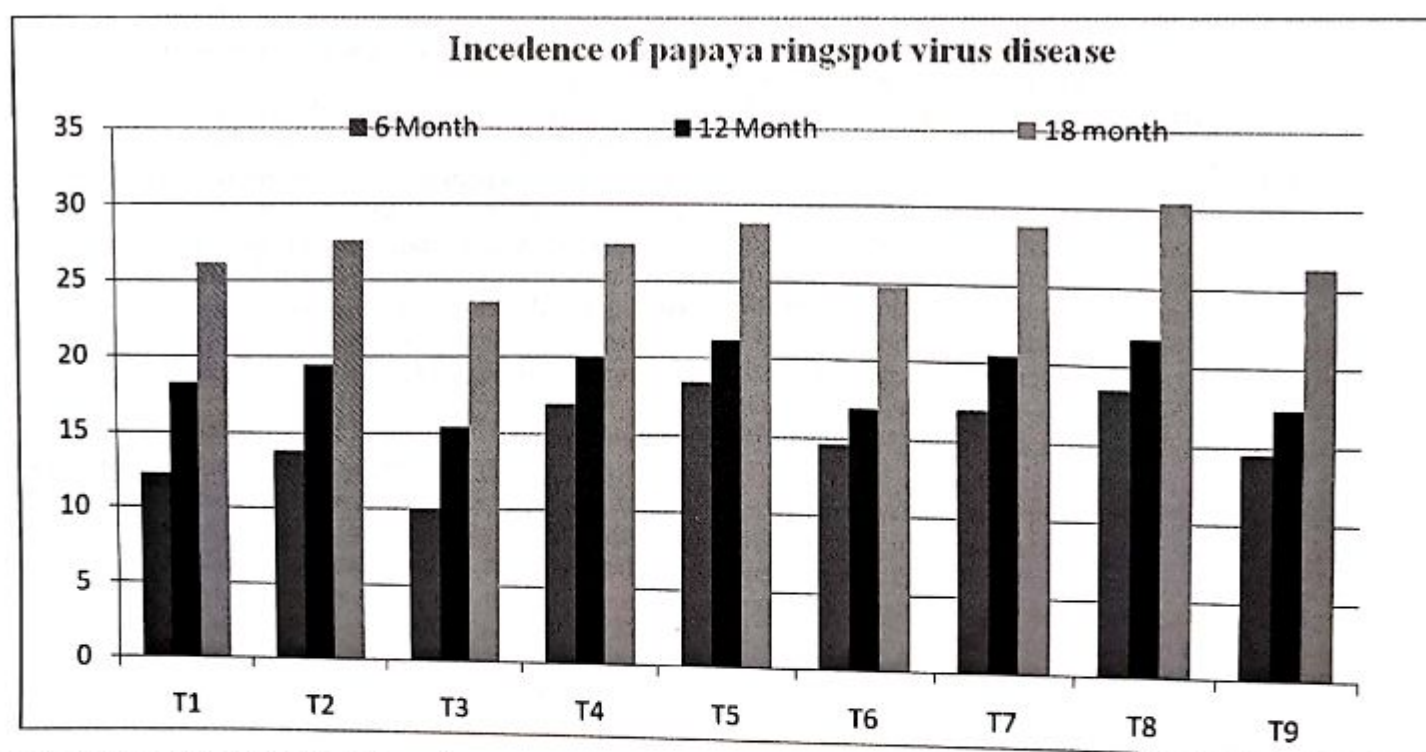


Figure 2. Effect of transplanting dates and crop geometry on incidence of papaya ring spot virus in papaya.

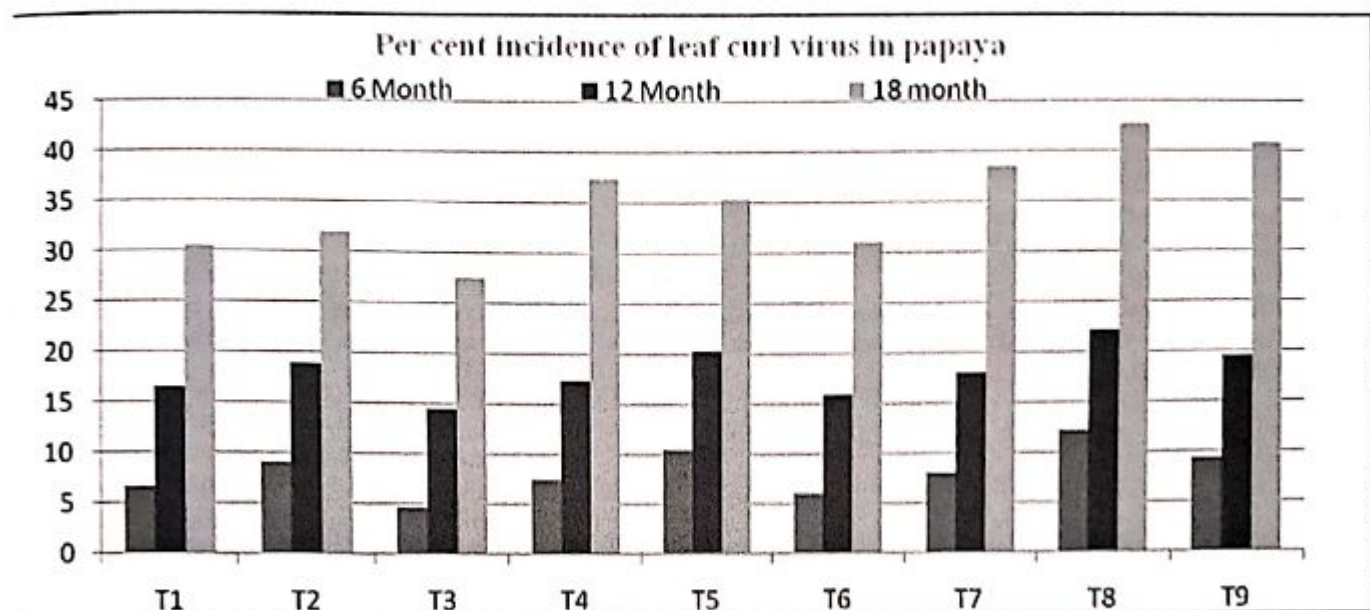
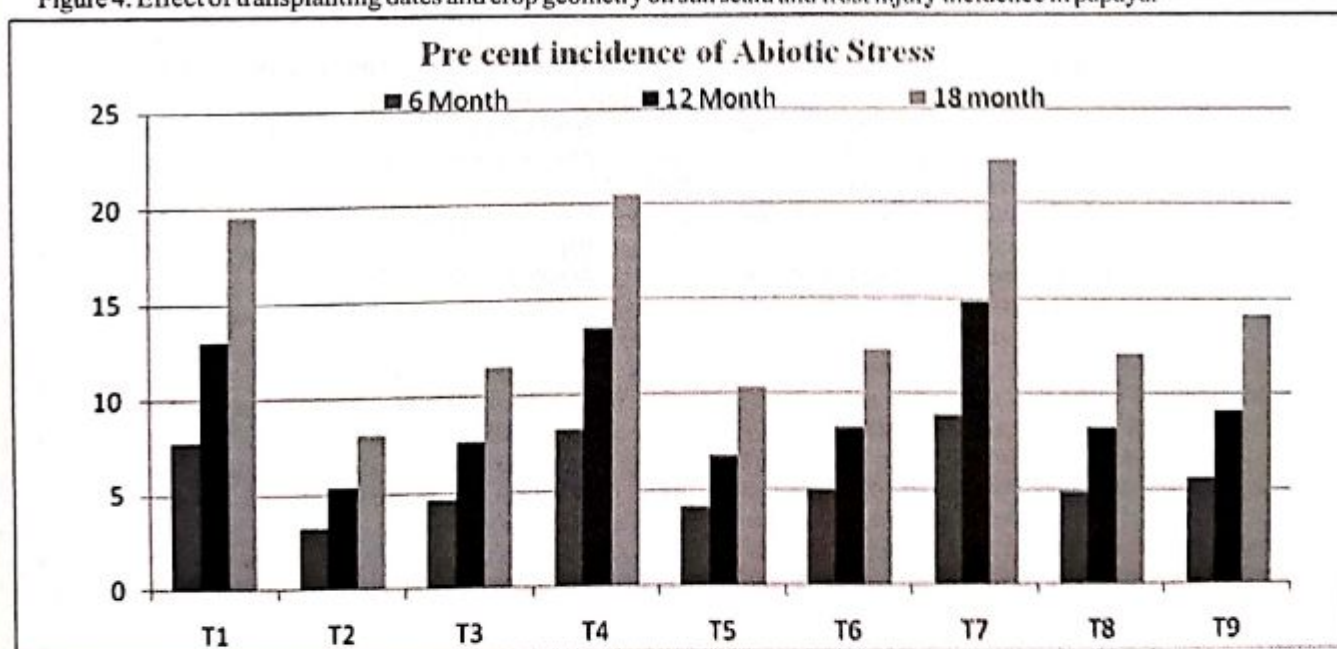


Figure 3. Effect of transplanting dates and crop geometry on incidence of leaf curl in papaya.

Figure 4. Effect of transplanting dates and crop geometry on sun scald and frost injury incidence in papaya.



References

- Allan P, Chalery JMC and Biggs D 1987. Environmental effects on clonal female and male of *Carica papaya* L. plants. *Scientia Hort.*, 32: 221-232.
- Amerine MA, Pangbron RM and Rossler EA 1965. Principles of sensory evaluation of food. Academic Press, New York and London.
- Anonymous 2013. Indian Horticulture Database-2011-12. Ministry of Agriculture, Government of India, Gurgaon, p5-6.
- AOAC 1984. Official Methods of Analysis, 12th (ed), Association of Official Agricultural Chemist. Washington D.C.
- Arnon DL 1949. Copper enzymes in isolated chloroplasts polyphenol oxidase in *Beta vulgaris*. *Plant Physiology*, 24: 1-15.
- Bhardwaj RL and Agrawal SK 2014. Effect of irrigation and crop geometry on growth, yield, quality and profitability of transplanted fennel (*Foeniculum vulgare* Mill.). *J. of Spices and Aromatic Crops*, 23: 5158.
- Bhardwaj RL, Dadhich SK and Meena CB 2013. Bench mark survey of papaya cultivation in district Sitohi. K.V.K, Sirohi, MPUAT, Udaipur, p3-6.
- Chadha KL 1992. Scenario of papaya production and utilization in India. *Indian J. of Horticulture*, 49: 97-119.
- Chattopadhyay PK, Bhowmik DJ, Maiti DC and Bose TK 1985. Optimum planting density for plant and ratoon crops of 'Giant Governor' Cavendish banana in West Bengal. *Indian J. Agriculture Science*, 55: 17-21.
- Chaudhuri P and Baruah K 2010. Studies on planting density in Banana cv. Jahaji (AAA). *Indian J. of Hill Farming*, 23:31-38.
- Kudada N and Prasad SM 1999. Effect of planting time on the incidence of papaya ringspot virus disease and yield of fruits. *Indian Phytopathology*, 52: 224-227.
- Mehta RS, Anwer MM and Sharma YK 2012. Effect of irrigation, nutrient levels and crop geometry on growth and yield of dill (*Anethum sowa* L.). *J. Spices and Aromatic Crop*, 21: 20-24.
- Misra ADD, Kumar A and Meitei WI 2014. Effect of spacing and planting time on growth and yield of onion var. N-53 under Manipur Himalayas. *Indian J. Hort.*, 71: 207-210.
- Mora-Aguilera G, Nieto-Angel D, Teliz D and Campbell CL 1996. Development of prediction model for papaya ringspot in Veracruz, Mexico. *Plant Disease*, 77: 1205-1211.
- Muthukrishnan CR and Irulappam J 1990. Papaya. (In) *Fruits Tropical and Subtropical*, p 314 - 315. Bose T. K. (Ed). Naya Prakash, Calcutta.
- Rashid MM, Quadir MA, Hossain MM 1987. Bangladeshher Phal (Fruit of Bangladesh). Rashid Publishing House, Bangladesh, Agril. Res. Inst. Campus Gazipur, p130-137.
- Ray PK, Yadav JP and Kumar A 1999. Effect of transplanting dates and mineral nutrient on yield and susceptibility of papaya to ringspot virus. *Horticultural Journal*, 12: 15-26.
- Reddy, 1991. Effect of spacing, plant density on growth, yield and quality of 'Dwarf Cavendish' banana. AICRP (TF) Res. Rep on Citrus, Banana, Pineapple, Papaya and Sapota, IIHR, Bangalore, p103- 105.
- Reynolds RE, Robinson JC 1985. Banana plant densities for National Information Bulletin, Citrus and sub trop. Fruit Res. Inst., 158: 14-16.
- Singh AK and Singh G 1998. Effect of time of planting on growth, fruiting behaviour and sex relations of papaya (*Carica papaya* L.). *Indian J. Agricultural Sciences*, 68:769-772.

Evaluation of Bottle gourd cv. Pusa Naveen under semi arid conditions of Panchmahal district of Gujarat

Raj Kumar^{1*}, B.S. Khadda¹, J.K. Jadav¹, A. K. Rai¹, S. Khajuria¹ and K. Lata²

¹ SMS, ² PC, KVK (CIAH), Krishi Vigyan Kendra- Panchmahals, (ICAR-Central Institute for Arid Horticulture)

Godhra-Vadodara Highway Vejalpur, Gujarat 389 340

Corresponding author e-mail: rajhortches@gmail.com

(Received: 12.10.2015; Accepted: 04.04.2016)

Abstract

The present study was carried out at Krishi Vigyan Kendra-Panchmahals district of central Gujarat during 2012-13. One of the major constraints of traditional bottle gourd farming is low productivity because of non-adoption of advanced technologies. The lack of suitable HYVs (High Yielding Varieties), technical knowledge, quality irrigation water and awareness with respect to use of protection measures were found to be the major constraints in bottle gourd production. To increase the production, productivity and quality of bottle gourd, Front Line Demonstrations were conducted at various farmers' field. All the recommended practices were provided to the selected farmers. Results of the study revealed that the improved variety of Bottle Gourd cv. Pusa Naveen recorded the higher average yield (273 q/ha) as compared to local check (235 q/ha) traditionally grown by the farmers. The percentage increase in the yield over local check (*padara bottle gourd*) and demonstration (Pusa Naveen) 16.17 was recorded. The technological gap in terms of productivity (17.0 q/ha) were computed. The technology index values 5.86 % was recorded. By adopting Bottle Gourd cv. Pusa Naveen along with improved production technologies, yield can be increased upto a great extent. This will substantially increase the income as well as the livelihood of the farming community.

Keywords: - Front Line Demonstrations, local check, bottle gourd, technology, yield

Introduction

Among, cucurbits, bottle gourd (*Lagenaria siceraria* (Mol.) Standl) is extensively grown in India and fruits are available throughout the year. Fruits at tender stage are used as a cooked vegetable and for preparation of sweets (e.g. *halva*, *kheer*, *burfi* and *petha*) and pickles. Hard shells of mature fruits are used as water jugs, domestic utensils, floats for fishing nets, etc. As a vegetable it is easily digestible. It has cooling effect and has diuretic and having cardio-tonic properties. Fruit pulp is used as an antidote against certain poisons and is good for controlling constipation, night-blindness and cough. A decoction made out of leaf is taken for curing jaundice (Thamburaj and Singh, 2001). In the study area, cucurbits are growing extensively as kitchen garden especially during kharif season or as commercial scale throughout the year. The tribals of the area are growing it and train the vines on boundary of the house and on pandal. Among cucurbits, bottle gourd is being grown by majority of the farmers than other cucurbitaceous vegetable. The area, production and productivity of cucurbits in the district is 6.0 lakh ha, 48.00 lakh M.T and 8.0 M.T., respectively (Anonymous, 2010). In Gujarat, it is grown in area of 46.69 lakh ha with production of 66.31 lakh M.T with the productivity of 14.20 M. T. (Anonymous, 2012).

Generally, the agricultural technology is not accepted by the farmers as such in all respects. There is always a gap between the recommended technology by the scientist /researcher and its modified form at the farmer's level which is

a major lacuna in the efforts of increasing agricultural production in the country. There is an urgent need to reduce this technological gap between the agricultural technology recommended by the scientists or researchers and its acceptance by the farmers on their field. In view of the above facts, frontline demonstrations were undertaken in a systematical and scientifically on farmers' field to show the worth of a new technology and convince the farmers to adopt it in their farming system.

Materials and Methods

Need assessment

The random survey of 60 bottle gourd growers of various farmers of Panchmahal district was conducted to identify the constraints in its cultivation. Preferential ranking technique was adapted to identify the constraints faced by the respondent farmers in bottle gourd cultivation. Farmers were also questioned to rank the constraints perceived as limiting bottle gourd cultivation in order of preference. The quantification of data was done by ranking the constraints and then calculating the Rank Based Quotient (RBQ) as per methods given by Sabarathanam (1988), which is as follows:

$$R.B.Q = \frac{f_i (n+1 - i_{th})}{N \times n} \times 100$$

Where

f_i = Number of farmers reporting a particular problem under i^{th} rank,

N = number of farmers
n = number of problems identified.

Experimental set up

Based on top rank farmer's problems identified, front line demonstrations were planned and conducted at the farmers' field. The main objective of the study is to increase the production, productivity of bottle gourd. All the demonstrations were conducted to motivate farmers exhibiting potentialities of improved variety of bottle gourd cv. Pusa Naveen. The genuine seeds were procured from National Seed Corporation, Godhra and distributed to ten selected farmers of villages viz. achhala, ramnath, richhiya, kharsaliya and sureli. The each farmer grow it in 0.5 ha land. All the participating farmers were trained about various aspects of bottle gourd cultivation. The demonstrated fields were prepared by one deep ploughing during May and two harrowing before sowing. A one fifth area was also allotted to grow local check (*padara bottle gourd*) for comparison. All the recommended practices i.e. seed treatment, spacing, recommended dose of manure and fertilizers, weed management, pest and management were adopted by the farmers in both treatments (local check (*padara bottle gourd*) and demonstration (Pusa Naveen).

Data recording and analysis

The data of both treatments were collected and analyzed with suitable statistical method. The data related to cost of cultivation, production, gross return and net return were collected in both treatments as per schedule. An average of cost of cultivation yield, net returns of different farmers was analyzed by the formula given by Samui *et al.* (2000).

$$\text{Average} = \frac{(F_1 + F_2 + \dots + F_n)}{N}$$

F = Farmer, N = No. of farmers

Technology gap: The technology gap shows the demonstration yield over potential yield. It was calculated by the formula given by Samui *et al.* (2000).

Technology gap = P_i (Potential yield) - D_i (Demonstration yield)

Technology index: Technology index shows the feasibility of the variety at the farmer's field. It was calculated by the formula given by Samui *et al.* (2000).

$$\text{Technology index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$$

The data thus collected were tabulated and statistically analyzed to interpret the results.

