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BIODIVERSITY OF ARTHROPOD FAUNA IN TAMIL NADU CABBAGE ECOSYSTEMS

K. SENGUTTUVAN* and S. KUTTALAM

Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore- 641 003

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ABSTRACT

The experiment was conducted to evaluvate the arthropods diversity in cabbage ecosystem during 2013 to 2014. The sampling of arthropods was conducted using four different methods. The collected arthropods were sorted out, identified to the lowest possible taxon and the biodiversity indices were estimated. The class Insecta was the most common, followed by Arachnida. A total of 2866 arthropods from 8 orders and 26 families were collected from cababge ecosystem. Totally, six families of Lepidoptera were collected with the majority of individuals falling under the family Plutellidae and Pyralidae in both sprayed and unsprayed cabbage fields. Among the endopterygotes, maximum individuals were from Lepidoptera, while Hemiptera was predominant in terms of individuals of exopterygota. Among the four families of hemipterans collected, majority of the individuals were from Aphididae and Pentatomidae followed by Pseudococcidae. The biodiversity indices were worked out and at generic level varied between a minimum of 32 during the first fortnight of April to a maximum of 40 during second fortnight of June in unsprayed cabbage. In sprayed cabbage, the maximum (38) was during the first fortnight of May and the minimum (26) during the first fortnight of April. Based on ordinal level and species level analysis, the species richness was not clear in variation from the Fisher's alpha index values. At generic level, the value was the highest in the first fortnight of May in sprayed field (10.198). The highest ordinal and familial level indices were 1.8397 in first fortnight of June and 7.8919 in second fortnight of June in sprayed cabbage.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) and cauliflower (*Brassica oleracea* var. *botrytis* L.) are important vegetables of cole crop group and the third major vegetable group primarily grown in the winter season in plains. The major cabbage and cauliflower growing states in India are Assam, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal. In India, cole crops were grown over an area 4,07,000 of hectares with an annual production of 89,71,000 tonnes in 2016-2017 (GoI, 2017). Ludwig and Reynolds (1988) reported that Shannon-Weiner index (H) and Evenness index (EI) were the most widely used indices by various ecologists to know the biodiversity of fauna. They also reported that diversity indices incorporate both species richness and evenness into a single value. *Diadegma semiclausum* and *Cotesia plutellae* were the major parasitoids of *Plutella xylostella* in cabbage ecosystem. A negative relationship existed between parasitism by *C. plutellae* and *D. semiclausum* indicating a competitive displacement between the two species (Talekar and Yang, 1993). The extent of natural parasitism of *P. xylostella* by these parasitoids vary beween 16 and 75 per cent in tropics and 80 per cent in hilly ares (Regupathy, 1996). Larval (*Cotesia plutellae*) and pupal (*Oomyzus sokolowaskii*) parasitisation of DBM to the extent of 10.8 - 26.8 per cent was noticed in cauliflower ecosystem (Sable *et al.,* 2008). The parasitisation rates of *C. plutellae* on DBM was to the tune of 16-50 per cent and there was a density dependent relationship between the parasitoid and the host (Jayarathnam, 1977). Mushtaque and Mohyuddin (1987) have observed decreased parasitism of DBM by *C. plutellae* in Pakistan during heavy use of insecticides. Studies by Talekar (1990) proved the toxicity of teflubenzuron to the pupae of *D. semiclausum,* the parasitoid of DBM.

Class Insecta has always been regarded as the most speciose class in the Animal Kingdom (Myers *et al*., 2000). This class also constitutes a substantial proportion of terrestrial species richness and biomass and plays a significant role in ecosystem functioning (McGeoch, 1998). Even so, known species diversity is only a small fraction of the total species diversity (Myers *et al*., 2000). The performance and effectiveness of

***Corresponding author E-mail:** senguttuvanphd@gmail.com

natural enemies might also be enhanced by chemical cues from the associated plants (Kuzhandhaivel Pillai *et al*., 2017).

Spiders are the most abundant predators of insects in terrestrial ecosystems (Edwards *et al*., 1976) and form one of the most ubiquitous groups of predaceous organism in the animal kingdom (over 30,000 species) (Rishikumar *et al*., 2012). Keeping the importance of fauna diversity the experiment was conducted to evaluvate the arthropods diversisity in cabbage ecosystem during 2013 – 2014 in Tamil Nadu, India.