Result and Discussion

Constraints in bottle gourd production

The constraints in bottle gourd production faced by the farmers were documented. The preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in bottle gourd production. The ranking given by the different farmers are given in Table 1. A perusal of data indicates that lack of suitable HYVs (high yielding varieties) was given the top rank by 33 respondent farmers. Based on the ranks given by the respondent farmers for the different constraints listed in table 1, rank based quotients were calculated and presented in Table 2. It is revealed from the study that lack of suitable HYVs (high yielding varieties), technical knowledge about various package and practices and quality irrigation and aware with respect to plant protection measures were the major constraints in bottle gourd production. Other constraints such as, damage of crop by wild animals, demand of local / deshi produce, weed infestation and low soil fertility were also found as cases of low productivity for bottle gourd production. Among all the constraints, weed infestation and low soil fertility got the least concern. These finding are in agreement of the results as reported by earlier workers (Ouma *et al.*, 2002, Joshi *et al.*, (2005) in maize production.

Performance of FLD

A comparison of productivity levels between demonstrated variety and local check is shown in table-3. During the period of study, it was recorded that in front line demonstrations, the improved variety Pusa Naveen recorded

Table 1. Ranks given by farmers for different constraints in bottle gourd cultivation (n=60)

S. No.	Production Constraints	Ranks							
		I	II	III	IV	V	VI	VII	VIII
1.	Lack of suitable HYVs	33	7	7	5	3	2	2	1
2.	Lack of technical knowledge	17	9	13	7	6	3	3	2
3.	Low soil fertility	4	6	5	6	7	12	13	7
4.	Lack of quality irrigation water	14	10	8	5	8	6	5	4
5.	Demand of local / desi produce	9	8	12	9	6	5	7	4
6.	Problems of wild animals	6	9	10	8	6	6	7	8
7.	Plant protection measures	9	8	10	7	6	5	7	8
8.	Weed infestation	7	10	10	8	6	8	7	4

Table 2. Frequency distribution of RBQ values given by farmers (n=60)

S. No.	Problems	R.B.Q	Overall rank
1	Lack of location specific suitable HYVs	83.96	I
2	Lack of technical knowledge	73.54	II
3	Low soil fertility	48.13	VIII
4	Lack of quality irrigation water	66.46	III
5	Demand of local / deshi produce	62.92	IV
6	Problems of wild animals	53.96	VII
7	Plant protection measures	55.83	V
8	Weed infestation	57.29	VI

290 q/ ha yield potential. The average yield of various demonstration was (273 q/ ha) higher than local check (235 q/ ha). The percentage increase in yield was recorded 16.17 over local check. Similarly, yield enhancement in different crops in front line demonstration had already been documented by Hiremath *et al.* (2007) in onion, Kumar *et al.* (2010) in bajara and Dhaka *et al.* (2010) in maize. From these results, it is evident that the performance of improved variety was found to be better than the local check under same environment conditions. The farmers were motivated by showing the results in term of productivity and they are adopting the technologies.

Technology gap

The technology gap shows the difference between potential yields over demonstration yield of the technology. The potential yield of the technology (variety Pusa Naveen) is 290 q. ha. The technology gap of 17.0 q/ha was recorded. The Front Line Demonstration was laid down under the supervision of KVK specialist at the farmer's field. There exist

a gap between the potential yield and demonstration yield. This may be due to the soil fertility and weather conditions. Hence, location specific recommendations are necessary to bridge the gap. These findings are similar to the findings of Sharma and Sharma (2004) in oilseeds at Baran district of Rajasthan and Kumar *et al.* (2014) in okra.

Technology index

Technology index shows the feasibility of the variety at the farmer's field. The lower the value of technology index more is the feasibility of the particular technology. The result of study depicted in Table- 3 revealed that the technology index value was 5.86. It means the technology bottle gourd cv. Pusa Naveen is suitable for the Panchmahals district of central Gujarat. The results of the present study are in consonance with the findings of Singh *et al.* (2007), Kumar *et al.* (2014) in okra and Hiremath and Nagaraju (2009) in onion.

Economics of frontline demonstrations

The economics of bottle gourd cultivation under front line demonstration was recorded (table- 4). The results of

Table 3. Potential yield, average yield, technology gap and index of demonstration

Variables	Potential yield (q/ ha)	Average yield (q/ ha)	Increase (%) over Local check	Technology gap (q/ ha)	Technology index (%)
Local check (<i>Padara</i> <i>bottle gourd</i>)	-	235	-	-	-
Demonstration (Pusa Naveen)	290	273	16.17	17.0	5.86

economic analysis of bottle gourd production revealed that the front line demonstration recorded higher gross returns (Rs. 76875/ ha) and net return (Rs. 47675 /ha) with higher cost benefit ratio (2.63) as compared to local check (Rs 61250, 33850 and 2.23, respectively). These results are in accordance

with the findings of Hiremath *et al.* (2007) onion, Kumar *et al.* (2014) in okra and Hiremath and Nagaraju (2009) in onion. Further, additional cost of Rs.1800 per hectare in demonstration has increased additional net returns Rs. 13825 per hectare with incremental benefit cost: ratio 8.68

suggesting its higher profitability and economic viability of the demonstration. More and less similar results were also

reported by Hiremath and Nagaraju (2009) in onion and Dhaka *et. al.* (2010) in maize.

Table 4. Cost of cultivation, Gross return, Net return & Benefit : Cost ratio

Variables	Cost of cultivation (Rs/ ha)	Gross return (Rs/ ha)	Net return (Rs ha)	Benefit: cost ratio
Local check (<i>Padara bottle gourd</i>)	27400	61250	33850	2.23
Demonstration (Pusa Naveen)	29200	76875	47675	2.63
Additional in demonstration	1800	15625	13825	8.68*

References

- Anonymous, 2010. Gujarat, State Government Report pp.26.
- Anonymous, 2012. Indian Horticulture Database-2012. NHB, Ministry of Agriculture, Government of India.
- Dhaka, B.L., Meena B.S. and Suwalka R.L. 2010. Popularization of Improved Maize Production Technology through Frontline Demonstrations in South-eastern Rajasthan. *J. Agri. Sci.*, 1(1): 39-42.
- Hiremath, S. M. and Nagaraju, M. V. 2009. Evaluation of front line demonstration trials on onion in Haveri district of Karnataka. *Karnataka J. Agric. Sci.*, 22(5): 1092-1093.
- Hiremath, S. M., Nagaraju, M. V. and Shashidhar, K. K. 2007. Impact of front line demonstrations on onion productivity in farmers field. Paper presented In: Nation Sem Appropriate Extn. Strat Manag Rural Resources, Univ. Agric. Sci., Dharwad, December 18-20, p. 100.
- Joshi, P. K., Singh, N. P., Singh, N. N., Gerpacio, R. V. and Pingali, P. L. 2005. Maize in India: Production Systems, Constraints, and Research Priorities. Mexico, D.F.: CIMMYT.
- Kumar, A., Kumar, R., Yadav, V. P. S. and Kumar, R. 2010. Impact Assessment of Frontline Demonstrations of Bajra in Haryana State. *Indian Res. J. Ext. Edu.*, 10(1): 105-108.
- Kumar, R., Khadda, B.S., Jadav, J.K., Rai, A. K. and Lata, K. 2014. Impact of front line demonstrations on productivity of Okra cv. Gujarat Okra-2 in Panchmahals district of middle Gujarat. *Ind. J. of Arid Hort.*, 8(1-2):68-70.
- Ouma, J. H, De, Groote and Gethi M. 2002. Focused Participatory Rural Appraisal of farmer's perceptions of maize varieties and production constraints in the Moist Transitional Zone in Eastern Kenya. IRMA Socio-Economic Working Paper No. 02-01. Nairobi, Kenya: CIMMYT and KARI.
- Sabarathanam, V. E. 1988. Manuals of Field Experience Training for ARS Scientists. Hyderabad: NAARM.
- Samui, S. K., Maitra, S, Roy, D. K, Mondal, A. K. and Saha, D. 2000. Evaluation on front line demonstration on groundnut (*Arachis hypogea* L.). *J. Indian Soc. Coastal Agric. Res.*, 18: 180-183.
- Sharma, R. N. and Sharma, K. C. 2004. Evaluation of Front Line Demonstration trials on oilseeds in Baran district of Rajasthan. *Madhya Journal of Extension Education*, 7: 72-75.
- Singh, D. K, Gautam, U. S. and Singh, R. K. 2007. Study on Yield Gap and Level of Demonstrated Crop Production Technology in Sagar District. *Indian Res J Ext. Edu.*, 7(2&3): 94-95.
- Thamburaj, S. and Singh, N. 2001. Textbook of Vegetables, Tuber crops and Spices Published by Directorate of Information and Publications of Agriculture ICAR, New Delhi pp 29-48.

Effect of plant growth regulators and thiourea on growth, yield and quality of bottle gourd cv. Pusa summer prolific long

Reena Kumari, Ashok Kumar Meena*, S P Singh and K K Meena
Department of Horticulture, S.K.N. College of Agriculture, Jobner-303329,

*Corresponding author email: ashokageco@gmail.com

(Received: 31.01.2015; Accepted: 10.09.2015)

Abstract

The present experiment was carried out on Bottle gourd cv. Pusa summer prolific long during kharif season 2012 with objective to know the effect of plant growth regulators and thiourea on growth, yield and quality of bottle gourd. The treatment comprised of plant growth regulators and thiourea, viz. T_0 (control), T_1 (100 ppm NAA), T_2 (200 ppm NAA), T_3 (300 ppm NAA), T_4 (150 ppm Ethrel), T_5 (300 ppm ethrel), T_6 (450 ppm ethrel), T_7 (100 ppm CCC), T_8 (200 ppm CCC), T_9 (300 ppm CCC), T_{10} (250 ppm thiourea), T_{11} (500 ppm thiourea), T_{12} (750 ppm thiourea) were replicated three times in a randomized block design keeping plot size of 6 m x 3 m. Regarding growth parameter. The exogenous application of NAA 300 ppm (T_3) recorded maximum vine length (6.80 m), nodes per vine (22.01) and leaf area (274.00 cm²). The CCC 300 ppm (T_9) treatment produced maximum primary branches (22.97) and secondary branches (9.30) per vine but minimum vine length (4.36 m), nodes per vine (18.05) and leaf area (203.26 m²) were observed in this treatment. The results showed that ethrel 450 ppm significantly increased female flower (22.65), fruit length (61.50 cm), fruit set (67.11%), fruit retention (50.20%), fruit weight (1.311 kg) fruit yield per vine (7.55 kg) and per hectare (549.84 g), net return (212120 per hectare) and B:C ratio (3.38). All over the results showed that most effective treatment for increasing the fruit growth and yield of bottle gourd was ethrel 450 ppm with cost benefit ratio (3.38).

Key words : Thiourea, Etherel, NAA

Introduction

Bottle gourd [*Lagenaria siceraria* (Molina) Standl.] cv. Pusa summer prolific long is a commonly grown and used vegetable in India. It is economically found growing in Ethiopia, Africa and Central America. It belong to family cucurbitaceae. Besides an important vegetable crop it has also got good medicinal value as well as nutritional value. Due to these qualities and people now a days becoming more health conscious. The intake of its demand have been increasing day by day. The fruits are also used as vegetable or for making sweets/halwa, kheer, petha, barfi and pickles. In India, bottle gourd is grown in the area of 11.69 thousand hectares with annual production of 142.82 thousand tones and having 12.21 tonnes/hectares productionvity (Sindhu, 2002). It occupies 5,120 hectares area in Rajasthan producing 17857 metric tones with a productivity of 3.4876 tonnes ha⁻¹ (Anonymous, 2011). In Jaipur district is occupies 1164 hectares area producing 1419 metric tones with a productivity of cucurbits, the growth regulators are more important due to their direct effect on males and female flowers ratio, fruit set, fruit drop and ultimately on yield. The use of plant growth regulators at proper stage play an important role in sex expression and yield of bottle gourd (Sircar, 1971). In bottle gourd, the production of staminate flowers is much more than pistillate flower. These situations lead to the use of plant growth regulators like NAA, Ethrel and CCC in bottle gourd which play an important role in sex expression and sex ratio and thiourea plays a vital role in

the physiology of plants both as a sulphhydryl compound and to some extent as an amino compound like urea. The stimulating action of thiourea in various physiological activities of plants is well known. Keeping these facts in view, the present investigation was under taken with objectives to know the effect of plants growth regulators and thiourea on growth yield and quality of bottle gourd.

Material and method

A field experiment on Bottle gourd cv. Pusa summer prolific long was carried out during kharif season of the year 2012 at college farm, S.K.N. College of Agriculture, Jobner (Jaipur). The soil having 8.2 pH, 0.85 EC (dSm⁻¹) and 0.13% organic carbon. The treatment comprised of plant growth regulators and thiourea viz. T_0 (control), T_1 (100 ppm NAA), T_2 (200 ppm NAA), T_3 (300 ppm NAA), T_4 (150 ppm Ethrel), T_5 (300 ppm ethrel), T_6 (450 ppm ethrel), T_7 (100 ppm CCC), T_8 (200 ppm CCC), T_9 (300 ppm CCC), T_{10} (250 ppm thiourea), T_{11} (500 ppm thiourea), T_{12} (750 ppm thiourea) were tested in randomized block design with three replications. The gross plot size was 6m x 3m with spacing of 2.5 m x 0.75 m (row x plant spacing). The bottle gourd three to four seeds per pit were sown on 12th July 2012 by dibbling method. Bottle gourd crop was fertilized with recommended dose i.e. 250 FYM, 60, 40, 60 NPK kg ha⁻¹. Nitrogen, phosphorus and potash fertilizer were applied in the form of urea, single super

phosphate and muriate of potash respectively. Half dose of nitrogen and whole quantity of phosphorus and potash were applied. The remaining half dose of nitrogen (60 kg/ha) was top dressed after one month of sowing. The observation on growth and yield parameters were recorded during investigation.

Results and Discussion

The data regarding the effect of plant growth regulators and thiourea on vine length are presented in Table 1. The data revealed that plant growth regulators and thiourea significantly increased as well as decreased the vine length and number of nodes per vine. The maximum vine length and number of nodes per vine was recorded under foliar spray of NAA 300 ppm (T₃) and minimum with CCC 300 ppm (T₉) but treatment NAA 200 ppm (T₂) was found at par with NAA 300 ppm (T₃). Chhonkar and Singh (1959) opined that the increase in vine length under application of NAA was on account of its stimulatory effect on observation of available nutrient present in the soil or by the modification in plant root system through the associated microflora of the soil similar results were also reported by Das and Das (1996) in pumpkin due to application of NAA (150 ppm).

The increased nodes on vine axis under exogenous application of NAA 250 ppm might be due to stimulatory effect of NAA on vine growth, cell division, cell elongation, cell enlargement (Chhonkar and Singh, 1959).

The maximum leaf area was found under exogenous application of NAA 300 ppm (T₃) and minimum in CCC 300 ppm (T₉) are presented in Table 2. The treatment NAA 200 ppm (T₂), NAA 100 ppm (T₁), Ethrel 150 ppm (T₄), Ethrel 300 ppm (T₅), Thiourea 250 ppm (T₁₀), Thiourea 800 ppm (T₁₁) and thiourea 750 ppm (T₁₂) were found statistically at par with NAA 300 ppm (T₃).

The effect of NAA on leaf area might be due to physiological process of plant that leads to accumulation of carbohydrates and minerals, which showed that gibberellins and auxins have some role in leaves other than cell elongation. These finding are in close conformity with the results reported by Sharma et al., (1988) in bottle gourd, Kabir et al., (1989) in bitter gourd, Das and Maurya (1992) and Das and Das (1996) in pumpkin, respectively.

The results of the present investigation revealed that the maximum number of primary branches and secondary branches were found under CCC 300 ppm (T₉) and minimum number of primary branches and secondary branches were found in control respectively (Table 3). These results are also in accordance with Randhawa and Singh (1976) in bottle gourd.

Among different treatment NAA 300 ppm (T₃) showed minimum days for first male flower appearance as compared to control (T₀) are presented in Table 4. The results obtained are in agreement with those Baruas and Das (1997) in

Bottle gourd, respectively.

The application of Ethrel significantly scheduled the days taken to first female flower reduced the days taken to first female flower appearance as compared to control are presented to Table 4. Among different treatment ethrel 450 ppm (T₆) showed minimum days for first female flower appearance as compared to control. The results were obtained by Verma et al. (1984) in bitter gourd.

The response of different treatment of different treatment on number of male and female flower per vine differed significantly (Table 5). As regards the number of male and female flower, it was observed that ethrel 450 ppm (T₆) treatment produced minimum number of female flowers per vine, respectively as compared to control where maximum number of male flowers and minimum number of female flowers per vine was produced. The results obtained area in accordance with the earlier findings of Sindhu et al. (1982) in Muskmelon, Saimbhi and Thakuar (1974) in bottle gourd.

Effect of plant growth regulators and thiourea was significantly different on fruit characters. The maximum fruit length was observed under ethrel 450 ppm (T₆) as compared to minimum fruit length in control (T₀), respectively (Table 6). These results are in conformity with Singh and Choudhary (1989) and Kumar et al. (2006) in bottle gourd.

The maximum fruit set was found under ethrel 450 ppm (T₆) and minimum in control (T₀) are presented to Table 7. The results reported by Hidayatullah et al. (2009) in monoecious cucumber.

The maximum fruit retention was found under ethrel 450 ppm (T₆) and minimum in control (T₀) are presented to table 7. This findings is in accordance with Singh and Agrez (2000) in mango.

Results showed that spray of plant growth regulators and thiourea significantly increased the fruit weight are presented to Table 8. The maximum fruit weight was recorded under ethrel 450 ppm (T₆) and minimum in control (T₀). These finding are in close consonance with those of Kshirsagar et al. (1996) in cucumber Sharma et al. (1988) and Patel (1992) in bottle gourd.

The maximum fruit yield per vine and per hectare under ethrel 450 ppm (T₆) might be due to higher number of female flower, higher number of fruits and higher fruit weight under ethrel 450 ppm (T₆) are presented to table 8. These finding are in close conformity with those of Kumar et al. (2006) in bottle gourd, Das and Das (1996) in pumpkin and Jadav et al. (2010) in cucumber.

Among the different treatment of plant growth regulators and thiourea significantly higher net returns and B:C ratio were obtained under the application of ethrel 450 ppm (T₆). This was due to higher yield in the treatments ethrel 450 ppm (T₆) resulting in higher net returns are presented to table 10).

Table 1. Effect of plant growth regulators and thiourea

Treatments	Vine length (m)	No. of nodes per vine	Leaf area (cm ²)	No. of primary branches per plant	No. of secondary branches per plant	Male flower	Female flower	No. of male flower per plant	No. of female flower per plant	Length of fruit set (cm)	Fruit retention	Fruit weight (kg)	Fruit yield /vine (kg)	Fruit yield/ hectare (g)	Net returns	B:C ratio
T ₀ Control	4.50	20.12	210.40	8.01	4.05	58.12	56.13	95.17	14.40	38.15	48.80	15.60	1.103	5.70	349.25	112546 1.81
T ₁ NAA 100 ppm	6.80	24.42	260.10	13.40	6.15	40.70	50.20	80.49	17.52	49.10	56.20	31.40	1.107	6.15	378.19	126147 2.00
T ₂ NAA 200 ppm	6.17	25.50	261.00	11.60	5.60	40.40	49.30	85.50	18.57	52.90	63.40	31.80	1.116	6.40	396.76	134530 2.11
T ₃ NAA 300 ppm	6.80	26.40	274.00	10.70	5.40	40.00	47.60	71.40	19.26	53.00	65.00	35.00	1.224	6.95	472.55	171594 2.65
T ₄ Ethrel 150 ppm	5.50	24.40	240.00	14.70	6.30	49.00	45.00	76.55	19.68	52.00	58.20	43.74	1.280	7.02	499.15	187257 3.00
T ₅ Ethrel 300 ppm	5.00	23.13	226.60	16.18	7.16	47.50	43.28	68.51	22.07	56.25	65.40	49.23	1.290	7.45	533.86	204373 3.27
T ₆ Ethrel 450 ppm	4.53	22.01	215.00	17.25	7.60	46.55	35.10	65.60	22.55	61.50	67.11	50.20	1.311	7.55	549.84	212120 3.38
T ₇ CCC 100 ppm	4.50	19.92	225.56	18.50	8.20	56.05	52.89	78.23	18.60	44.33	59.66	22.87	1.250	6.14	426.35	150415 2.40
T ₈ CCC 200 ppm	4.40	18.98	214.80	18.78	8.32	54.00	52.13	73.81	19.08	46.65	61.25	26.50	1.260	6.40	447.96	160539 2.53
T ₉ CCC 300 ppm	4.36	18.05	203.26	20.97	9.30	52.00	52.08	70.18	20.44	48.35	64.15	29.00	1.272	6.70	473.42	172591 2.69
T ₁₀ Thiourea 250 ppm	5.79	25.82	243.05	13.39	6.14	45.79	50.25	75.80	18.51	57.80	57.45	29.55	1.117	6.08	377.26	126374 2.03
T ₁₁ Thiourea 500 ppm	5.47	23.35	258.10	11.58	5.25	41.20	49.10	70.77	17.50	52.50	61.85	30.81	1.125	6.30	393.71	134422 2.15
T ₁₂ Thiourea 750 ppm	5.00	22.15	258.90	11.70	5.41	41.17	49.08	70.68	17.48	52.53	64.55	30.79	1.127	6.65	416.32	145550 2.32
SEm±	0.35	1.23	10.95	0.75	0.34	1.98	2.80	4.33	1.19	2.64	2.55	2.21	0.050	0.32	18.97	9042 0.14
CD (P=0.05)	1.01	3.58	31.95	2.19	0.98	5.79	8.18	12.63	3.47	7.70	7.45	6.46	0.14	0.94	55.36	26393 0.42

Reference

- Anonymous 2011. Vital Agriculture statistics. Directorate of Agriculture, Government of Rajasthan, Jaipur. pp. 155.
- Baruas, G.K.S. and Das, R.K. 1997. Effect of plant growth regulators on yield of bottle gourd at different sowing dates. *Annals of Agricultural Research*, 18 (3): 371-374.
- Chhonkar, V.S. and Singh, S.N. 1959. Effect of L-Napthalene acetic acid on the growth, quality and yield of tomato. *Indian Journal of Horticulture*, 16 (4): 236-242.
- Das, B.C. and Das, T.K. 1996. Studies on the response of GA₃, NAA and ethrel on vegetative growth and yield of pumpkin. *Orissa Journal of Horticulture*, 24 (1&2): 74-78.
- Das, T.K. and Maurya, A.N. 1992. Efficacy of growth regulating substances on vegetative growth and yield of pumpkin. *Orissa Journal of Agricultural Research*, 5 (1&2): 69-74.
- Hidayatullah, A., Bano and Khokhar, K.M. 2009. Sex expression and level of phytohormones in monoecious cucumber as effected by plant growth regulator. *Sarhad Journals of Agriculture*, 25 (2): 173-177
- Jadav, R.G., Patel, T.V., Parmer, A.B. and Saiyad, M.Y. 2010. Sex modification of cucumber vegetable through PGRs. *Journal of Pure Applied Sciences*, 18 : 13-14.
- Kabir, J., Chatterjee, R., Biswas, B. And Mitra, S.K. 1989. Chemical alteration of sex expression in bitter gourd. *Progressive Horticulture*, 21 (1-2): 69-72.
- Kshirsagar, D.B., Desai, V.T., Patil, B.T. and Pawar, B. 1996. Effect of plant growth regulators on sex expression and fruiting in cucumber cv. Himangi. *Journal of Maharashtra Agricultural Universities*, 20 (3) : 473-474.
- Kumar, S., Dixit, S.K. and Mishra, H.R. 2006. Effect of plant growth regulators on yield and yield attributing characters of bottle gourd. *Advances of Plant Science*, 19(2): 419-421.
- Patel, A.K. 1992. Assessment of the effectiveness of MH and CEPA on growth, sex behaviour and yield of bottle gourd. *South Indian Horticulture*, 36(6): 336-339.
- Randhawa, K.S. and Singh, D. 1976. The effect of certain growth influencing substances and sowing techniques on the vegetative growth, sex ratio, early and total yield of bottle gourd. *Journal of Research Punjab Agriculture University*, 13 : 367-371.
- Randhawa, K.S. and Singh, D. 1976. The effect of certain growth influencing substances and sowing techniques on the vegetative growth, sex ratio, early and total yield of bottle gourd. *Journal of Research Punjab Agriculture University*, 13 : 367-371.
- Saimbhi, M.S. and Thakur, M.R. 1974. Growth, sex expression and yield of bottle gourd as affected by CEPA-TIBA and CCC. *Haryana Journal of Horticultural Sciences*, 3 (3&4): 195-200.
- Sharma, N.K. Arora, S.K. and Dhankar, B.S. 1988. Effect of plant growth substances on growth, flowering, sex expression and fruit yield in bottle gourd. *Haryana Agricultural University Journal of Research*, 18 (4): 291-297.
- Sidhu, A.S. 2002. Current status of vegetable research in

- India, Tropical Seed Company Publication and Research Articles.
- Sidhu, A.S., Pandita, M.L. and Hooda, R.S. 1982. Effect of growth regulators on growth, flowering, yield and quality of muskmelon. *Haryana Agricultural University Journal of Research*, 12 : 231-235.
- Singh, R.K. and Choudhary, B. 1989. Differential response of three genera of cucurbits to boron and plant growth regulators. *Indian Journal of Horticulture*, 46 (2) : 215-221.
- Singh, Z. and Agrez, V. 2000. Fruit set, fruit retention and yield of mango in relation to ethylene. International symposium on tropical and subtropical fruits, *ISHS Acta Horticulturae*, 575.
- Sircar, S.M. 1971. Flowering, parthenocarpy and fruit setting. *Plant Hormone Research in India*, 1 : 11.
- Verma, V.K., Sirohi, P.S. and Choudhary, B. 1984. Note on the response to chemical seed treatment on sex expression and fruiting in bitter gourd. *Indian Journal of Horticulture*, 41 : 113-115.

Response of chilli (*Capsicum annuum* L.) to organic and inorganic mulches

Puspa Laxmi Debbarma*, Pinaki Acharyya and Uttam Saha
University of Calcutta, 51/2 Hazra Road, Kolkata-700019

* Corresponding authors e-mail: puspadebbarma13@gmail.com
(Received : 01.11.2015; Accepted: 4.01.2016)

Abstract

A field study was conducted to evaluate the effect of different mulch materials on growth, yield and qualitative characters of chilli (cv. Bullet) from Feb to June 2013. Different mulches used were black polyethylene mulch, yellow polyethylene mulch, transparent polyethylene mulch, mango leaf, paddy straw, saw dust and sun grass and bare soil was the control. Different mulches generated higher soil temperature and moisture regimes over the control. Weed population was significantly suppressed under black polyethylene mulch. Days to 50 per cent flowering and days to first harvest were recorded at 44.93 and 46.23 days after transplanting under black polyethylene mulch as compared to rest of the treatments. Plant height, number of primary branches per plant, number of leaves, fruit yield, average fruit weight recorded higher values under black polyethylene mulches however, it failed to have significant impact on fruit quality parameters.

Keywords: Chilli, mulching, yield, qualitative traits

Introduction

Chilli (*Capsicum annuum* L.) is an important vegetable crop and belongs to the family Solanaceae. Chilli is widely cultivated throughout tropical and subtropical zones and is native to Mexico. In West Bengal, chilli is cultivated round the year. The growth and development of this crop is influenced by many edaphic factors but optimum soil temperature and moisture are the two most crucial inputs. Water deficit often limits the crop growth and development. Young chilli seedlings cannot withstand either water deficit or excess soil moisture while older plants can withstand deficit or excess water (Ayoub, 1986). Similarly, heavy rains too pose a constraint as the plants are incapable of tolerating too damp a situation or submergence. In the winter, production is hampered due to lack of irrigation as well as minimal rainfall. Most determinate crops are sensitive to water stress especially at the time of floral initiation, during flowering, and to a lesser extent, during fruit development (Hegde, 1989). In crops, where the vegetative growth and reproductive processes overlap, the reason for water stress becomes difficult to explain (Begg and Turner, 1976). To improve the productivity of crops where either water deficiency or excess frequently occurs, proper water management is necessary (Hale and Orcutt, 1987). During the summer months, the conservation of soil moisture may help in preventing the loss of water through evaporation from the soil facilitating maximum utilization of moisture by the plants.

Organic mulch (plant materials) and synthetic mulches (plastic of different colours) are widely used in vegetable production for their efficacy to conserve soil moisture by altering water distribution between soil evaporation and plant transpiration, and modifying soil temperature. Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and

checks the water evaporation. Thus, it facilitates better retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Dilipkumar et al., 1990). The present study was undertaken to evaluate the changes in temperature and soil moisture and to evaluate the growth, yield and quality of chilli under humid tropical conditions grown under different mulch materials.

Materials and Methods

The field experiment was laid out during Feb to June 2013 at Agricultural experimental farm of Calcutta University at Baruipur, 24- Parganas (South). The soil was uniform, fertile medium texture, clay loam having pH 6.4. The experiment was laid out in a randomized block design (RBD) having three replications. The seeds were sown in chilli pots on 2nd December, 2012. Before sowing, the seeds were treated with Bavistin @ 2g/kg seeds to check the damping off, to enhance germination and to get a healthy crop stand. The experimental land was ploughed and cross ploughed 2 to 3 times. Split application of NPK was applied @ 50:25:25 kg/ha. Full dose of phosphorus, potassium and one third of nitrogen were applied after preparation of pits. The remaining nitrogen was applied in 2 split doses successively at one month interval from transplanting. Mulched layers were placed before transplanting and an "x" cut was given at a spacing of 45 x 45 cm, to accommodate ten plants per plot. After 45 days, transplanting was carried out in the mulched field. Requisite cultural practices in form of timely irrigation, weeding and pesticides application were done. When the plants attained an optimum height, bamboo stakes were tied to support the crops for proper stand. The data were recorded on five randomly selected plants in each plot for the entire morphological feature, and yield attribute characters as well as estimation of

some qualitative parameters. For qualitative characters the observations were recorded from composite samples of five fruits in each plot.

To study the qualitative parameters like total chlorophyll content of leaves and ascorbic acid content was done following the method of Arnon and Witham (1949 and 1971) and Rangana (1986).

Data collected on various parameters were statistically analysed (Panse and Sukhante, 1978) to evaluate the treatment effects on morphological traits, yield and qualitative performance of chilli.

Data on weed counts were collected from each plot of all replicates. For weed count half square meter area (0.5 m x 0.5 m) was fixed randomly before emergence of weeds. Total amount of weeds growing within the area were weighed on fresh weight basis. These observations were recorded 45 days after transplanting.

Data on soil temperature was measured by use of Fisher band bimetal dial thermometer. Thermometers were installed between rows in centre of one replication of each treatment at 10 cm depth. The temperatures in °C were recorded daily for maximum at 2.30 hrs. Soil moisture estimation was carried out through gravimetric method.

Results and Discussion

Organic as well as synthetic mulches significantly increased the plant height, number of primary branches per plant, leaf area and fruit yield over the control (Table 1 and Table 2). The effect of synthetic mulches was more pronounced on fruit yield than the organic mulches. Higher fruit yield under black polyethylene was ascribed to favourable and integrated effect of moderation in hydrothermal regime that enhanced the root growth for better uptake of water nutrients and lesser weed population thus producing better height and plant spread (Munguia *et al.* 1998 and Gollifer 1993).

Minimum days to 50 percent flowering (44.93 days) and days from fruit set to fruit maturity were observed in plants grown under black polyethylene mulch. Organic mulches and unmulched ones exhibited delayed 50 percent flowering. It is well known fact that mulches create favourable condition such as higher temperature, conserves soil moisture and reduces weed population, which accelerates plant growth and early flowering. Similar findings were reported by Vos and Sumarmi (1997).

Estimation of important qualitative components viz, total chlorophyll content of leaf (mg/g) and ascorbic acid content (mg/g) were done as depicted in Table 3. Chlorophyll is one of the major chloroplast components for photosynthesis and relatively higher chlorophyll content (stay green) had a positive relationship with photosynthesis (Shangguan *et al.*, 2000). In chilli, mulching with black polyethylene exhibited higher total chlorophyll content with respect to other treatments followed by yellow polythene mulch and mango leaf mulch. Least chlorophyll content was observed in

transparent polyethylene mulch. Similar to present findings, earlier Bahadur *et al.* (2009) observed significant increase in chlorophyll content. An optimum soil moisture and hydrothermal soil regime with relative water content might have contributed for improved physiological attributes of plant under mulched condition.

Ascorbic acid content of fruit was least affected by different mulch materials.

Dry weight content of weed (g/m²)

The dry weight of weeds per plot was significantly influenced by different mulch materials (Table 4). The average dry weight of weed was least under black polyethylene mulch. Transparent polyethylene mulch showed higher dry weight of weed among the mulches. Straw mulch was also found to be most effective in controlling weed growth as compared to other organic mulches and control (Singh, 1994 and Srivastava *et al.* 1994).

Soil temperature (°C)

Soil temperature at 10cm depth (Fig-1) was markedly influenced by different mulch materials. The maximum increase in soil temperature at noon was observed under transparent polyethylene mulch (1.98°C to 3.23°C). Increase in soil temperature under transparent polyethylene mulch is attributed to its greenhouse effect (Hanks *et al.* 1961, Mahrer *et al.*, 1984). It has been observed that transparent mulch permits the incoming short wave radiation to pass through but its transmissivity to long wave radiation is highly reduced due to formation of water droplets on its lower surface. These observations are in accordance to the findings of Gupta and Acharya (1993) and Ashworth and Harrison (1983). Organic mulches lowered the soil temperature by 0.75°C to 2.74°C. The decrease in soil temperature under such vegetative mulches is partially due to their higher albedo (not measured) partially due to greater conservation of solar energy into evaporative flux and increase in diffusion path of heat transfer to the soil (Gupta and Acharya 1993).

Soil moisture (per cent)

Maximum soil moisture content (Fig 2) during the cropping season was recorded under black polyethylene mulch which conserved 18.34 percent higher moisture level than control, followed by yellow and transparent mulch. Increased soil moisture in the synthetic mulch treatments might be due to increased infiltration capacity, reduced atmospheric losses from soil surface and increased resistance to vapour transfer from soil surface to the atmosphere. Among the organic mulches, paddy straw was found most effective followed by mango leaf. It is an established fact that mulching the soil surface with vapour barrier or with reflecting materials can reduce the intensity with which external factors such as radiation and wind act upon the surface. Similar findings were observed by Srivastava *et al.* (1984). Beneficial effect of organic mulches in reducing evaporation as reflected by

Table 1. Effect of different mulch materials on morphological traits of chilli (*Capsicum annum*, L. var. Bullet

Treatments	Plant height (cm)	Number of Primary branches per plant	Total number of leaves per plant	Leaf length (cm)	Leaf width (cm)	Leaf area (cm ²)	Days to 50 percent flowering	Days from fruit set to fruit maturity
T ₁	57.50	4.61	260.25	8.26	3.49	13.25	44.93	46.23
T ₂	54.73	4.33	252.10	7.85	3.07	12.85	49.60	49.83
T ₃	56.00	4.60	259.46	8.11	3.40	13.22	46.66	46.89
T ₄	54.10	4.33	252.21	7.99	3.08	13.10	49.00	49.00
T ₅	53.46	4.26	255.33	7.99	3.34	13.13	48.66	47.93
T ₆	54.23	3.66	249.43	7.73	3.06	12.59	51.33	50.43
T ₇	53.16	3.66	243.70	7.58	3.14	12.66	53.13	50.00
T ₈	48.70	2.66	225.76	7.44	2.99	12.84	56.73	54.23
C.D. at 5%	2.53	0.89	6.51	NS	0.32	NS	3.56	3.43

Note: T1-Black polyethylene mulch, T2-Mango leaf mulch, T3-Yellow polyethylene mulch, T4-Paddy straw mulch, T5-Transparent polyethylene mulch, T6-Saw dust mulch, T7-Grass mulch, T8- Control (without any treatment).

Table 2. Effect of different mulch materials on fruit characters and yield of chilli (*Capsicum annum* L. Var. Bullet

Treatments	Number of fruits per plant	Individual fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Pedicle length (cm)	Average fruit weight per plant (g)
T ₁	47.51	3.38	3.75	3.44	2.76	152.23
T ₂	42.53	3.22	3.37	3.25	2.37	139.58
T ₃	44.73	3.33	3.65	3.36	2.47	144.82
T ₄	43.73	3.31	3.38	3.35	2.27	140.78
T ₅	44.03	3.32	3.58	3.31	2.63	142.02
T ₆	41.00	3.22	3.37	3.31	2.51	130.36
T ₇	41.66	3.21	3.25	3.14	2.36	129.50
T ₈	32.60	3.19	3.23	3.15	2.26	107.41
C.D. at 5%	1.82	NS	NS	NS	NS	14.40

Note: T1-Black polyethylene mulch, T2-Mango leaf mulch, T3-Yellow polyethylene mulch, T4-Paddy straw mulch, T5-Transparent polyethylene mulch, T6-Saw dust mulch, T7-Grass mulch, T8- Control (without any treatment).