MATERIAL AND METHODS

Studies were conducted at Jahirnayakanpalayam, Coimbatore and Erisibetta, Kotagiri and TNAU Farm, Najanadu, Horticultural Research Station, Ooty. The various methodologies followed for the survey and collection of arthropods, preservation and their identification and diversity analysis are described in detail hereunder. To develop a package of methods for quantitative sampling of arthropod communities, collections were made using four different methods *viz*., active searching, net sweeping, pitfall trap and rubbish trap. For carrying out arthropod collection, the plot was divided into 100 quadrats (10 m x 10 m). Five such quadrats were chosen each at random and the entire plot was covered during the sampling period.

All arthropod species were identified to the lowest possible taxon. Insects were identified with the help of Dr. M. Ganesh Kumar, Professor, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore and also according to the principles of Lefroy (1984), Richards and Davis (1983), Poorani (2002) and Firake *et al.* (2012).

Diversity analysis of arthropods in cabbage ecosystem

Alpha diversity indices

The following indices were used to assess and compare the diversity and distribution of arthropods in cabbage ecosystem. Species richness and diversity version II (Pisces Conservation Ltd., www.irchouse.demon.co.uk) (Henderson, 2003) programmes were used to assess and compare the diversity of arthropods in sprayed and unsprayed cabbage ecosystems.

Species richness

Fishers alpha (Fisher *et al.,* 1943)

It presents the alpha log series parameter for each sample. This is a parametric index of diversity that assumes the abundance of species following the log series distribution.

$$\alpha x, \frac{\alpha x^2}{2}, \frac{\alpha x^3}{3}, \frac{\alpha x^n}{n}$$

Where, each term gives the number of species predicted to have 1, 2, 3, … n individuals in the sample.

Q Statistic (Kempton and Taylor, 1976)

This presents the interquartile diversity index for each sample. It measures the interquartile slope of the cumulative abundance curve and was estimated

$$Q = \frac{1}{2}nR_1 + \sum nr + \frac{\frac{1}{2}nR_2}{\ln\left(\frac{R_2}{R_1}\right)}$$

where,

nr - the total number of species with abundance R

$R_1 and\ R_2$ – 25 per cent and 75per cent quartile of the cumulative species curve

nR_1 - the number of individuals in the class where R_1 falls

nR_2 - the number of individuals in the class where R_2 falls

Species number (Magurran, 1987) : This represents the total number of species in each sample.

Margalef's D (Clifford and Stephenson, 1975)

It is calculated as species number minus one divided by the logarithm of the total number of individuals. This program uses the natural logarithm.

$$D_{Mg} = \frac{(S-1)}{\ln N}$$

where,

S - total number of species recorded

N - the total number of individuals summed overall S species

Shannon diversity index (Batten, 1976)

This represents the Shannon - Weiner (also called as Weaver) diversity index for each sample and is defined as:

$$H' = \sum P_i \ln P_i$$

where

P_i - The proportion of individuals in the ith species

H' - This program calculates the index using the natural logarithm

Brillouin diversity index (Magurran, 1987)

The Brillouin index H is calculated as follows:

$$H = \ln N! - \sum_{i=1}^{s} \frac{\ln n_i!}{N}$$

where,

N - is the total number of individuals in the sample

n_i - is the number of individuals belonging to the ith species and s is the species number.

Species Dominance indices

Simpson's index (Simpson, 1949)

Simpson's index describes the probability that a second individual drawn from a population should be of the same species as the first.

$$D = \sum \frac{[N_i(N_i - 1)]}{[N_t(N_t - 1)]}$$

where,

N_i is the number of individuals in the ith species

N_t is the total number of individuals in the sample

Hence, larger its value, greater the diversity. The statistic 1 - C gives a measure of the probability of the next encounter being from another species (Hulbert, 1971).

Berger Parker diversity index (Berger and Parker, 1970)

A simple dominance measure is the Berger Parker index. The index expresses the proportional importance of the most abundant species.

$$d = \frac{N_{max}}{N}$$

where,

N_{max} is the number of individuals in the most abundant species

N-is the number of individuals in the sample

McIntosh index (McIntosh, 1967)

This index was calculated using the following formula proposed by McIntosh (1967) as

$$D = \frac{N - U}{N - \sqrt{N}}$$

where,

N is the total number of individuals in the sample

U is given by the expression,

$$U = \sqrt{\sum n_i^2}$$

Where, is the number of individuals belonging to the ith species and the summation is undertaken for over all the species.