Table 3. Effect of different mulch materials on qualitative characters of chilli (*Capsicum annum* L. Var. Bullet

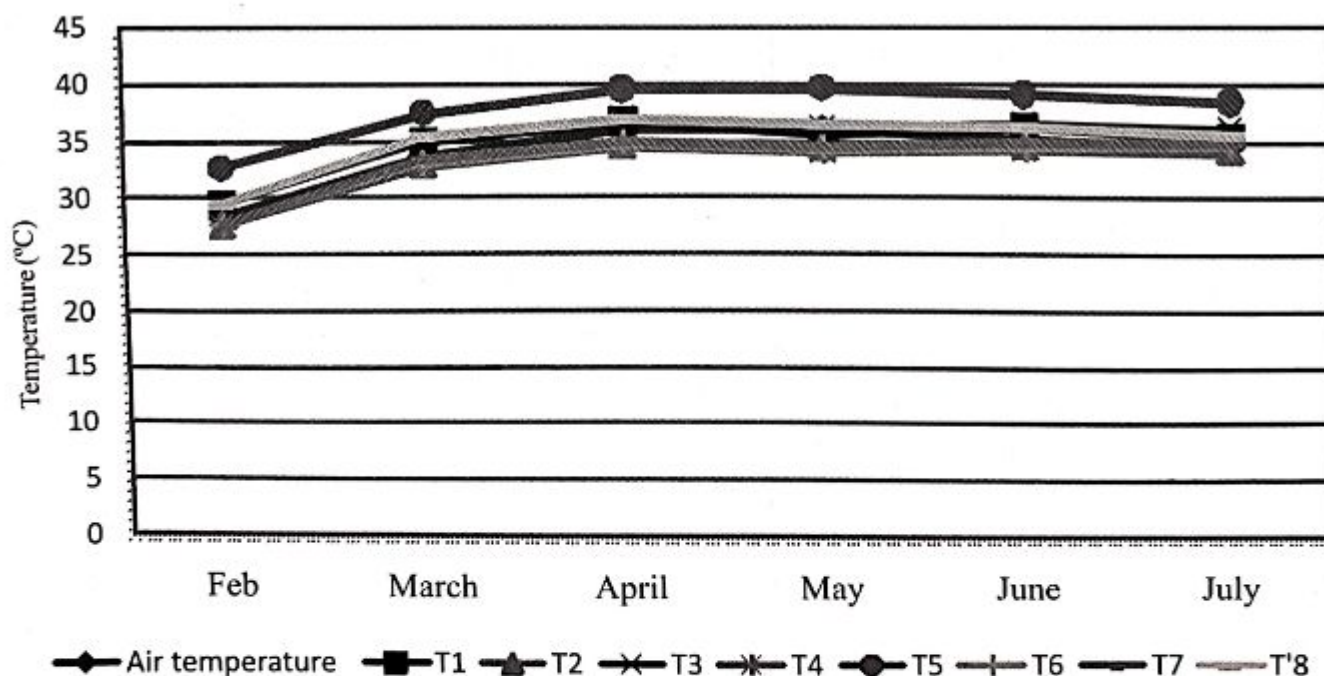
Treatments	Total chlorophyll content of leaf (mg/g)	Ascorbic acid content (mg/g)
T ₁	1.04	102.86
T ₂	0.87	101.46
T ₃	0.88	102.30
T ₄	0.78	101.80
T ₅	0.64	102.50
T ₆	0.73	101.54
T ₇	0.76	101.68
T ₈	0.75	101.69
C.D. at 5%	0.10	NS

Note: T1-Black polyethylene mulch, T2-Mango leaf mulch, T3-Yellow polyethylene mulch, T4-Paddy straw mulch, T5-Transparent polyethylene mulch, T6-Saw dust mulch, T7-Grass mulch, T8- Control (without any mulch).

Table 4. Effect of different mulch materials on weed populations of Chilli (*Capsicum annum* L. var., Bullet

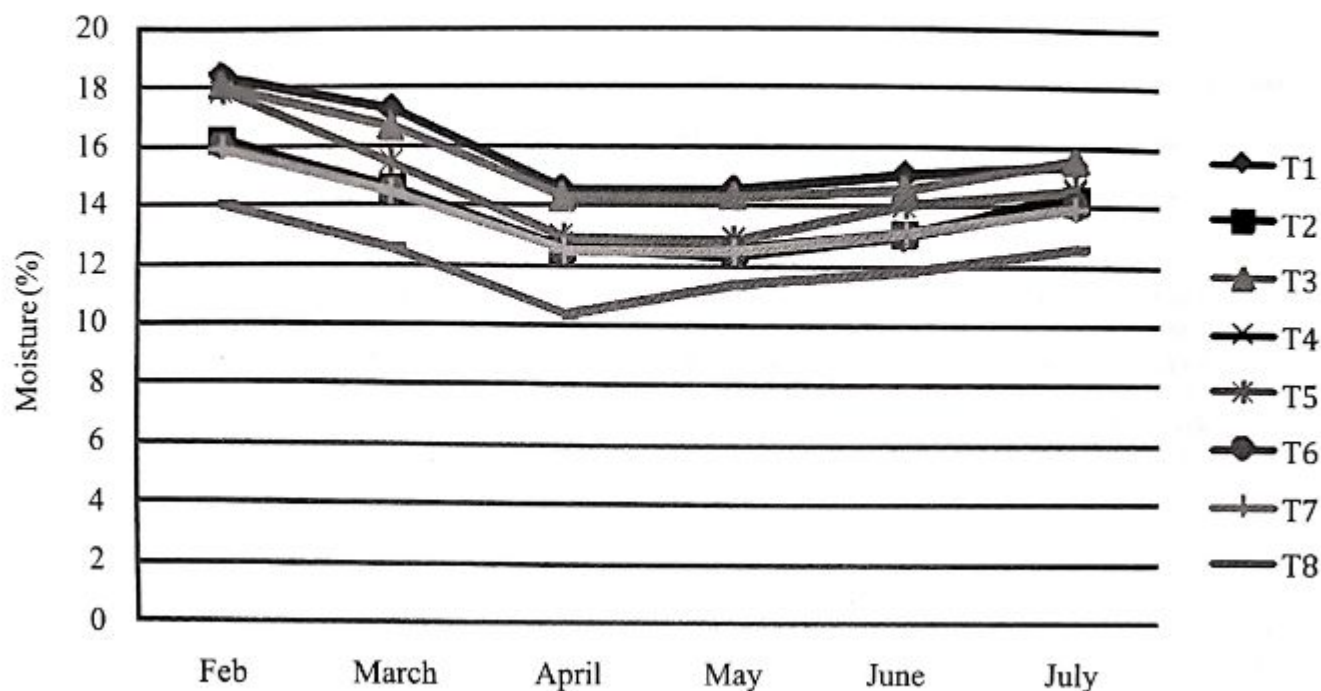
Treatments	Weed content (g)
T ₁	16.62
T ₂	20.90
T ₃	17.62
T ₄	20.26
T ₅	30.93
T ₆	22.23
T ₇	22.00
T ₈	43.83
C.D. at 5%	2.21

Note: T1-Black polyethylene mulch, T2-Mango leaf mulch, T3-Yellow polyethylene mulch, T4-Paddy straw mulch, T5-Transparent polyethylene mulch, T6-Saw dust mulch, T7-Grass mulch, T8- Control (without any mulch).



T₁ - Black polyethylene mulch, T₂ - Mango leaf mulch, T₃ - Yellow polyethylene mulch, T₄ - Paddy straw mulch, T₅ - Transparent polyethylene mulch, T₆ - Saw dust mulch, T₇ - Sun grass Mulch, T₈ - Control (without any mulch).

Fig-1:- Mean monthly Soil Temperature at 10 cm depth under different mulch materials and unmulched control in Chilli (*Capsicum annum* L.), cv. Bullet.



T₁- Black polyethylene mulch, T₂- Mango leaf mulch, T₃- Yellow polyethylene mulch, T₄- Paddy straw mulch, T₅- Transparent polyethylene mulch, T₆- Saw dust mulch, T₇- Sun grass mulch, T₈- Control (without any mulch).

Fig-2: - Soil Moisture content (%) at 15 cm depth under different mulches and unmulched control in Chilli (*Capsicum annuum* L.), cv. Bullet.

increased moisture storage in soil has also been reported by various workers (Serk and Spaan. 1997).

References

- Ashworth, S. and Harrison, H. 1983. Evaluation of mulches for use in the home garden. *Hort Sci.*, 18: 180-182.
- Ayoub, K. 1986. Effect of available soil moisture on the yield of chilli (*Capsicum annuum*). *Technology Sayur Sayuran*, 2: 57-59.
- Bahadur, A., Lama, T.D., Rai, A., Sharma, R.P and Singh, K.P. 2009. Response of hybrid tomato to drip irrigation scheduling and Plastic mulching. *Veg. Sci.*, 36: 175-78.
- Begg, J. E. and Turner, T. C. 1976. Crop water deficits. *Adv. Agron.*, 28: 161-217.
- Dillip Kumar, G., Sachin, S.S. and Rajesh, Kumar. 1990. Importance of mulch in crop production. *Indian J. Soil. Cons.*, 18: 20-26.
- Gollifer, D. E. 1993. Effects of application of mulch and K on *Capsicum annuum*. *Papua New Guinea J. Agri. For. and Fisheries*, 36: 22-29.
- Gupta, R. And Acharya, C.L. 1993. Effect of mulch indeed hydrothermal regime on root growth, water use efficiency, yield and quality of strawberry. *J. Indian Soc. Soil Sci.*, 41: 17-25.
- Hegde, D. M. 1989. Effect of soil moisture and nitrogen on plant water relations, mineral composition and productivity of bell pepper (*Capsicum annuum* L.). *Indian J. Agron.*, 34: 30-34.
- Hale, M. G. and Orcutt, D. M. 1987. The physiology of plants under stress. *Wiley Interscience*. New York.
- Hanks, R.J., Bowers, S.A. and Bark, L.D. 1961. Influence of soil surface conditions on net radiation, soil temperature and evaporation. *Soil Sci.*, 91: 233-238.
- Mahrer, Y., Naot, O., Rawitz, E. And Katan, J. 1984. Temperature and moisture regimes in soils mulched with transparent polyethylene. *Soil Science Society of American Journal*, 48:362.
- Munguia, L.J., Quezada, R., Zermeno, G.A. and Penna, V. 1998. Plastic mulch effect on the spatial distribution of solutes and water in the soil profile and relationship with growth and yield of muskmelon crop. *Plasticulture*, 116: 27-32.
- Panse, V.G. and Sukhante, P.V. 1989. Statistical methods for

agricultural workers. Indian council of Agricultural Research, New Delhi, India.

Ranganna, S. 1986. Hand book of analysis and quality control for fruit and vegetable productivity, Tata Mc Graw Hill Publishing Co., (second edition), 123-124: 126-127.

Shangguan, Z.P., Shao, A., and Dyckmar, I. 2000. Effect of nitrogen and water deficit on net photosynthetic rates and chlorophyll fluorescence in winter wheat. *J. Plant Physiology*, 156: 46-51.

Singh, I.P. 1994. Effect of organic mulches on weed population, yield and percentage of sun scald fruits of summer tomato variety Pant Bahar. *Recent Hort.*, 1: 80-83.

Shrivastava, P.K., Parikh, M.M. and Swami, N.G. 1994. Effect

of drip irrigation and mulching on tomato yield. *Agril. Water Management*, 25: 179-184.

Srivastava, B.K., Sharma, A.K., Singh, N.P. and Pandey, U.B. 1984. Effect of organic mulches and irrigation levels on soil temperature, water economy and yield of summer tomato. *Veg. Sci.*, 11(1): 1-9.

Sterk, G. And Spaan, W.P. 1997. Wind-erosion control with crop residues in the Sahel. *Soil Science Society of America Journal*, 61: 911-16.

Vos, J. G. M. and Sumarni, N.1997. Integrated crop management of hot pepper (*Capsicum_spp.*) under tropical lowland conditions. Effects of mulch on crop performance and prediction. *J. Horti. Sci.*, 72: 415-424.

Variability in *bael* (*Aegle marmelos* Correa) germplasm collected from Rajasthan

R.S. Singh*, S. R. Meena, A.K. Singh, R. Bhargava and B. D. Sharma
ICAR- Central Institute for Arid Horticulture, Bikaner-334 006 (Rajasthan)

*Corresponding author e- mail: rssinghl@yahoo.com

(Received: 28.09.2015; Accepted: 8.12.2015)

Abstract

Bael (*Aegle marmelos* Correa.) is a nutritive and medicinally important drought hardy fruit tree found throughout the country. Its fruit is eaten as fresh and also used for making several value added products. A survey for biodiversity of *bael* was conducted in Chomu, Jaipur, Sariska area of Alwar district during April-May, 2014 to identify elite type germplasm having better horticultural traits. Twelve fruit samples from different location were collected for physical and biochemical analysis. Seedlings of different age groups were available on the farmer's field. However, in Sariska forest naturally grown *bael* trees having very small size fruits of inferior quality were observed. Variability in fruit shape- oval to cylindrical, round, fruit weight from 0.580kg to 1.860kg, number of fruit 21- 130 per tree was observed. The pulp colour light yellow to dark yellow and TSS ranged from 22.4 to 40.6°brix. Out of these, four plus tree (*Bael* accession, 4, 6, 10 and 12) were marked having superior bearing habit, medium fruit size and better fruit quality in respect of pulp colour, taste, high TSS (°brix) content and low acidity (0.22%) for further study.

Key words: *Bael*, *Aegle marmelos*, variability, germplasm, Sariska forest, Rajasthan,

Introduction

Bael (*Aegle marmelos* Correa.) is an important fruit tree for semi arid and hot arid regions of the country. It is a highly nutritious and favorite fruit throughout the country because of its medicinal and nutraceutical values. Besides fresh eaten, many products like jam, squash, candy, nectar, beverages, powder, RTS, etc. are prepared from fruits (Singh and Roy, 1984; Sharma *et al.* 2007; Singh *et al.* 2011). This fruit can supplement the dietary needs of the rural people, where very less nutritious fruit is available. Exploitation of its horticultural traits is necessary to increase fruit production in low rainfall areas. Analysis of the fruit gave the following values: 61.5g moisture, 1.8 g protein, 0.39 g fat, 31.8 g carbohydrates, 1.7 g minerals, 55 mg carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1mg niacin and 8.0 mg vitamin C per 100 g of edible portion (Gopalan *et al.* 1985). In India, *bael* fruits mature after 10-11 month of flowering and harvested during mid March to mid June. In recent times, to make better use of fruits there has been a renewed interest in the *bael* as a main component in ayurvedic preparations, health food, beverages and delicious drink, etc (Singh *et al.* 2011).

Keeping in view, a survey was under taken in villages of Chomu tehsil, Jaipur, Sariska forest, Alwar district, Rajasthan to identify trees having better quality of fruits, higher fruits yield, medium to heavy bearing types, suitability for processing and fruit cracking tolerance. The details of survey, identification of elite type, fruiting and quality characters and production system have been discussed in this paper.

Material and Methods

A survey was undertaken during the year 2014 to identify genotypes having better quality and productivity of fruits and also having tolerance to cracking. The farmer's field and forest area were surveyed in villages near by Chomu, Karvakidhani, Jaipur and Bhakeda, Narayan-Pura, Umren, Sahodi, Goth, Chhagu-Rampura, Malakheda, Dhigawada, Bhada, Kushalgarh, Rajgarh in Alwar district. Efforts were made to identify only prolific bearer, dwarf type, with thin skull, less number of seeds and medium size fruits. A total 12 genotypes having better fruit characters were marked. The trees having very small size, more number of fruits and more number of seeds in fruits were not marked. The method of random sampling from population after gathering information about particular genotype to record morphological and qualitative characters was used. The number of fruits per tree was counted at survey site and information on fruiting pattern was also collected from farmers. The physical attributes like fruit shape, size and average fruit weight, specific gravity were recorded and kept for proper ripening at room temperature. Number of seeds/fruit, No. of seed per sacs, skull thickness and weight were recorded. The colour of pulp was visually observed.

Total Soluble Solids (TSS°brix) of fruit pulp was measured by Digital Hand refractometer. Titratable Acidity (%) was estimated by titrating known amount of pulp against 0.1N NaOH using phenolphthalein as indicator (Ranganna, 1984). The ascorbic acid content in fruit was estimated using standardized 2, 6-dichlorophenol- indophenol dye and

expressed in terms of mg per 100g fruit pulp.

Results and Discussion

The mean data pertaining to physical characters of *bael* germplasm is presented in table -1. The data showed considerable variability for all the characters studied. The number of fruit per tree varied from 21-130. Higher number of fruit was recorded in *bael* accession -8 (130Nos.) followed by *bael* accession-10 (115Nos.) in trees identified in villages Malakheda, Dhigawada of Alwar district. The number of fruit 104 per tree was noted in *bael* accession-4 in Chomu having less acidity and high TSS content. In Chomu area of Jaipur, mostly seedlings are planted on the boundary of fields and growing under dry land conditions. Looking to potential of this crop, now farmers are taking interest to conserve the bael plants. There is a fast genetic erosion in wild bael genotypes, therefore, its conservation has become necessary (Srivastava *et al.*, 1998). Rai and Dwivedi (1992) reported vivid account of *bael* genetic diversity available in India. The genetic diversity in *bale* germplasm was also observed at different locations by Rai *et al.*, (1991). The tree heights were comparatively lower in Chomu area than farmer's field in Alwar which depends on soil and climatic conditions. Apart from the tree morphological characters, wide variability exists in fruit size and shape, bearing habit, flesh colour, texture, fiber content, sugar content, mucilage content, etc. (Pandey *et al.*, 1986; Singh *et al.*, 2009). Variation in fruiting, size and shape was also noticed during survey. No systematic plantations of *bael* in Alwar were observed. However, cracking in fruits was also observed in *bael* trees grown in Chomu, Jaipur and Alwar district. In Sariska forest, the trees were big in size and less in population. The trees having very small size fruit of inferior quality, more number of seeds and bitter in taste, which were generally eaten and damaged by monkeys as stated by foresters. Therefore, these types were not suitable from horticultural traits point of view. Lal (2002) evaluated 12 genotypes collected from Jaipur area (Rajasthan) and found that 8 genotypes produce fruits of excellent quality under semi-arid conditions.

Variation in morphological and physico-chemical

characters of fruits have been reported by Nath *et al.* (2003) in fruit samples collected from eastern India. The number of fruits per trees, fruit weight and fruit yield per tree varied greatly among the different accessions collected and reported that big size and old *bael* trees are available in eastern part of country.

In the present study, variability in weight of fruits was observed from 0.585 to 1.860kg, fruit size (length 10.14-15.93cm and width 10.47-14.15cm) besides fruit shape as depicted in fig. -1. One tree in Dhigawada village was having cylindrical fruit (average fruit weight 865g.) and farmer informed that this type is more suitable for making sherbet and skull is thin of this type.

The variation in size, colour, length& width, weight and quality has also been described by Rai *et al.* (1991). The characters viz, fruit weight, fruit length, number and weight of seed per fruit, fibre content, contributed maximum in genetic divergence. These characters may be used in selecting diverse parents in hybridization and intercrossing between clusters to develop superior clones of *bael* with most desirable traits (Rai, *et al.*, 2002). Variation in shape was round, oval, obviated and one type was flat cylindrical. The pulp colour was light yellow to dark yellow in maximum germplasm. The small size fruits were having more seeds which were not considered promising for further collection of scion. The number of seeds per fruit varied from 50 to 128. The skull thickness was also differed among germplasm (table-1). The rind (skull) thickness varied from 1.08 mm to 4.25mm among germplasm which is also a good character while selecting a type with respect to cracking tolerance. The average weight of skull/rind ranged from 136g to 360g among germplasm.

Total Soluble Solids (TSS) was measured and variation was observed from 22.4 to 40.6° brix at ripening stage in fruits. Titrable acidity was estimated in pulp and it also varied from 0.22 to 0.32 %. The finding is in accordance to Lal, (2002) and Nath *et al.* (2003). The maximum ascorbic acid content was found 16.1 in *bael* accession -4 collected from chomu, Jaipur. The plants were grown under totally dry land conditions. The data presented showed that range of ascorbic acid/ in fruit pulp was 9.1 to 16.1mg per 100g (table-



Fig. 1: Variability in *bael* germplasm collected from Chomu and Alwar, Rajasthan



Fig: View of variability in *Bael* fruits

1). The ascorbic acid content was the higher in bael accession-4 (16.10 mg/100g) while lowest (9.10) was in sample collected from Dhigawada village, Alwar and number of fruit was maximum in this germplasm. Variation in ascorbic acid content in bael germplasm was possibly being due to genetic character or climatic factors. Similar results have also been reported by Rai *et al.* (2002) and Singh *et al.* (2011).

Thus, on the basis of overall assessment, bael accession- 4, accession- 6, accession-10 and accession-12 were found promising and have been marked for collection of bud wood for further evaluation under hot arid conditions.

References

- Gopalan, C.; Ramasastri, B.V. and Balasubramaniam, S.C. 1985. Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad, p 87.
- Lal, G. 2002. Evaluation of bael (*Aegle marmelos* Correa) germplasm in semi-arid regions of Rajasthan. *Curr. Agric.*, 26 (1-2): 127-129.
- Pandey, N. C., Singh, A. R., Maurya, V. N. and Katiyar, R. K. 1986. Studies on bio-chemical changes in bael (*Aegle marmelos* Correa) fruit. *Prog. Hort.*, 18(1-2): 29-32.
- Rai, Deepti, Misra, K.K. and Singh, V.P. 2002. Analysis of genetic divergence in bael (*Aegle marmelos* Correa) germplasm. *Prog. Hort.*, 34(1): 35-38.
- Rai, M. and Dwivedi, R. 1992. Bael (*Aegle marmelos* Correa) diversity in India. In: *Underutilized fruits of medicinal value*, IBPGR Newsletter, 10:13-14.
- Rai, M., Dwivedi, R. and Gupta, P. N. 1991. Variability and potentials of identified germplasm of bael (*Aegle marmelos* Correa.). *Indian Jour. Pl. Gen. Resources*, 4(2): 86-92.
- Ranganna, S. 1984. Manual of analysis of Fruit & Vegetable Products.. Tata McGraw Hills Pub. Co., New Delhi.
- Sharma, P.C., Bhatia, Vivek, Bansal, N. and Sharma Archana 2007. A review on bael tree. *Natural Product Radiance*, 6(2):171-178.
- Singh, A.K., Singh, S., Singh, R.S., Bagle, B.G. and Sharma, B. D. 2011. The Bael- fruit for dryland, Tech. Bull.No. 38, CIAH, CHES, Vejalpur, Godhra, p.46.
- Singh, H.K.; Srivastava, A.K., Prasad, J. and Dwivedi, R. 2009. Descriptor of bael (*Aegle marmelos* Correa.) AICRP on Arid Zone fruits, NDUA&T, Faizabad, (UP), p.23.
- Singh, R. N. and Roy, S. K. 1984. *The Bael*. Indian Council of Agricultural Research, New Delhi, p.25.
- Srivastava, A.K., Singh, H. and Singh I. S. 1998. Genetic diversity in Bael (*Aegle marmelos* Correa). *Indian Horticulture*, cover page, II.
- Nath, V. Pandey, D. and Das, Bikas 2003. Diversity of Bael (*Aegle marmelos* Correa) in East Central India, *Indian Jour. Plant Genetic Res.*, 16:85-89.

Effect of plant growth regulators and chemicals on seed germination of Ker (*Capparis decidua* L.) under nursery conditions

B.M. Muralidhara^{1*}, R.S. Singh², R. Bhargava¹ and G.L. Veena

¹ICAR- Central Institute for Subtropical Horticulture, Lucknow (UP)

²ICAR- Central Institute for Arid Horticulture, Bikaner, Rajasthan

*e-mail address of corresponding author: muralidhar.bm@gmail.com

(Received : 14.09.2015; Accepted: 25.01.2016)

Ker (*Capparis decidua* L.) of family Capparidaceae is a multipurpose tree which is distributed throughout the arid regions of India and other countries. The plant is xerophytic in nature and is highly tolerant to drought conditions for long period. The plant is used traditionally as anti-inflammatory, laxative, anti-diabetic, anthelmintic, antibacterial, astringent, digestive, diaphoretic and anodyne. Ker fruits are used to make delicious pickle. The major constraint in development of orchards of this species is lack of true to type planting material. This is on account of fact that systematic vegetative propagation technique is yet to be standardized. Presence of inhibitors has been shown in cuttings of ker (Bhargava *et al.*, 2000). Ker is commonly propagated through seeds. However, the uniformity of seed germination and subsequent seedling growth further aggravate the problem. Accordingly, in the present study, an attempt was made to study the effect of different concentrations of GA₃, KNO₃ and Salicylic acid on germination of ker seeds and seedling growth.

The present study was carried out at ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan, under shade net house condition during 2014. The experimental design selected was CRD. Fifteen seeds were used for each treatment, which was replicated thrice.

Fully ripen ker fruits were harvested and soaked in water for 12 hours for easy extraction of seeds. Seeds are extracted by crushing the fruits by hand. The different growth regulators and chemical solutions are prepared and seeds are soaked in ten treatments such as, GA₃ 100 ppm, GA₃ 200 ppm, GA₃ 300 ppm, KNO₃- 1%, KNO₃- 2%, KNO₃- 5%, Salicylic acid- 100 ppm, Salicylic acid 200 ppm, soaking in water for 12 hours and shade dried for 12 hours and untreated control. Then the seeds were sown in polythene bags (25x10cm) containing pot mixture consisting of sand, FYM and soil (1:1:1) during last week of May. Light irrigation was given under nursery at alternate day interval. They were examined daily for germination counts after the date of sowing. The date of first plumule emergence from the seeds above soil level was recorded and computing the difference between date of sowing and plumule emergence was recorded as days required for germination. The seeds which showed the emergence of cotyledon leaves were considered as germinated. After 30 days, the number of seeds germinated in each replication were

added and calculated on percentage basis as below (Stephen, 2008).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

The experimental values were analyzed statistically by using completely randomized design (CRD) with three replications of each. Means were compared using

WASP (WEB Agri Stat Package ICAR Research Complex Goa) test at 1% level of significance.

Data presented in table 1 showed that, the significant differences were found among the treatments for germination. The days taken for initiation and 50 per cent germination were very minimum in seeds treated with GA₃ 300 ppm (7.20 and 7.80 days, respectively) which was at par with GA₃ 200 (7.40 and 8.0 days respectively) and GA₃ 100 ppm (7.60 and 8.40 days respectively). Maximum number of days were taken in control (11.8 and 14.2 days) respectively. The initiation of germination was earlier in GA₃ treatments due to the stimulative effect of gibberellins on germination of seeds. It initiates synthesis of hydrolyzing enzymes, particularly amylase, which produces hydrolyzed food which is utilized for growth of embryo and thereby enhanced the germination (Paleg, 1965). Similar results were also reported in guava by Rodriguez (1985) and Suryakanth *et al.* (2005); in mango by Muralidhara *et al.*, (2015), Venkata Rao and Reddy, (2005), Shalini *et al.* (1999) and Padma and Reddy, (1998) and in khirni by Reddy and Khan (2001). It has also been postulated that GA₃ might antagonized the effects of inhibitors present in seeds (Kalyani *et al.*, 2014). Similarly, the treatment with different concentrations of KNO₃ also reduced the days taken for initiation of germination and days taken to 50% germination as compared to control. This is illustrated by the fact that days taken for 50% germination were 10, 9.4 and 12.40 days at 1%, 2% and 5%, respectively as compared to 14.20 days with control. This may be due to the priming effect of KNO₃, which led to improvement in uniformity of germination.

The highest percentage of germination (97.33 %)

was noticed, in seeds which were treated with GA₃ 300 ppm. This was at par with GA₃ 200 ppm (94.66%) and GA₃ 100 ppm (91.99%). Minimum germination percentage was recorded in control (64%). Similar results were also shown by KNO₃ and Salicylic acid which also improved germination percentage to the tune of above 80%. There is no significant difference for survival per cent of seedlings. The poor germination of seed is

a problem in Ker but survival per cent is very low due high temperature and hot blowing wind. The maximum loss of seedlings was noted at initial stage of growth after germination due to soft fleshy tender plants.

Thus from the foregoing account it can be concluded that application of GA₃, KNO₃ and Salicylic acid improves germination percentage as well as uniformity of germination

Table 1. Effect of presowing seed treatments on germination of Ker under nursery conditions

Treatments	Days taken for Initiation of germination	Days taken to 50% germination	Germination (%)	Survival (%) of seedlings
GA ₃ 100 ppm	7.60	8.40	91.99	29.01
GA ₃ 200 ppm	7.40	8.00	94.66	28.19
GA ₃ 300 ppm	7.20	7.80	97.33	30.19
KNO ₃ 1%	8.40	10.00	84.00	27.05
KNO ₃ 2%	8.40	9.40	89.33	26.92
KNO ₃ 5%	9.40	12.40	81.33	27.89
Salicylic acid 100 ppm	9.40	11.40	81.33	27.94
Salicylic acid 200 ppm	9.40	10.80	80.00	25.14
Water soaking	10.20	12.60	81.33	23.02
Control	11.80	14.20	64.00	22.88
CD (0.01)	0.88	1.38	7.39	NS

of seeds in *Capparis decidua*.

References

- Bhargava, R., Vishal Nath and Pareek, O.P. 2000. Note on role of plant growth inhibitors in sprouting of *Capparis decidua* cuttings. *Curr. Agric.*, 24(1):131-133.
- Kalyani, M., Bharad, S.G. and Polu, Parameshwar. 2014. Effect of growth regulators on seed germination in guava. *Int. J. Bio. Sci.*, 5: 81-91.
- Muralidhara, B.M., Reddy, Y.T.N., Akshitha, H.J. and Srilatha, V. 2015. Effect of presowing treatments on germination, growth and vigour of polyembryonic mango seedlings. *Env. and Eco.*, 33 (3):1014-1018.
- Padma, M. and Narayana Reddy, Y., 1998. Effect of pre sowing treatment of stones and kernels on mango (*Mangifera indica* L.) germination. *J. Res. ANGRAU.*, 26(2): 17-21.
- Paleg, L. 1965. Physiological effects of gibberellins. *Annuals Reviews of Plant Physiology*, 16: 291-322.
- Reddy, Y.T.N. and Khan, M.M. 2001. Effect of osmopriming on germination, seedling growth and vigour of khirni (*Mimusops hexandra*) seeds. *Seed Res.*, 29(1): 24-27.
- Rodriguez, N. 1986. Influence of soaking in distilled water, gibberellic acid and erogistim on guava (*Psidium guajava*) seed germination. *Seed Abstract*, 9(6):1779.
- Shalini Pillewan, Bagde, T.R. and Bharti, Bhaisare, 1999. Growth of mango (*Mangifera indica* L.) seedlings as influenced by stone treatment. *J. Soils & Crops*, 9(2): 227-230.
- Stephen. 2008 <http://www.employees.csbsju.edu/ssaupe/index.html>
- Suryakanth, L. B., Mukunda, G.K. and Raghavendra Prasad, G.C. 2005. Studies on seed germination in guava cvs. Taiwan guava and Allahabad Safeda. *Karnataka J. Hort.*, 1(3):47-50.
- Venkata, Rao, and Reddy, Y.T.N., 2005. Effect of osmopriming on germination, seedling growth and vigour of mango (*Mangifera indica* L.) stones. *Karnataka J. Hort.*, 1(4): 29-35.

Standardization of growing substrate and irrigation appendage nutrition in rose (*Rosa hybrida*) cv. 'Grand Gala'

Deepti Bisht

**Department of Agriculture Sciences and Engineering, IFTM University, Lodhipur.

Moradabad - 244102 (Uttar Pradesh)

email- diptibisht.pnt@gmail.com

(Received: 27.11.2014; Accepted 20.09.2015)

Acclaimed as the Queen of the flowers, roses are one of the nature's beautiful creations among all the flowers. Roses are the top ranking cut flowers and are the largest traded flowers in the world and share about 51% of the world flower market. The global floriculture market is valued around US \$ 11-billion and India accounts for a mere 0.2% of the global export business in cut flowers and associated floricultural products. Presently, growing of flowers in our country is practiced in open field conditions. Flowers grown in open conditions are exposed to various biotic and abiotic stresses. Under such conditions, it is not possible to produce blemish free, high quality flowers in terms of bud size, stem length, lush green leaves and pests and diseases free materials which are normally produced under controlled environments in other countries. Therefore, it makes imperative to take up cut flower cultivation of roses for better quality under greenhouse conditions particularly when production of cut flower is made for export purpose.

A variety of commonly used mineral components as growing media under protected environment for commercial flower production are sand, grit, pumice, perlite, vermiculite, clay granules, rockwool, etc. A good medium maximizes root and shoot growth by providing a proper ratio of air to water space, good nutrient uptake by the roots, adequate drainage and water holding capacity furthermore fertigation is one of the most advanced technologies and ideally suited for polyhouse to get high production of quality flowers.

In view of foregoing facts, it is therefore, considered appropriate to assess growing media (locally available alternate organic and inorganic substrates like cocopeat, FYM, compost, vermicompost, saw dust, rice husk, etc.) for efficient release of water, nutrients and to develop appropriate and effective methodology for nutrition through water soluble fertilizers. As a consequence of above facts an investigation was carried out at Model Floriculture Center, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar to find out best growing media composition and prompt fertigation schedule for market lead cut rose variety 'Grand Gala' under protected condition.

One year old budded plants of rose cv. 'Grand Gala' were planted on September 10, 2011 under polyhouse at the spacing of 30x25 cm with 6 plants/bed having the size of bed 1m² and the height of plant was observed at the end of each year (i.e. April flush of each year). The cultivar 'Grand Gala' belongs to hybrid tea group, which is the world's top most

cultivar used as cut flower. Five growing media viz; Soil + FYM (G₁), Soil + Vermicompost (G₂), Soil + Cocopeat (G₃) and Soil + Rice husk (G₄) mixed in the ratio of 2: 1 (v/v) and G₅ (Soil) taken as control were used for experiment. N, P and K were applied through irrigation water starting from 4th week of planting in month of October. 50, 100 and 150 and 0 ppm concentration of NPK were applied through water soluble fertilizers. Rate of application of fertigation solution was 10 litres per m² and fertigation frequency was kept twice a week. For the present experiment there were five growing media and four fertilizer levels as mentioned and replicated thrice. Observations regarding plant growth flower morphology, yield and vase life were recorded at end of April flush on both years. Pooled observations for both growing years i.e. 2011 and 12 and 2012 and 13 were analyzed statistically with two-way analysis of variance as described by Pansey and Sukhatme (1952).

The observations recorded on plant height indicated that the plant height was maximum in growing media G₂ (soil + vermicompost, 97.63 cm) which was followed by G₁ (97.29 cm) and this maximum value was recorded significantly higher over all other growing media other than G₁ (97.29 cm). Although lowest value of plant height (90.08 cm) was found in soil (control) which was significantly lower than all other values. Data regarding fertilizer doses revealed that minimum plant height (93.31 cm) was found in control (no fertilizer) whereas, maximum height was observed in nutritional dose of 150 ppm NPK (96.29 cm) which was significantly higher than all other fertilizer doses. When interactions data were studied it revealed that maximum value for plant height was recorded in G₂F₃ (100.61 cm) which was significantly higher than all other interaction but was statistically at par with G₁F₁. Lowest plant height was observed in G₂F₄ (87.22 cm) which was significantly lower than all other interactions. Lofty plant height with modified growing media and fertigated N P K might be due to soil fortification and balanced dose of primary nutrients. Reasonable nutrition and optimal substrate conditions interaction synergistically resulted in convenient nutrient uptake and their utilization in maximum biomass synthesis. The marked increase in plant height may be attributed towards the use of inorganic nitrogen viz., NO₃⁻ and NH₄⁺ form. As supply of nitrogen increases the cell number and cell size, it is due to the fact that N is an essential constituent of protein and low nitrogen availability must cause

a decrease in protein synthesis which causes a decrease in cell size especially in cell division. Ammonical form of nitrogen maintains a higher leaf N level than NO_3^- and extended the period of photosynthesis. Akin results correlating plant height increment with FYM added substrate and balanced nutrition supplement also have been reported by Hazarika and Dhaduk (2010) in Dutch rose and Dhiman *et al.* (2010) in Chrysanthemum. A significant increase in plant height was obtained with 300 ppm N, 300 ppm P and 200 ppm K per week and use of FYM fortified media in rose cv. 'Montezuma' (Mishra *et al.*, 2002). When collective data gaze at number of flower production per m^2 for both years (2012 and 2013) analyzed, it was observed that growing media G_2 (soil + vermicompost) had more number of flowers (68.76) which was significantly higher than all growing media except G_1 (67.92) which was found at par to it, moreover minimum number of flowers was recorded in G_3 (32.65). When nutritional doses were observed, it was found that F_3 exhibited maximum number of flowers (62.19) and which was significantly higher than all other nutritional levels and minimum flower count per m^2 was recorded in F_4 (57.33). Interactions between growing media and nutritional doses revealed that maximum numbers of flowers were observed in interaction between G_3F_3 (79.05) and minimum in G_3F_4 i.e. control. G_3F_3 was significantly higher than all other interactions. From the above result analysis, it can be concluded that G_2 and F_3 exhibited maximum number of flowers whereas G_1 and F_4 (control) showed lower number of flowers and interaction between them G_3F_3 and G_3F_4 recorded maximum and minimum number of flowers. Results obtained on number flowers per m^2 that in case of rice husk addition and fertigation with 150 ppm NPK were maximum and the treatments effects were statistically at par. The increase in number of flower may be due to the increased leaf area which could have led to increased production and accumulation of photosynthates from leaves (source) to flowers (sink). Per unit area flower in gerbera also increased when fertigated with water soluble fertilizers (Sujatha *et al.*, 2002). Bhattacharjee and Mukharjee (1981), and Cheng (1987) also recorded increased flower yield in orchids and gloxinia, respectively, when grown in amended media.

Collective data analysis for year 2012 and 2013 revealed maximum flower bud length (5.02 cm) was found in growing media G_1 (soil + rice husk) followed by G_2 (soil + vermicompost). Minimum flower bud length (2.91 cm) was recorded in G_3 (soil). Among nutritional doses, maximum flower bud length (4.58 cm) was recorded in F_1 (150 ppm NPK) and interactions between growing media and nutritional doses were found non-significant. The reason behind higher bud length might be judicious endow of phosphorus and potash boost-up the process of flower bud growth. Organic stuff amended growing media also alleged favor for brisk growth in meristematic regions and this might be synergized by prompt supply of nutrients moreover resulted in flower bud

length. Similar findings have also been reported by Nandre *et al.* (2005) in China aster, Shashidhara and Gopinath (2005) in *Calendula officinalis* cv. Red Orange, Godse *et al.* (2006) in gladiolus and Thane *et al.* (2007) in gerbera. Gaurav *et al.* (2001) found that 175 ppm K and N, and P at 50 ppm increased the length of flowers buds in roses under naturally ventilated polyhouse conditions. Analysis for the data parenting number of petals per flower revealed that lowest value (23.85) was observed in growing media G_1 (control) soil while, maximum number of petals per flower was depicted in G_2 (28.11) which was significantly higher than other growing media. Highest number of petals per flower were recorded in F_3 (28.16) which were significantly higher than F_2 and F_4 but were at par with F_1 and F_3F_4 (25.41). Observations in terms of interactions revealed that lowest petals number (19.27) was recorded in G_3F_4 control (soil). Maximum number was observed in G_2F_3 (30.5) which was the interaction of soil + vermicompost and 150 ppm NPK and was found significantly higher to all interactions. More petals were produced by balanced fertigation along with optimally fortified growing media by vermicompost and this increase may be due to more number of branches produced by this treatment which resulted in more carbohydrate synthesis which increased number of petals. Maximum number of petals (25.41) in rose cv. First Red was also reported by Ashok and Rengasamy (2000) who studied the effect of fertigation with ammonium nitrate @150 mg per liter along with use of 20 percent vermicompost in growing media.