Evenness indices

Evenness (E) is a measure of how similar the abundances of different species or categories are in a community. When all species in a community are equally abundant, the evenness index should be maximum and decrease towards zero as the relative abundances of the species diverge away from evenness closer to zero. It indicates that most of the individuals belong to one or a few species or categories, when the evenness is close to one; it indicates that each species / category consists of the same number of individuals.

$$E = \frac{H'}{\ln(S)}$$

where,

S – Total number of species in a community

H' - prime is the number derived from the Shannon diversity index

Equitability (Magurran, 1987)

Equitability or evenness refers to the pattern of distribution of the individuals between the species. This measure of equitability (J) compares the observed Shannon- Weiner index against the distribution of individuals between the observed species which would maximize diversity. If H is the observed Shannon - Weiner index, the maximum value this could take, where S is the total number of the species in the habitat. Therefore, the index is:

$$J = \frac{H}{\log S}$$

RESULTS AND DISCUSSION

Collection and identification of arthropods under cabbage ecosystem

Arthropods collected at fortnightly intervals from April, 2013 to June, 2014 in sprayed and unsprayed cabbage fields were documented, identified up to the lowest taxonomic level possible and various biodiversity indices were worked out. The survey yielded a wide array of 2866 individuals of arthropods from 26 families and eight orders of insects (Table 1).

The class Insecta was the most common, followed by Arachnida. Totally, six families of Lepidoptera were collected with the majority of individuals falling under the family Plutellidae and Pyralidae in both sprayed and unsprayed cabbage fields. Among the endopterygotes, maximum individuals were from Lepidoptera, while Hemiptera was predominant in terms of individuals of exopterygota. Among the four families of hemipterans collected, majority of the individuals were from Aphididae and Pentatomidae followed by Pseudococcidae (Table 1).

In case of Aphididae, 310 individuals of *Myzus persicae* (Sulzer) were collected with majority of individuals from unsprayed cabbage. Orthoptera was represented by three families *viz*., Gryllidae (*Gryllus* sp.), Pyrgomorphidae (*Chrotogonus* sp.) and Tettigoniidae (*Conocephalus* sp.) with majority of individuals from unsprayed cabbage field. The single family represented under the order Mantodea was Mantidae with 16 individuals of *Mantis religiosa* L. from unsprayed field. The order Hymenoptera was represented by four families. The maximum number of individuals belonged to family Braconidae (249), followed by Ichneumonidae (74) and Tenthredinidae (44) in both sprayed and unsprayed cabbage.

Diptera was represented by three families with majority of individuals collected falling under Syrphidae of all genus (143) followed by Tachnidae (103) and Tipulidae (31). Majority of species under Tachinidae belonged to the genus *Exorista larvarum* L. (64). Under Coleoptera three families were collected with majority of individuals belonging to Coccinellidae (110). Only 27 individuals of Meloidae were collected (Table 1).

Biodiversity indices

Among the collection, 8 orders of arthropods were recorded. Based on this primary arthropod data, different sets of alpha diversity indices were calculated.

Alpha diversity indices at ordinal, family, generic and species level

The species number calculated based on the generic level varied between a minimum of 32 during the first fortnight of April to a maximum of 40 during second fortnight of June in unsprayed cabbage. In sprayed cabbage, the maximum (38) was during the first fortnight of May and the minimum (26) during the first fortnight of April (Table 2).