Data as regards vase life in ordinary tap water exhibited that maximum vase life was found in growing media G_1 (10.32 days) and minimum was found in G_3 (8.14 days). Maximum value for vase life (10.32 days), it was significantly higher than all other growing media. Effect of nutritional doses and interactions did not show any significant effect on vase life. Like to above all vegetative and flower characters, combination of growing substrates and fertigation doses, some improvement in vase life were also reported. It might be due to overall food nutrient status of flowers under these substrates combinations and proper nutrient supplement. These findings are matching with those of Kathiresan and Venkatesha (2002) in gladiolus and Barreto *et al.* (2002) in gerbera.

Minimum days (11.86) from bud appearance to harvesting were recorded in G_4 (soil + ricehusk) while longest duration was recorded (16.04) from bud appearance to harvesting was recorded in G_1 (soil + FYM). Among nutritional levels and interactions between growing media and nutrition no significant results were found. Reduction in days taken to bud appearance to harvesting with organic stuff amended growing media and irrigation with soluble fertilizers might be due to enhanced photosynthetic rate which increases carbohydrate reserves of the plants resulted in hasty growth and development. Talukdar and Barooah (1987) had also obtained shrieked duration of flower growth and development in *Dendrobiums*, when grown in sawdust based media. Early

harvesting and reduced duration of harvestable flower production in roses in response to NPK @ 300 ppm was also observed (Palai *et al.*, 2002).

NPK Application in the form of fertigation and growing media modification with mortal organic stuff lofted plant growth (plant height) and increased flower yield (number of flowers per m²) of *Rosa hybrida* L. cv. 'Garand Gala'. Moreover these treatments were also effective to

increase flower size (flower bud length) and number of petals per flower. Treatments were also effective to reduce the duration from bud appearance to harvesting and vase life of flowers in ordinary tap water. Best results were observed with NPK fertigation @ 150 ppm and use of rice husk in growing media although synergetic effect of these treatments were also most effective to improve growth, yield and quality of rose cv. 'Grand Gala'.

Table 1. Effect of growing media and nutrition supplement through irrigation water on plant growth yield and flower bud size in rose cv. 'Grand Gala'.

Treatments	Days taken for Initiation of germination	Days taken to 50% germination	Germination (%)	Survival (%) of seedlings
GA ₃ 100 ppm	7.60	8.40	91.99	29.01
GA ₃ 200 ppm	7.40	8.00	94.66	28.19
GA ₃ 300 ppm	7.20	7.80	97.33	30.19
KNO ₃ 1%	8.40	10.00	84.00	27.05
KNO ₃ 2%	8.40	9.40	89.33	26.92
KNO ₃ 5%	9.40	12.40	81.33	27.89
Salicylic acid 100 ppm	9.40	11.40	81.33	27.94
Salicylic acid 200 ppm	9.40	10.80	80.00	25.14
Water soaking	10.20	12.60	81.33	23.02
Control	11.80	14.20	64.00	22.88
CD (0.01)	0.88	1.38	7.39	NS

Table 2. Effect of growing media and nutrition supplement through irrigation water on flower quality, flowering duration and vase life in rose cv. 'Grand Gala'

Treatment	Number of petals per flower					Days taken from bud appearance to harvesting					Vase life in tap water				
	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
G ₁	26.22	26.61	29	25.33	26.79	16.22	16.33	15.5	16.11	16.04	9.55	9.55	9.22	9.66	9.50
G ₂	28.5	25.67	30.5	27.77	28.11	16.22	15.39	15.17	15.28	15.51	9.61	10.00	9.50	8.72	9.46
G ₃	28.11	27.11	26.72	27.67	27.40	13.55	15.39	14.33	12.5	13.94	10.67	10.72	10.66	11.05	10.77
G ₄	28.22	28.22	28.94	27.00	28.09	12.16	13.28	10.50	11.50	11.86	10.83	11.16	11.00	10.72	10.93
G ₅	25.00	25.50	25.61	19.27	23.85	12.22	15.33	14.72	19.5	15.44	7.33	8.61	9.39	7.89	8.31
Mean	27.21	26.62	28.16	25.41		14.08	15.14	14.04	14.98		9.60	10.01	9.95	9.61	
CD	G	F	G x F			G	F	G x F			G	F	G x F		
	1.95	1.48	2.96			1.28	NS	NS			0.41	NS	NS		

References

- Ashok, A. and P. Rengasamy. 2000. Effect of N fertigation at different levels and sources on the growth of cut rose cv. "First Red" under greenhouse conditions. *South Indian Hort.*, 48: 139-141.
- Barreto, M.S., Jagtap, K.B., Misra, R.L. and Misra, S. 2002. Studies on polyhouse gerbera substrate. In: *Proceedings of National Symposium on Indian Floriculture in the New Millennium*, Bangalore, pp. 173-176
- Bhattacharjee, S.K. and Mukharjee, T. 1981. Effect of potting media on growth and flowering of some epiphytic and terrestrial orchids. *Haryana Journal of Horticultural Science*, 25: 7-10
- Cheng, B.T. 1987. Sawdust as a greenhouse growing medium. *Journal of Plant Nutrition*, 10(9-16): 1437-1446.
- Dhiman, S.R., Thakur, P., Gupta, Y.C. and Bhalla, R. 2010. Standardization of potting medium for growing chrysanthemum as pot mum. In: *Proc. National Symp. on Lifestyle Floriculture: Challenges and Opportunities*. Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). March 2010. pp76.
- Gurav, S., S. Katwate, S. Patel, M. Patel, B. Singh, R. Mirra

- and S. Missa. 2002. Fertigation of roses under natural ventilated polyhouse conditions. *Floriculture Research Trend in India*, pp. 222-223.
- Hazarika, A. and Dhaduk, B.K. 2010. Vegetative growth of greenhouse Dutch rose influenced by different potting media. In: *Proc. National Symp. On Lifestyle Floriculture: Challenges and Opportunities*. Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). March 2010. pp 129.
- Kathiresan, C. and Venkatesha, J. 2002. Effect of biofertilizers with levels of N and P on gladiolus. In: *Floriculture Research Trend in India. Proc. of National Symposium on Indian Floriculture in the New Millennium*, Bangalore, pp. 118-121.
- Mishra, H.N., Palai, S.K. and Mishra, M. 2002. Nutritional requirement of rose. In: *Recent floriculture research trends in India*. R.L. Misra and Sanyant Misra (eds.). New Delhi: ISOH. pp. 230-231.
- Nandre, D.R., Jogdande, N.D., Dalal, S.R., Bansode, A.B. and Chaudhale, B.S. 2005. Effect of *Azotobacter* on growth and yield of China aster under reduced nitrogen levels. *Advances in Plant Sciences*, 18(1): 87-89.
- Palai, S.K. Mishra, M. and Mishra, H.N. 2002. Response of rose cv. Montezuma to different levels of N, P and K fertigation. *Orissa Journal of Horticulture*, 30 (1): 51-53.
- Shashidhara, G.R. and Gopinath, G. 2005. Growth, flowering, yield, quality and economics of calendula (*Calendula officinalis* Linn.) as influenced by nutrients and bioinoculants. *Journal of Ornamental Horticulture*, 8(4): 249-253.
- Sujatha, K., Gowda, J.V.N. and Khan, M.M. 2002. Effects of different fertigation levels on gerbera under low cost greenhouse. *Journal of ornamental Horticulture*, New series. 5(1): 54-59.
- Talukdar, M. and Barooah, S. 1987. Effect of post mixture on flowering in *Dendrobium densiflorum*. *Acta Horticulturae*, 205: 145-148.
- Thane, S.R., Shembekar, R.Z., Bhongle, S.A. and Badge, S.A. 2007. Effect of integrated nutrient management on flower quality, yield and vase life of gerbera (*Gerbera jamesonii* H. Bolus) grown under shade net conditions. *Plant Archives*, 7(2): 679-680.

Bio-Efficacy of different insecticides against Custard apple mealy bug, (*Maconellicoccus hirsutus*)

V. K. Bhamare and R. M. Dheware*

Department of Agricultural Entomology, College of Agriculture, Latur-413 512 (MS),

Custard apple Research Station, Ambajogai

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani

*Corresponding author e-mail: drvijaybhamare@gmail.com,

(Received: 21.09.2015; Accepted: 05.01.2016)

Custard apple or sugar apple (*Annona squamosa* L.) is considered as the new super fruit of 21st century belonging to the family Annonaceae. It is one of the important minor fruit crops in India, commonly known as *sitaphal*, *sita palam*, *sharifa*, *sita pazham*, *sita phalmu*, *katal*, *ata* and sweet sop depending upon the region. Fruits can be called as a delicacy of dry region due to its very sweet delicate flesh and are rich in carbohydrate mainly in the form of sugar, protein, calcium, phosphorus and iron. It is grown throughout the plains of India except temperate region. The major custard apple growing states are Maharashtra, Gujarat, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Bihar, Assam, Rajasthan, Orissa and Tamil Nadu. Approximately 55,000 hectares are dedicated to custard apple cultivation (Anonymous, 2014). In Maharashtra, custard apple is grown in Pune, Beed, Aurangabad, Nanded, Dhule, Jalgaon, Nandurbar, Osmanabad, Latur, Ahmednagar, Solapur, Bhandara and Wardha districts. Balaghat hills of Marathwada are famous for natural occurrence of custard apple plantation. The fruit tolerates a variety of conditions from saline soils to droughts.

In custard apple cultivation, insect-pests remain as a major constraints in India. The 20 species of insect-pests has been reported on this crop (Butani, 1979), in which the mealy bug species viz., striped mealy bug, *Ferrisia virgata* (Cockerell), pink mealy bug, *Maconellicoccus hirsutus* (Green), citrus mealy bug, *Planococcus citri* (Risso), passion vine mealy bug, *Planococcus pacificus* Cox and mango mealy bug, *Perissopneumon ferox* Newstead (Hemiptera: Pseudococcidae) are the major causing roots and significant fruit yield loss. Recently, the heavy infestation of mealy bug (*M. hirsutus*) was recorded on custard apple orchards during fruiting stage from October to November in different parts of Maharashtra. The heavy infestation was recorded up to 40-80% during November (Kapadia *et al.*, 2009). Both nymphs and adults are damageable, they fasten their mouth at fissure and furrow of rounded fleshy tubercles of the green fruits and suck the sap through piercing and sucking action. If the infestation occurs on developing stage, the fruit size becomes diminished, shrivelled and undergo premature dropping. These mealy bugs also infest at fruit stalks, leaves and terminal shoots causing, yellowing and drying symptoms. Bugs excretion contains honeydew which encourages the growth of sooty mold on leaves and fruits which attracts black ants to

help in the spread of these mealy bugs. The sooty mould also reduces the photosynthetic efficiency of the plant (Maruthadurai and Karuppaiah, 2014). Once the mealy bug load is increased on fruits it is very difficult to manage the pest with conventional insecticides. Keeping this in view, the present investigation was undertaken to study the bio-efficacy of different newer insecticides along with conventional and botanical insecticide against mealy bug on custard apple.

A field experiment was conducted on custard apple (variety Dharur-6) orchard at Custard apple Research Station, Ambajogai, (VNMKV, Parbhani) Maharashtra during *Mrig Bahar* of 2014-15. The experiment was conducted in randomly block design with three replications. There were taken eleven treatments viz., imidacloprid 70 WS @ 0.005 per cent, imidacloprid 17.8 SL @ 0.004 per cent, imidacloprid 30.5 SC @ 0.004 per cent, thiamethoxam 25 WG @ 0.005 per cent, acetamiprid 20 SP @ 0.002 per cent, clothianidin 50 WDG @ 0.01 per cent, diafenthiuron 50 WP @ 0.07 per cent, dimethoate 30 EC @ 0.04 per cent, fipronil 5 SC @ 0.02 per cent, azadirachtin 0.03 WSV @ 0.03 per cent and untreated control. Spraying was undertaken after developing heavy infestation of mealy bug population on custard apple fruits. The pre count of nymphs and adults of mealy bug noted on a day prior to application and post count at 1, 3, 5, 7 and 10 days after spraying. Efficacy of insecticides was judged on the basis of level of mealy bug incidence on randomly selected fruits. The generated data on survival of mealy bug population was transformed into values and subjected for statistical analysis according to Gomez and Gomez (1984).

Statistically non-significant difference was noted in mealy bug population prior to spraying. Mealy bug population ranged from 32.33 to 46.78 nymphs and adults per fruit one day before spray. All insecticide treatments were significantly superior over untreated control in minimizing the incidence of mealy bug on 1, 3, 5, 7 and 10 day after spray treatment (DAS) (Table 1). At one day after spraying, significantly minimum population of custard apple mealy bug (6.37 nymphs and adults/fruit) was recorded with imidacloprid 70 WS @ 0.005 per cent followed by imidacloprid 30.5 SC @ 0.004 per cent (7.67 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (8.13 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (10.43 nymphs and adults /fruit) and thiamethoxam 25 WG @ 0.005 per cent (10.80 nymphs and

adults/fruit). All these treatments were statistically at par with each other. Acetamiprid 20 SP @ 0.002 per cent (14.03 nymphs and adults /fruit), dimethoate 30 EC @ 0.04 per cent (16.40 nymphs and adults /fruit), clothianidin 50 WDG @ 0.01 per cent (18.97 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (21.31 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (22.29 nymphs and adults/fruit) were found next effective treatments.

At three day after spraying, significantly lowest population of custard apple mealy bug (8.34 nymphs and adults/fruit) was recorded from the plants treated with imidacloprid 70 WS @ 0.005 per cent followed by imidacloprid 30.5 SC @ 0.004 per cent (9.64 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (10.11 nymphs and adults/fruit) and imidacloprid 17.8 SL @ 0.004 per cent (12.41 nymphs and adults/fruit). All these treatments were statistically at par with each other. Thiamethoxam 25 WG @ 0.005 per cent (12.77 nymphs and adults/fruit), acetamiprid 20 SP @ 0.002 per cent (16.01 nymphs and adults/fruit), dimethoate 30 EC @ 0.04 per cent (18.27 nymphs and adults /fruit), clothianidin 50 WDG @ 0.01 per cent (20.94 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (22.46 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (24.26 nymphs and adults/fruit) were found next effective treatments.

At five day after spraying, imidacloprid 70 WS @ 0.005 per cent evidenced significantly lowest population of custard apple mealy bug (10.37 nymphs and adults/fruit) which was followed by imidacloprid 30.5 SC @ 0.004 per cent (9.64 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (12.28 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (14.58 nymphs and adults/fruit) and thiamethoxam 25 WG @ 0.005 per cent (14.95 nymphs and adults/fruit). All these treatments were statistically at par with each other. The next effective treatments were dimethoate 30 EC @ 0.04 per cent (18.18 nymphs and adults/fruit), acetamiprid 20 SP @ 0.002 per cent (20.19 nymphs and adults /fruit), clothianidin 50 WDG @ 0.01 per cent (23.12 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (25.46 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (26.11 nymphs and adults/fruit).

At seven day after spraying, imidacloprid 70 WS @ 0.005 per cent achieved minimum population of custard apple mealy bug (12.62 nymphs and adults/fruit) and statistically at par with imidacloprid 30.5 SC @ 0.004 per cent (14.07 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (14.55 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (16.83 nymphs and adults/fruit) and thiamethoxam 25 WG @ 0.005 per cent (17.20 nymphs and adults/fruit). Acetamiprid 20 SP @ 0.002 per cent (20.29 nymphs and adults/fruit), dimethoate 30 EC @ 0.04 per cent (22.72 nymphs and adults/fruit), clothianidin 50 WDG @ 0.01 per cent (25.38 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (27.73 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (28.71 nymphs and adults/fruit) were found subsequently effective treatments.

At ten day after spraying, imidacloprid 70 WS @ 0.005 per cent exhibited most effective treatment in reducing population of custard apple mealy bug (15.26 nymphs and adults/fruit) which was followed by imidacloprid 30.5 SC @ 0.004 per cent (16.70 nymphs and adults/fruit), diafenthiuron 50 WP @ 0.07 per cent (16.98 nymphs and adults/fruit), imidacloprid 17.8 SL @ 0.004 per cent (19.47 nymphs and adults/fruit) and thiamethoxam 25 WG @ 0.005 per cent (19.83 nymphs and adults/fruit). All these treatments were statistically at par with each other. Subsequently effective treatments in reducing population of custard apple mealy bug were dimethoate 30 EC @ 0.04 per cent (23.07 nymphs and adults/fruit), acetamiprid 20 SP @ 0.002 per cent (25.15 nymphs and adults/fruit), clothianidin 50 WDG @ 0.01 per cent (27.82 nymphs and adults/fruit), fipronil 5 SC @ 0.02 per cent (30.30 nymphs and adults/fruit) and azadirachtin 0.03 WSV @ 0.03 per cent (31.14 nymphs and adults/fruit). The descending order of effectiveness of different treatment was imidacloprid 70 WS > imidacloprid 30.5 SC > diafenthiuron 50 WP > imidacloprid 17.8 SL > thiamethoxam 25 WG > dimethoate 30 EC > acetamiprid 20 SP > clothianidin 50 WDG > fipronil 5 SC > azadirachtin 0.03 WSV when compared with control.

The present investigation revealed that imidacloprid 70 WS @ 0.005 per cent, imidacloprid 30.5 SC @ 0.004 per cent, diafenthiuron 50 WP @ 0.07 per cent, imidacloprid 17.8 SL @ 0.004 per cent and thiamethoxam 25 WG @ 0.005 per cent were significantly superior in reducing population of custard apple mealy bug. The present findings are in conformity with the findings of Kulkarni and Patil (2013) who reported that imidacloprid @ 0.005 per cent (4.79 nymphs and adults/fruit) and diafenthiuron @ 0.02 per cent (4.88 nymphs and adults/fruit) found effective insecticides in minimizing population of custard apple mealy bug. Tanwar *et al.* (2010) reported imidacloprid 17.8 SL (0.6 ml/l), thiamethoxam 25 WG (0.6 g/l) and dimethoate 30 EC (2 ml/l) better insecticides for reducing papaya mealy bug. Whereas, Tanwar *et al.* (2007) recommended imidacloprid 200 SL @ 1 ml/l for reducing *M. hirsutus* population. Similarly, Biradar *et al.* (2006) reported that diafenthiuron 50 SC @ 800 and 1600, and at 600, 800 and 1600 g per ha resulted in the lowest mealy bug colonies 10 days after sprayings during first and second spray treatments, respectively. In the present investigation, the conventional insecticide viz., dimethoate 30 EC @ 0.04 per cent proved equally effective in minimizing mealy bug population. However, botanical insecticide viz., azadirachtin 0.03 WSV @ 0.03 per cent evidenced least effective as compared to chemical insecticides. These results found supports from the investigation of Kulkarni and Patil (2013) who reported NSKE 5 per cent as a least effective treatment in managing custard apple mealy bug. Whereas, Sawant *et al.* (2007) recommended foliar spray of azadirachtin 1 per cent @ 2ml per litre or 5 per cent @ 1 ml per litre for the effective management of *M. hirsutus*. Anonymous (2014) reported that azadirachtin 10000 ppm @ 3ml per litre documented effective against custard apple mealy bug. The present study clearly

Table 1. Effect of different insecticides on the population of custard apple mealy bug

Treatments	Dose (%)	Mean population of mealy bug per fruit					
		1 day before Spraying	Days after spraying				
			1	3	5	7	10
Imidacloprid 70 WS	@ 0.005	44.33 (6.67)*	6.37 (2.60)	8.34 (2.96)	10.37 (3.28)	12.62 (3.62)	15.26 (3.97)
Imidacloprid 17.8 SL	@ 0.004	38.00 (6.16)	10.43 (3.31)	12.41 (3.58)	14.58 (3.89)	16.83 (4.20)	19.47 (4.47)
Imidacloprid 30.5 SC	@ 0.004	40.67 (6.41)	7.67 (2.86)	9.64 (3.19)	11.82 (3.50)	14.07 (3.81)	16.70 (4.15)
Thiamethoxam 25 WG	@ 0.005	32.33 (5.72)	10.80 (3.33)	12.77 (3.64)	14.95 (3.90)	17.20 (4.19)	19.83 (4.50)
Acetamiprid 20 SP	@ 0.002	34.44 (5.88)	14.03 (3.79)	16.01 (4.04)	20.19 (4.55)	20.29 (4.56)	25.15 (5.05)
Clothianidin 50 WDG	@ 0.01	41.78 (6.47)	18.97 (4.39)	20.94 (4.61)	23.12 (4.84)	25.38 (5.08)	27.82 (5.31)
Diafenthiuron 50 WP	@ 0.07	35.44 (5.94)	8.13 (2.89)	10.11 (3.21)	12.28 (3.55)	14.55 (3.85)	16.98 (4.16)
Dimethoate 30 EC	@ 0.04	39.44 (6.29)	16.40 (4.10)	18.27 (4.31)	18.18 (4.30)	22.72 (4.80)	23.07 (4.84)
Fipronil 5 SC	@ 0.02	46.78 (6.84)	21.31 (4.65)	22.46 (4.78)	25.46 (5.09)	27.73 (5.30)	30.30 (5.54)
Azadiractin 0.03 WSV	@ 0.03	35.78 (6.00)	22.29 (4.75)	24.26 (4.97)	26.11 (5.16)	28.71 (5.38)	31.14 (5.61)
Untreated Control	-	35.22 (5.96)	34.72 (5.91)	36.70 (6.07)	38.87 (6.26)	41.14 (6.43)	43.57 (6.63)
S.E. $\pm$		4.92	0.26	0.22	0.22	0.22	0.21
C.D. at 5%		NS	0.79	0.66	0.65	0.67	0.63

*Figures in parentheses are square root transformed values ($\sqrt{x+0.5}$)

N.S.: Non-significant

indicates that newer insecticides proved effective tool in minimizing the population of custard apple mealy bug on fruits under the circumstances of heavy infestation. It also illustrates that population of custard apple mealy bug should be kept under control from the beginning of infestation for avoiding population reaching to beyond control.

References

- Anonymous 2014. AESA based IPM package for custard apple. Dept. of Agriculture and Co-operation, Ministry of Agriculture, Govt. of India: 08.
- Anonymous 2014. Eco friendly management of mealy bugs on custard apple. Annual Group Meeting Report 2014, ACRP on Arid Zone Fruits, ICAR-CIAH, Bikaner-334 006: 178-179.
- Biradar A P, Kabadagi C B and Patil D R 2006. Evaluation of diafenthiuron 50 SC (Polo) against grape mealy bugs *Maconellicoccus hirsutus* (Green). *International Journal of Agricultural Science*, 2 (2): 470-471.
- Butani D K 1979. Insect and fruits. Periodical expert book agency, New Delhi: 415.
- Kapadia M N, Butani P G, Jethva D M, Virani V R and Beria N N. 2009. Integrated management of mealy bugs in Custard apple. *Annals of Plant Protection Sciences*, 17 (2): 459-526.
- Kulkarni S R and Patil S K 2013. Efficacy of different biopesticides and insecticides against mealy bugs on custard apple. *Pest Management in Horticultural Ecosystems*, 19 (1): 113-115.
- Maruthadurai R and Karuppaiah V 2014. Managing menace of insect pests on custard apple. *Popular Kheti*, 2 (3): 108-111.
- Sawant S D, Kulkarni N S, Sawant I S, and Mani M 2007. Package of practices for managing major diseases and insect pests on grapes. *Technical Bulletin*, 8, NRCG, Pune: 16.
- Tanwar R K, Jayakumar P and Vennila S 2010. Papaya mealy bug and its management strategies. *Technical Bulletin* 22, NCIPM, New Delhi: 18.
- Tanwar R K, Jayakumar P and Monga D 2007. Mealy bugs and their management. *Technical Bulletin* 19, NCIPM, New Delhi: 12.

Influence of scion size on graft success in custard apple cv. Balanagar

A.S. Lohakare*, B.M. Kalalbandi and T.B. Tambe¹

College of Horticulture, Vasant Rao Naik Marathwada Agricultural University, Parbhani-431 402 (M.S.)

¹Professor, Officer Incharge, Fruit Research Station, Himayat Bagh, Aurangabad (M.S.)

Corresponding author email : anshul_agricos@rediffmail.com

(Received: 28.05.2015; Accepted: 05.01.2016)

Custard apple (*Annona squamosa* L.) belongs to family Annonaceae and now gaining popularity on waste and dry lands. Custard apple is mainly propagated through seed and therefore, there exists a great variation in respect of growth, yield and fruit quality amongst the trees grown in the orchard. However, it is a common experience to come across individual free plant exhibiting superior fruit quality and profile yield. If such promising trees are further perpetuated vegetatively the desirable types can be multiplied and orchards with uniform fruit quality can be established. Kudmulwar *et al* (2008) reported that softwood grafting was effective in terms of percentage success, percent of survival, shoot length and the number of functional leaves. However the studies in respect of standardization of scion size viz., length and diameter for achieving maximum graft success through softwood grafting have yet not been carried out. Keeping the point under consideration the present study was therefore, undertaken to find out the most suitable size of scion shoot for obtaining maximum success for softwood grafting in custard apple cv. Balanagar.

The experiment was undertaken at Fruit Research Station, Himayat bagh, Aurangabad. during 30th January, 2014 to 31st July 2014. One year old custard apple seedlings of uniform in growth of local type were selected as rootstock. The scion wood of past season growth of known cultivar Balanagar was used for grafting purpose. The experiment was laid out in Factorial Randomized Block Design with eighteen treatments replicated thrice and in each treatment twenty seedlings were grafted. The treatment consisted of T₁ L-20 cm D-4 mm, T₂ L-20 cm D-5 mm, T₃ L-20 cm, D-6mm, T₄ L-18 cm D-4 mm, T₅ L-18cm, D-5mm, T₆ L-18cm D-6 mm, T₇ L-16 cm D-4 mm, T₈ L-16 cm D-5 mm, T₉ L-16 cm D-6 mm, T₁₀ L-14 cm D-4 mm, T₁₁ L-14 cm D-5 mm, T₁₂ L-14 cm D-6 mm, T₁₃ L-12 cm D-4 mm, T₁₄ L-12 cm D-5 mm, T₁₅ L-12 cm D-6 mm, T₁₆ L-10 cm D-4 mm, T₁₇ L-10 cm D-5 mm and T₁₈ L-10 cm D-6 mm. The data on days required for bud sprouting, success percent of grafts after 60 days, number of branches, number of leaves per graft after 180 days, survival percent after 180 days and sprout length (cm) after 180 days of grafting were recorded. The data collected were subjected to statistical analysis as suggested by Panse and Sukhatme (1967) and presented in Table 1 and 2.

Data pertaining to individual effect of scion length and diameter on sprout length and graft success is presented in Table 1. There was significant difference in all the scion length and diameter affectively the sprout length and success. Significantly minimum days were required for bud sprouting (8.77 days), more success percent of graft after 60 days (80.00%), number of branches (1.82), number of leaves per graft after 180 days (15.26), survival percent after 180 days (81.11) and sprout length (37.44) was recorded in scion length of 14 cm. While scion stick of 20 cm recorded more days bud sprouting (13.66 days) while less success percent of grafts after 60 days (16.66%), number of branches (0.96), number of leaves per graft after 180 days (5.51), survival percent after 180 days (16.6%) and sprout length after 180 days (17.77 cm). Regarding scion diameter of 6 mm recorded less number of days for bud sprouting (10.83 days), more success percent of grafts after 60 days (63.88%), number of branches (1.56), number of leaves per graft after 180 days (13.84), survival percentage after 180 days (64.44%) and sprout length after 180 days (28.44 cm), while more number of days required for bud sprouting (11.15 days), less success percent of grafts after 60 days (46.11%), number of branches (1.31), number of leaves per graft after 180 days (9.16), survival percent after 180 days (46.66%) and sprout length after 180 days (25.166) was recorded in scion stick of 4 mm in diameter.

The data presented in Table 2 indicated significant differences among different treatments as influenced by scion length and diameter on graft success in custard apple cv. Balanagar. It was observed that the treatment T₁₂ sprouted early (7.33) followed by T₁₁ (8.33) and treatment T₁₃ (10.00). This treatment was at par with treatment T₆ and T₁₇ (10.00) respectively. The maximum number of days (14.33) required for bud sprouting was recorded in treatment T₇. This was statistically at par with treatment T₁ (14.00). Early sprouting in thick scion may be attributed to greater amount of reserve food material (Carbohydrates) in the scion shoot and early union is owing to the more surface contact between scion and rootstock. The results are on lines of Hartman and Kester (1986), Pathak (1990) and Joshi *et al* (2011) in custard apple. The highest percent graft success at 60 days after grafting was noticed in T₁₂ (93.33%) followed by T₁₃ (83.33%) and T₁₄ (80.00). It was at par with treatment (T₁₁, T₁₅, and

Table 1. Influence of scion length and diameter on growth and success of graft in custard apple cv. Balanagar under nursery condition.

Treatments	Days required for bud sprouting	Success per cent of grafts after 60 days (%)	Number of branches	Number of leaves/graft after 180 days	Survival per cent after 180 days	Sprout length after 180 days (cm)
Scion length (L)						
L ₁ - 20 cm	13.666	16.66	0.96	5.511	16.66	17.777
L ₂ - 18 cm	11.111	31.11	1.17	9.200	33.33	19.333
L ₃ - 16 cm	11.333	55.55	1.60	11.755	54.44	23.111
L ₄ - 14 cm	8.777	78.88	1.82	15.266	78.88	31.111
L ₅ - 12 cm	11.000	80.00	1.66	14.466	81.11	37.444
L ₆ - 10 cm	10.777	71.11	1.50	14.622	71.11	29.777
SE+	0.46	1.88	0.6	0.55	2.11	0.93
CD at 5%	1.40	5.66	0.18	1.65	6.33	2.79
Scion diameter (D)						
D ₁ - 4 mm	11.555	46.11	1.31	9.166	46.66	25.166
D ₂ - 5 mm	10.944	56.66	1.48	12.400	56.66	25.666
D ₃ - 6 mm	10.833	63.88	1.56	13.844	64.44	28.444
SE+	0.32	1.33	0.04	0.38	1.49	0.65
CD at 5%	0.99	4.00	0.14	1.16	4.47	1.97

Table 2. Interaction effect of scion length and diameter on growth and success of graft in custard apple cv. Balanagar.

Treatments	Days required for bud sprouting	Success per cent of grafts after 60 days (%)	Number of branches	Number of leaves/graft after 180 days	Survival per cent after 180 days	Sprout length after 180 days (cm)
T ₁ - L 20 cm, D 4 mm	14.000	13.33	1.13	3.333	13.33	14.666
T ₂ - L 20 cm, D 5 mm	12.666	10.00	0.76	2.933	10.00	17.000
T ₃ - L 20 cm, D 6 mm	14.333	26.66	1.0	10.266	26.66	21.666
T ₄ - L 18 cm, D 4 mm	11.333	13.33	0.53	1.533	16.66	19.000
T ₅ - L 18 cm, D 5 mm	12.000	36.66	1.4	14.000	43.33	20.000
T ₆ - L 18 cm, D 6 mm	10.000	43.33	1.6	12.066	40.00	19.000
T ₇ - L 16 cm, D 4 mm	11.333	33.33	1.33	6.866	30.00	20.666
T ₈ - L 16 cm, D 5 mm	10.333	60.00	1.8	13.333	60.00	19.000
T ₉ - L 16 cm, D 6 mm	12.333	73.33	1.66	15.066	73.33	29.666
T ₁₀ - L 14 cm, D 4 mm	10.666	66.66	1.66	13.133	70.00	29.333
T ₁₁ - L 14 cm, D 5 mm	8.333	76.66	1.8	15.333	73.33	22.000
T ₁₂ - L 14 cm, D 6 mm	7.333	93.33	2.0	17.333	93.33	42.000
T ₁₃ - L 12 cm, D 4 mm	10.000	83.33	1.8	16.066	83.33	39.666
T ₁₄ - L 12 cm, D 5 mm	12.333	80.00	1.4	13.133	76.66	41.000
T ₁₅ - L 12 cm, D 6 mm	10.666	76.66	1.73	14.200	83.33	31.666
T ₁₆ - L 10 cm, D 4 mm	12.000	66.66	1.44	14.066	66.66	27.666
T ₁₇ - L 10 cm, D 5 mm	10.000	76.66	1.66	15.666	76.66	35.000
T ₁₈ - L 10 cm, D 6 mm	10.333	70.00	1.4	14.133	70.00	26.666
SE+	0.81	3.27	0.10	0.95	3.65	1.61
(L X D) CD at 5%	2.43	9.81	0.32	2.86	10.96	4.83
CV %	7.65	10.64	13.25	14.16	11.81	11.03



Figure 1 Plate showing the length of scion grafted on rootstock



Figure 2 Plates showing an entire view of the experiment

T_{17}). The minimum percentage success was noticed in treatment T_1 (10.00). The maximum number of branches per graft were recorded in treatment T_{12} (2.0) followed by treatment T_{13} (1.8) which was at par with treatment T_4 and T_{11} . The minimum number of branches per graft was observed in treatment T_4 (0.53). The data regarding number of leaves per graft recorded after 180 days of grafting revealed significant differences among the treatments. The maximum number of leaves (17.33) was recorded in the treatment T_{12} where scion length was 14 cm while 6 mm diameter followed by treatment T_{13} (16.06) and T_{17} (15.66) which were at par with treatments T_9 and T_{11} . The minimum numbers of leaves (1.53) were produced

by the grafts where scion length was 18 cm and thickness 4 mm in diameter (T_4). The maximum sprout length (42.00 cm) after 180 days of grafting was recorded when the scion length was 14 cm and 6 mm thickness (T_{12}). The next best treatment in respect of sprout length (41.00 cm) was T_{14} scion length 12 cm and thickness 5 mm which was at par with T_{13} (39.66 cm) and T_{17} (35.00 cm). The minimum sprout length (14.66 cm) was observed in treatment T_1 where scion was used 20 cm length and having 4 mm thickness. It might be due to same thickness of rootstock and scion performed at optimum time makes a congenial union resulted better growth of grafts. The results are in conformity with findings of Tewari *et al* (2005). The maximum survival percentage (93.33 %) was recorded when the scion length was 14 cm and thickness 6 mm in diameter (T_{12}) followed by treatment T_{13} and T_{15} (88.33 %) respectively which was at par with treatment T_{14} and T_{17} (76.66) respectively. The minimum success percentage (10.00%) was recorded when the scion length 20 cm and thickness 5 mm in diameter (T_1) which was at par with treatment T_1 (13.33%). This might be due to better callusing and proper union of stock and scion as reported by Tewari *et al* (2007) in ber which confirms present findings.

References

- Hartman, H.T. and Kester, D.E. 1986. Plant propagation. Prentice Hall of India, Pvt. Ltd. New Delhi. India. pp. 399-447.
- Joshi, P.S., Jadhao, B.J. and Chaudhari, G.V. 2011. Studies on vegetative propagation in custard apple. *Asian J. Hort.*, 6(1): 261-263.

Kudmulwar, R.R., Kulkarni, R.M., Bodamwad, S.G., Katkar, P.B. and Dugmod, S.B. 2008. Standardization of soft wood grafting season on success of custard apple (*Annona squamosa* L.). *The Asian J. Hort.*, 3(2):281-282.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical method for agriculture workers publication ICAR, New Delhi.

Pathak, R.K. 1990. *Phal Briksh Pravardhan*. ICAR, New Delhi, India. pp.92-138.

Tewari, R.K., Bajpai, C.K. and Kumar Sunil 2007. Bench grafting in ber (*Ziziphus spp.*). *Indian J. Agric. Sci.*, 77(4): 239-40.

Tewari, R.K., Bajpai, C.K. and Rai, P. 2005. Production and establishment of aonla through bench grafting. *ICAR News*, 11(1): 9.

Effect of micro-nutrients spray on yield attributing characters of mango (*Mangifera indica* L.) cv. Amrapalli

Lalji Yadav, A.L. Yadav, Govind Vishwakarma*, D.K. Yadav and P.K. Yadav
Narendra Deva University of Agriculture and Technology,
Kumarganj- Faizabad- 224 229 (U.P.)

*Corresponding author e-mail: govind0139@gmail.com

(Received: 11.12.2014; Accepted: 22.12.2015)

The mango occupies a pre-eminent place amongst the fruit crops grown in India as the king of fruits. Mango belongs to family Anacardiaceae. The mango is the choicest fruit of Hindustan, and people eat it from immature to ripening stage. Mango (*Mangifera indica* L.) is the fifth most important fruit of the world after apple, citrus, banana and grape. It is cultivated in more than 100 countries because of its delicious taste, excellent flavour, attractive fragrance and excellent source of vitamin A and C. Mango occupies about 70 per cent of the total area under fruits in India covering an area of 5.51 million hectares. The major mango producing countries are India (12.53 Mt), China (3.67 Mt), Mexico (1.67 Mt), Thailand (1.80 Mt), Pakistan (16.06 Mt), Indonesia (1.14 Mt) and Philippines (1.003 Mt). India shares in world mango production and share was 40.1% (N.H.B. Data Base, 2009) which has not increased since then substantially. The total annual production of mango in India is estimated to be 16.07 million tonnes, cultivated in 2.4 million hectare (2010-11). All the parts of the plant have various uses. Both ripe and unripe mangoes are used extensively by food processing industry to prepare a wide variety of products such as syrup, jam, squash juice cereals flakes and toffee etc. The ripe mango, used to prepare pickles, chutney, slices, amchur, candy, jam, jelly preserve, squash etc from unripe mango. Chemical composition of mango differs with the variety and stage of maturity. It is a rich source of carbohydrate as well as vitamin A and C. A comprehensive report has been made on the chemical composition after analysis of more than 5 varieties of mango (Anonymous, 1964) such as Fazli, Chausa, Langra, Dashari etc. Mango is one of the best exporting materials both in fresh and processed form and is being exported to U.K., U.S.A., France, Kuwait, Bahrain, Afghanistan, Malaysia, Qatar and Singapore etc.