Based on ordinal level and species level analysis, the species richness was not clear in variation

Table 1. Diversity of arthropods at families and generic level in cabbage ecosystem

Order	Family	Geneus	Sprayed	Un-sprayed	Total
Araneae	Araneidae	*Araneus* sp.	2	5	**7**
Araneae	Tetragnathidae	*Leucauge* sp.	4	5	**9**
Araneae	Oxyopidae	*Oxyopes ratanae* (Tikade)	0	2	**2**
Coleoptera	Chrysomelidae	*Phyllotreta cruciferae* (Goeze)	2	9	**11**
Coleoptera	Chrysomelidae	*Raphidopalpa foveicollis* (Lucas)	9	23	**32**
Coleoptera	Coccinellidae	*Chilocorus nigritus* (Fabricius)	0	4	**4**
Coleoptera	Coccinellidae	*Coccinella septempunctata* (Linnaeus)	4	15	**19**
Coleoptera	Coccinellidae	*Coccinella transversalis* (Fabricius)	8	19	**27**
Coleoptera	Coccinellidae	*Cheilomenes sexmaculata* (Fabricius)	1	13	**14**
Coleoptera	Coccinellidae	*Micraspis discolor* (Fabricius)	5	9	**14**
Coleoptera	Curculionidae	*Myllocerus viridanus* (Fabricius)	7	8	**15**
Coleoptera	Curculionidae	*Myllocerus* sp.	5	7	**12**
Diptera	Syrphidae	*Syrphus torvus* (Osten Sacken)	23	26	**49**
Diptera	Syrphidae	*Episyrphus balteatus* (de Geer)	26	29	**55**
Diptera	Syrphidae	*Sphaerophoria* sp.	3	5	**8**
Diptera	Syrphidae	*Sphaerophoria scripta* (Linnaeus)	15	16	**31**
Diptera	Tachinidae	*Exorista bombycis* (Louis)	18	21	**39**
Diptera	Tachinidae	*Exorista larvarum* (Linnaeus)	22	42	**64**
Diptera	Tipulidae	Unknown sp.	4	27	**31**
Hemiptera	Aleyrodidae	*Aleyrodes proletella* (Linnaeus)	16	69	**85**
Hemiptera	Aphididae	*Myzus persicae* (Sulzer)	133	310	**443**
Hemiptera	Aphididae	*Brevicoryne brassicae* (Linnaeus)	57	67	**124**
Hemiptera	Pentatomidae	*Bagrada picta* (Fabricius)	8	41	**49**
Hemiptera	Pentatomidae	*Nezara viridula* (Linnaeus)	10	18	**28**
Hemiptera	Pseudococcidae	*Coccidohystrix insolita* (Green)	7	35	**42**
Hymenoptera	Apidae	*Xylocopa* sp.	7	10	**17**
Hymenoptera	Apidae	*Xylocopa aestuans* (Linnaeus)	15	19	**34**
Hymenoptera	Apidae	*Synhalonia* spp.	10	20	**30**
Hymenoptera	Apidae	*Apis cerana indica* (Fabricius)	8	23	**31**
Hymenoptera	Braconidae	*Cotesia plutellae* (Kurdjumov)	92	157	**249**

(Table 1 Continued)

(Table 1 Continued)

Order	Family	Geneus	Sprayed	Un sprayed	Total
Hymenoptera	Ichneumonidae	*Hyposoter ebeninus* (Gravenhorst)	10	13	**23**
Hymenoptera	Ichneumonidae	*Diadegma insulare* (Cresson)	19	32	**51**
Hymenoptera	Tenthredinidae	*Athalia proxima* (Klug)	22	22	**44**
Lepidoptera	Crambidae	*Hymenia recurvalis* (Fabricius)	7	7	**14**
Lepidoptera	Crambidae	*Crocidolomia binotalis* Zeller	19	19	**38**
Lepidoptera	Lymantriidae	*Euproctis subfasciata* (Walker)	9	9	**18**
Lepidoptera	Noctuidae	*Plusia signata* (Fabricius)	16	16	**32**
Lepidoptera	Noctuidae	*Trigonodes hyppasia* (Cramer)	13	13	**26**
Lepidoptera	Noctuidae	*Spirama retorta* (Clerck)	16	16	**32**
Lepidoptera	Noctuidae	*Spodoptera litura* (Fabricius)	4	4	**8**
Lepidoptera	Noctuidae	*Trichoplusia ni* (Hubner)	24	25	**49**
Lepidoptera	Noctuidae	*Agrotis ipsilon* (Hufnagel)	9	8	**17**
Lepidoptera	Pieridae	*Pieris brassicae* (Linnaeus)	16	14	**30**
Lepidoptera	Pieridae	*Pieris repae* (Linnaeus)	20	22	**42**
Lepidoptera	Plutellidae	*Plutella xylostella* (Linnaeus)	186	504	**690**
Lepidoptera	Pyralidae	*Sylepta lunalis* (Guenee)	27	28	**55**
Mantodea	Mantidae	*Mantis religiosa* (Linnaeus)	14	16	**30**
Orthoptera	Gryllidae	*Gryllus* sp.	17	17	**34**
Orthoptera	Pyrgomorphidae	*Chrotogonus* sp.	15	16	**31**
Orthoptera	Tettigoniidae	*Conocephalus* sp.	13	14	**27**
		Total	**997**	**1869**	**2866**