In India, mango is distributed in all parts of the country except in hilly regions above 915 meter from the mean sea level. The mango being a deep rooted tree needs soil profile of at least 2 meter depth. It has been observed the mango is cultivated well on alluvial as well as lateritic soil but deep black cotton soil of India have generally been considered unsuitable for mango cultivation. For mango growing the water table should be below 180 cm and pH of soil 5.5-7.5 has been found suitable (Singh, 1960). Although the mango is a tropical fruit growth equally well under semi-tropical conditions. The most favourable temperature for the growth of

young mango plant is 25 °C. The flowering of mango in India takes place as early as November-December in Rayalaseema area of Andhra Pradesh, February-March in Northern India and slightly earlier January-February in eastern parts of the country. Since the flowering process is entirely depended on climatic conditions prevailing in an area. At some locations, like Kanyakumari, which have a very specific microclimate even cultivar like Neelum, Bangalora and Rumani have a tendency to flower in the off season and the fruit usually mature during January-February, much earlier than anywhere else in India. Although India has major area and production in the world, however, producing states in India are Andhra Pradesh (2.37 Mt), Uttar Pradesh (1.915 Mt), Bihar (1.872 Mt), Karnataka (1.180 Mt), Tamilnadu (0.70 Mt) (APEDA, Data Base). The average fruit production in India is 8-10 tons/ha which is quite lower than the world production of 14-16 tones/ha. The intensity of damage cause by fruit dropping can be minimized by foliar application of micro-nutrients, its also helps in improvement of quality and fruit yield.

The present investigation entitled "Effect of micro-nutrients spray on yield attributing character of mango (*Mangifera indica* L.) cv. Amrapali" was carried out at Main Experimental Station, Department of Horticulture, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumargaj), Faizabad (U.P.) during the year 2011-12. Ten year old uniform in vigour plants of mango cv. Amrapali were selected for the study. The soil of orchard was sandy loam having pH 7. This region is characterized by sub-humid and sub-tropical climate. Approximately, 1200 mm precipitation occurs, out of which about 85 per cent is concentrated from mid June to end of September. Three distinct seasons viz., winter, summer and rainy prevail in the region. Winter months are cool and occasional frost occurs during this periods. A few rains are also encountered during winter. The summer season starts from April and continuous up to onset of monsoon. Hot scorchy winds are common during summers.

The experiment was laid out in Randomized Block Design (R.B.D.), with seven treatments, T₁- ZnSO₄ (0.5%), T₂ - FeSO₄ (0.5%), T₃ - Borax (0.5%), T₄ - MnSO₄ (0.5%), T₅- Urea (0.5%), T₆- K₂SO₄ (0.5%), T₇- Control (Water Spray) replicated three times. The Chemical was sprayed as aqueous solution. The uniform management practices with respect to nutrition and irrigation were adopted for experimental trees.

The Spray of nutrients was done at pea stage after fruit set. The fruits were harvested at the best physiological maturity. The observations were recorded on per cent fruit drop, fruit retention, fruit yield, fruit size and fruit weight. Data on fruit drop was recorded from five randomly pre-tagged branches. Data on misshapen fruits were recorded by taking the weight of such fruits after harvesting of fruits of all the treatments under investigation separately. Size of fruit was recorded with the help of meter scale and thread. Statistical analyses of the data obtained in the different sets of experiments were calculated as suggested by Panse and Sukhatme (1985) and results were evaluated at 5 per cent significance.

Observations on effect of different treatments were recorded to assess the growth behaviour under uniform management situation. Data pertaining to per cent fruit drop significantly recorded minimum due to foliar application of $ZnSO_4$ @ 0.5% at different fruit development stages shown in Table-1. A perusal of data recorded on number of fruits/ shoot, fruit retention and fruit drop per cent have been presented in (Table-1) clearly indicated that number of fruits, fruit retention and minimum fruit drop per cent were recorded maximum with the spray of $ZnSO_4$ @ 0.5% whereas maximum fruit drop, minimum number of fruits and fruit retention per cent were noted in control (water spray). Fruit retention per cent increase might be due to increase the endogenous level of auxin and other metabolites. The role of zinc is known to be essential for the biosynthesis of auxin (IAA) as it is an activator of the enzyme tryptophan synthetase. Increased fruit retention under sprays is suggestive of interference that the treatments have in one way or other influencing the auxin balance to prevent fruit drop. Boron plays an important role in the translocation of food materials from leaf to developing fruits and thereby it reduces the fruit dropping. The beneficial effect of urea is increasing fruit retention because role of urea in improving the plant vigour thereby increasing food reservoirs. Similar observations on fruit drop and fruit retention in mango have been recorded by Singh *et al.* (1991) stated that appreciable decreased fruit drop and increased fruit retention in mango with the foliar spray of urea 3.0 per cent. Maximum fruit retention, fruit set and reduced fruit drop were also noted in aonla fruits by Vishwakarma *et al.* (2013) with the spraying of combined spray of Calcium carbonate and Borax (0.4 per cent each).

Data recorded on fruit yield (kg/ tree) duplicated in

Table 1 that application of $ZnSO_4$ @ 0.5% was found to be best to increase fruit yield, whereas, minimum (24.92 kg) fruit yield/ tree was observed in control. The increased fruit yield due to foliar feeding of nutrients, might be attributed to more uptake of nutrients because efficient absorption and consequently more luxuriant vegetative growth in the initial stage, which later on resulting more metabolites for developing fruits. The importance of these nutrients in improving the physiological activities, which improve width of fruit, length of fruit and weight of fruit, ultimately increasing the yield. These results are in close conformity with the findings of Singh *et al.* (2001) found that combined spray of 0.5% $ZnSO_4$, 0.2% Borax and 0.4% $CuSO_4$ significantly increased fruit yield in aonla cv. Fransis. Dhua and Datta (2002) reported that foliar application of $ZnSO_4$ @ 0.1%, $FeSO_4$ @ 0.5% and $Mn SO_4$ @ 2% concentration at the flowering and before flowering + pea stage on the quality of mango fruit cv. Himsagar, significantly enhance higher fruit yield and quality over the untreated control. Kumar *et al.* (2004) stated that spray of micronutrients effectively increased the yield of Litchi cv. Dehradun.

It is evident from the data shown in (Table-1) indicated that significantly increased in fruit size and fruit weight. The maximum fruit length, fruit breadth, fruit weight and fruit volume were recorded with the spray of $ZnSO_4$ @ 0.5%. The minimum fruit size was recorded with control treatment. The reasons for increase fruit size due to spraying of nutrients might be attributed to efficient absorption and accumulation of metabolites in initial stage of developing fruit. Spraying of $ZnSO_4$, which provide zinc to the plant, might have regulated the cell-wall permeability, thereby allowing more mobilization of water in fruit attributing to larger fruit size. Increase in weight and volume of fruits by zinc application might be due to rapid cell division and higher pulp content. The increase in fruit weight by urea spray may be due to the accumulation of more food material in fruit trees. These results are in close conformity with foliar application of GA_3 @ 20ppm + NAA @ 50ppm + $ZnSO_4$ @ 0.4% + Urea @ 2% in phalsa fruit (Kumar *et al.* 2014). Yadav *et al.* (2011) also reported such result by the application of micro-nutrients on flowering, fruiting yield and quality of mango cv. Amrapali under high density orcharding which resulted maximum fruit weight.

Table 1. Showing the effect of micro-nutrients spray on yield attributing characters of mango fruit.

Treatments	Number of fruits/ shoot	Fruit drop (%)	Fruit retention (%)	Fruit yield (kg/tree)	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Volume of fruit (cm ³)
T ₁ : $ZnSO_4$ @ 0.5%	3.57	91.17	8.83	40.46	10.11	6.62	152.72	151.11
T ₂ : $FeSO_4$ @ 0.5%	2.31	93.67	6.33	37.44	9.09	6.26	148.17	140.25
T ₃ : Borax @ 0.5%	3.54	92.33	7.67	37.70	9.62	6.51	151.65	150.33
T ₄ : $MnSO_4$ @ 0.5%	2.31	93.34	6.66	32.33	8.95	5.84	137.43	131.50
T ₅ : Urea @ 2.0%	2.03	94.35	5.65	35.21	8.92	5.43	134.76	124.50
T ₆ : K_2SO_4 @ 2.0%	2.85	92.48	7.52	35.58	9.42	5.73	150.71	145.20
T ₇ : Control	1.92	95.64	4.36	24.92	8.75	5.55	120.28	121.75
S Em +	0.23	0.33	0.57	2.23	0.48	0.36	5.80	5.04
C.D. at 5%	0.70	NS	1.76	6.87	NS	NS	17.86	15.52

Reference

- Anonymous. 1964. *Agriculture in ancient India*. Raychaudhary, S.P. (Tech. Ed.) I.C.A.R., New Delhi.
- Dhua, R.S. and Dutta, P. 2002. Improvement on fruit quality of Himsagar mango through application of zinc, iron and manganese. *Horticultural Journal*, 15 (2): 1-9.
- Kumar, S., Kumar, S. and Verma, D.K. 2004. Effect of micronutrients and NAA on yield and quality of litchi cv. Dehradun. *Abstr. In Proc. of International Seminar on Rec. Trend in Hi-Tech Hort. and PHT*. Organized by CSAUA&T, Kanpur from Feb. 4-6: 193.
- Kumar, S., Yadav, A.L., Vishwakarma, G. and Yadav, D.K. 2014. Effect of foliar feeding of nutrients and plant growth regulators on vegetative growth and yield of phalsa (*Grewia subinaequalis* D. C.). *Res. Environ. and Life Sci.*, 7(4) 293-294.
- Panse, V.G. and Sukhatme, P.V. 1967. Statistical method for agricultural workers. *ICAR, Pub. New Delhi*.
- Singh, H.K., Srivastava, A.K., Dwivedi, R. and Kumar, P. 2001. Effect of foliar feeding of micro-nutrients on plant growth fruit quality, yield and internal fruit necrosis of aonla cv. Francis. *Prog. Hort.*, 33 (1): 83-83.
- Singh, J.N., Rajput, C.B.S. and Prakash, S. 1991. Effect of urea spray on vegetative growth and fruit-weight of different mango cultivar. *Haryana J. Hort. Sci.*, 20: 35-38.
- Singh, L.B. 1960. *The mango: Botany, Cultivation and Utilization*, Leonard Hill, London.
- Vishwakarma, G., Yadav, A. L., Singh, H. K. and Singh, J. 2013. Effect of foliar feeding of calcium and boron on yield and quality of aonla (*Emblica officinalis* Gaertn.) cv. NA-6. *Plant Archives*, 13 (2), pp. 1135-1138.
- Yadav, A.K., Singh, N.K. and Singh, H.K. 2011. Studies on integrated nutrient management in flowering, fruiting, yield and quality of mango. cv. Amrapalli under high density orcharding. *India Journal of Horticulture*, 68 (4): 453-460.

Effect of drip irrigation and bioregulators on water use efficiency and fruit yield of Kachri (*Cucumis melo* var. *callosus*)

S R Bhunia, I M Verma, Mohd. Arif and K Balai

College of Agriculture, S K Rajasthan Agricultural University, Bikaner- 334 006

(Received: 11.12.2015, Accepted: 18.02.2016)

Rajasthan, particularly western region comes under hyper arid zone with very scarce water resource. Thus, more crop per drop of water is main motto of any agricultural production system in these region of the state. Kachri is one of the major cucurbitaceous vegetable of the region is grown extensively. The crop is generally grown as rainfed kharif crop. Growing the crop as irrigated summer crop can be highly profitable. Among the irrigation methods drip irrigation is proved superior as it maintains moisture content at near about field capacity in one hand and eliminates water losses on other hand. The superiority of drip irrigation has been a well established fact particularly in cucurbits (Devaranavadi *et al*) (1). Sulphydryl (-SH-) compounds improve phloem translocation of photosynthate and crop productivity. Thus, they act as bioregulators and play an important role in improving water use efficiency through enhanced phloem translocation and yield formation in arid regions. Thiourea (500ppm) significantly increase yield and quality of tubers in potato (Mani *et al*) (2). Beside thiourea, effect of N-acetyl cysteine and thioglycolic acid (TGA) also influence the fruit yield and water use efficiency of kachri. The information on bioregulators, and drip irrigation on kachri growth and yield are meager. Hence, there is a felt need to generate precise information on irrigation requirement of kachri through drip and effect of bio-regulators on kachri.

A field experiment was conducted on kachri during summer season of 2011 and 2012 at Niche Area Excellence Farm, S K Rajasthan Agricultural University, Bikaner situated in western hyper arid zone of Rajasthan. The soil was sandy loam in nature, having field capacity 6.50%, PWP 1.8%, bulk density 1.52 g/cc, pH (1:2) 8.4, electrical conductivity (1:2) 0.2 dS/m. The soil is very low in organic matter (0.11%) and medium in available P (32.4 kg/ha) and high in available K (336 kg/ha). The experiment was laid out in randomized block design with three replications. The treatments consist of three irrigation levels (40%, 60% and 80% ETc) and four bio-regulators levels (control- water spray, thiourea 500ppm, N-acetyl cysteine @ 20 ppm and TGA @ 100ppm) foliar spray at vegetative and flowering stage. The total irrigation water provided were 202.76, 291.42 and 380.08 mm at 40%, 60% and 80% ETc, respectively including the rainfall of 26.2 mm (Table 1). Ground water was below 10 m throughout the growth period. Kachri variety AHK 200 was sown using seed

rate of 3 kg/ha in 60 cm x 120 cm crop geometry and final harvesting was done on June 30 in both the years. In total 4 to 5 picking of fruits were done during crop growing period. All the cultural operations were carried out as per recommendations.

Irrigation levels

Increasing irrigation levels from 40% to 80% ETc under drip increased fruit yield (Table 2). The highest fruit yield was recorded 278.35 q/ha at 80% ETc against 249 and 274.7 q/ha with 40% and 60% ETc through drip irrigation respectively. However 60% and 80% ETc gave at par fruit yield. This findings are in collaboration with Manjunatha and Manjunatha. (3).

Drip irrigation levels from 40% to 80% ETc saved water by 423.44 to 246.12 mm over surface irrigation which used 626.2 mm water. Hence, increased yield coupled with less water use in drip irrigation recorded higher water use efficiency (WUE) 122.80, 94.26 and 73.23 kg/ha-mm at 40%, 60% and 80% ETc, respectively (Table 2). Lower water use efficiency in surface irrigation (absolute control) may be due to loss of irrigation water from sandy loam soil through deep percolation resulted in higher water use but lowered grain yield. Drip irrigation system saved quite a large amount of water, which can be useful in horizontal expansion of crop area in winter season when mostly irrigated crops are raised in Rajasthan.

Bio-regulator

Foliar spray of N-acetyl cysteine (20 ppm) recorded higher fruit yield (272.16 q/ha) over thiourea spray (500 ppm) (268.36 q/ha), TGA (100ppm) (268.73 q/ha) and control (260.13 q/ha). The fruit yield in control and thiourea, thiourea and N-acetyl cysteine and N-acetyl cysteine and TGA are find significantly at par (Table 2). The highest fruit weight of round gourd was also recorded with N-acetyl cysteine (20 ppm) spray (110.4 gm) as compared to control (105.5 gm), thiourea spray (500 ppm) (107.8 gm), TGA (100ppm) (108.0 gm).

Interaction effect

Drip irrigation level 80% ETc gave highest fruit yield with the bioregulator spray of N-acetyl cysteine (281.0 q/ha) which is significantly at par with 60% and 80% ETc drip

Table 1. Month-wise irrigation events and irrigation water applied (mean of two years)

Month	Irrigation events	Irrigation water applied in mm (Drip irrigation)		
		40% ETc	60% ETc	80% ETc
March (14 to 31)	9	5.57	8.36	11.15
April	15	51.93	77.91	103.89
May	15	77.49	116.24	154.99
June (1-21)	11	42.27	63.41	84.55
Total	50	177.26	265.92	354.58
Rainfall (mm)		25.5	25.5	25.5
Total		202.76	291.42	380.08

Table 2. Effect of irrigation and bioregulators on yield, yield attributes, water use and water use efficiency of kachri (pooled of two years)

Treatment	Fruit yield (q/ha)	No. of fruits/plant	Fruit Weight (g)	Water use (mm)	WUE (kg/ha-mm)
Irrigation level (ETc)					
40%	249	12.5	101.5	202.76	122.80
60%	274	14.4	110.6	291.42	94.26
80%	278	14.7	111.7	380.08	73.23
Surface irrigation	225	12.4	101.1	626.2	35.93
CD at 5%	8	1.1	2.5	-	-
Bio-regulator spray					
Control	260	13.3	105.5	291.42	89.26
Thiourea (500 ppm)	268	13.9	107.8	291.42	92.08
N-acetyl cysteine (20 ppm)	272	14.3	110.4	291.42	93.39
TGA (100 ppm)	268	14.0	108.0	291.42	92.21
CD at 5%	9	NS	2.9	-	-

Table 3. Inter action effect of irrigation and bioregulator on fruit yield and water use efficiency of Kachri

Treatment	Fruit yield (q/ha)			Water use efficiency (kg/ha-mm)		
	40% ETc	60% ETc	80% ETc	40% ETc	60% ETc	80% ETc
Control	235.4	270.4	274.6	116.09	92.78	72.24
Thiourea (500 ppm)	251.5	275.3	278.3	124.03	94.46	73.22
N-acetyl cysteine (20 ppm)	257	278.5	281.0	126.75	95.56	73.93
TGA (100 ppm)	252.1	274.6	279.5	124.33	94.22	73.53
CD at 5%	16.5			-		

irrigation and control of bioregulator (Table 3). The fruit yield in 80% ETc and thiourea spray (278.3 q/ha) was found significantly at par with 60% and 80% ETc drip irrigation and control of bioregulator. Drip irrigation level 40% ETc gave highest WUE with the bioregulator spray of N-acetyl cysteine (126.75 Kg/ha-mm) over 60% and 80% ETc drip irrigation and bioregulator spray of N-acetyl cysteine.

References

Devaranavadi, V S, Shirahatti, S S and Patil, M G (2011) Effect of different drip irrigation level on growth and yield of bitter melon (*Momordica charantia* L.) in

semi arid conditions of Karnataka. *International Journal of Agricultural Engineering*, 4(2):179-182.

Mani F, Bettaieb T, Zheni K, Doudech N and Hannachi C (2013) Effect of thiourea on yield and quality of potato (*Solanum tuberosum* L.). *Journal of Stress Physiology & Biochemistry*, 9(1):87-95.

Manjunatha M V and Manjunatha Hebbara (2010) Response of ridge gourd to various levels of drip and surface irrigation in saline vertisols of canal command, Karnataka. *Asian Journal of Soil Science*, 5(2):257-260.