from the Fisher's alpha index values. At generic level, the value was the highest in the first fortnight of May in sprayed field (10.198). The highest ordinal and familial level indices were 1.8397 in first fortnight of June and 7.8919 in second fortnight of June in sprayed cabbage (Table 2).

Margelef's D value is based on generic level varied between a minimum of 4.5213 during the first fortnight of April and maximum of 6.1451 during first fortnight of May in sprayed cabbage. In unsprayed cabbage, the index value was the highest during the second fortnight of June (6.6195) and the lowest during the first fortnight of April (5.9322).

Analysis of data using Q statistic is presented in Table 2. The index value based on ordinal level ranged from 1.5922 to 3.1423 and 1.4923 to 1.8766 in sprayed and unsprayed cabbage fields, respectively and showed significant variation. On the generic level, the value was maximum in the first fortnight of May (6.1451) and minimum in the first fortnight of April (4.5213) in sprayed cabbage. In unsprayed cabbage, the value was the

Table 2. Arthropod diversity in cabbage ecosystem

Alpha diversity	Month	Fort night	Sprayed field				Unsprayed			
			Ordinal level	Familial level	Generic level	Species level	Ordinal level	Familial level	Generic level	Species level
Species richness indices (Species number)	April	I	7	19	26	28	7	22	32	37
		II	7	19	33	36	8	22	37	41
	May	I	8	24	38	40	8	25	40	44
		II	8	23	34	36	8	24	37	43
	June	I	8	23	32	32	8	26	38	41
		II	7	21	31	35	8	26	40	46
Species richness indices (Fishers alpha)	April	I	1.5999	6.2122	7.2704	11.1610	1.4386	6.4866	11.1330	10.2060
		II	1.3431	4.8089	7.9829	11.6130	1.4627	5.2302	10.4760	9.5418
	May	I	1.6574	7.0337	10.1980	14.7980	1.4833	6.3127	11.9700	10.6640
		II	1.7362	7.1160	9.3368	13.8270	1.5061	6.1120	11.0210	10.5660
	June	I	1.8397	7.7991	9.2812	12.9130	1.4665	6.5402	10.9190	9.5749
		II	1.6901	7.8919	10.0390	18.3830	1.4491	6.4271	11.4820	10.9430
Species richness indices (Margalef’s D)	April	I	1.2406	3.7219	4.5213	5.5828	1.1482	4.0186	5.9322	6.0822
		II	1.0899	3.2696	5.1626	6.3575	1.1967	3.5902	6.1546	6.1139
	May	I	1.3138	4.3169	6.1451	7.3200	1.2096	4.1473	6.7394	6.6358
		II	1.3584	4.2691	5.6445	6.7918	1.2237	4.0208	6.2934	6.5487
	June	I	1.4145	4.4456	5.4946	6.2642	1.1991	4.2825	6.3381	6.1248
		II	1.2892	4.2974	5.6105	7.3056	1.1881	4.2433	6.6195	6.8339
Species richness indices (Q Statistic)	April	I	2.1370	7.9348	4.5213	15.2790	1.8766	7.6258	17.3120	18.2050
		II	1.9534	7.2135	5.1626	13.6690	1.8205	7.9348	15.9290	16.8390
	May	I	2.0019	8.7806	6.1451	15.2230	1.5654	7.1946	20.0250	19.5700
		II	1.7565	7.3135	5.6445	13.0480	1.4923	7.4654	15.1660	18.3590
	June	I	1.5922	8.0926	5.4946	12.1160	1.5837	6.9376	13.3950	17.4620
		II	3.1423	7.7370	5.6105	15.5090	1.6345	7.7900	14.7880	17.5610

(Table 2 continued)

(Table 2 continued)

Alpha diversity	Month	Fort night	Sprayed field				Unsprayed			
			Ordinal level	Familial level	Generic level	Species level	Ordinal level	Familial level	Generic level	Species level
Species richness indices (Brillouin diversity index)	April	I	1.3144	2.3136	1.9919	2.6896	1.4576	2.4936	2.8124	2.1231
		II	1.4255	2.0923	1.8765	2.4315	1.4456	2.1374	2.4107	1.9076
	May	I	1.5659	2.3856	2.0413	2.7274	1.4827	2.2848	2.6014	1.9951
		II	1.5058	2.4277	2.0375	2.7900	1.4862	2.3884	2.6488	2.0462
	June	I	1.5485	2.3747	2.0049	2.6663	1.5234	2.2402	2.4300	1.9184
		II	1.6147	2.4306	2.0786	2.8727	1.5748	2.4178	2.6966	2.0615
Species richness indices (Shannon-Weiner index)	April	I	1.4009	2.5413	2.1511	3.0090	1.5250	2.6855	3.0757	2.2751
		II	1.4794	2.2218	1.9785	2.6398	1.4898	2.2483	2.5741	1.9992
	May	I	1.6362	2.5675	2.1780	2.9967	1.5303	2.4139	2.7912	2.0994
		II	1.5819	2.6308	2.1824	3.0832	1.5340	2.5238	2.8402	2.1574
	June	I	1.6381	2.6087	2.1661	2.9754	1.5673	2.3635	2.5959	2.0103
		II	1.7262	2.7135	2.2871	3.3048	1.6188	2.5416	2.8721	2.1621
Species dominance indices (Simpson's index)	April	I	3.1437	10.2540	3.7672	16.2370	3.8698	11.8900	16.4480	3.7903
		II	3.4642	5.9544	3.5161	7.2336	3.5229	5.7260	6.5415	3.4767
	May	I	4.3022	9.0700	3.7077	12.3190	3.6878	6.7960	8.1941	3.5710
		II	4.2267	10.5970	3.7481	15.2750	3.9165	8.0028	9.2406	3.6225
	June	I	4.6711	10.5000	3.7520	14.4930	4.1033	6.5821	7.0846	3.5130
		II	5.1852	13.6160	3.8615	26.6340	4.3064	8.2553	9.5360	3.6293
Species dominance indices (McIntosh index)	April	I	0.4734	0.7426	0.5144	0.8094	0.5263	0.7571	0.8022	0.5109
		II	0.4914	0.6260	0.4873	0.6660	0.4917	0.6121	0.6403	0.4810
	May	I	0.5525	0.7111	0.5038	0.7603	0.5051	0.6490	0.6848	0.4889
		II	0.5510	0.7407	0.5088	0.7942	0.5222	0.6815	0.7071	0.4935
	June	I	0.5802	0.7438	0.5117	0.7917	0.5329	0.6417	0.6564	0.4840
		II	0.6119	0.7903	0.5238	0.8686	0.5445	0.6845	0.7097	0.4924

(Table 2 continued)

Alpha diversity	Month	Fort night	Sprayed field				Unsprayed			
			Ordinal level	Familial level	Generic level	Species level	Ordinal level	Familial level	Generic level	Species level
Species dominance indices (Berger parker diversity index)	April	I	0.4734	0.1825	0.5000	0.1587	0.3871	0.1667	0.1452	0.5000
		II	0.4914	0.3089	0.5000	0.3089	0.4323	0.3314	0.3314	0.5000
	May	I	0.5525	0.2330	0.5000	0.1796	0.3865	0.2822	0.2822	0.5000
		II	0.5510	0.1850	0.5000	0.1850	0.3344	0.2361	0.2361	0.5000
	June	I	0.5802	0.1702	0.5000	0.1702	0.3411	0.3032	0.3032	0.5000
		II	0.6119	0.1524	0.5000	0.1238	0.3260	0.2597	0.2597	0.5000
Evenness indices (Equitability J)	April	I	0.6737	0.7800	0.5684	0.7773	0.7334	0.8243	0.8178	0.5846
		II	0.7115	0.6819	0.5228	0.6819	0.7164	0.6901	0.6844	0.5137
	May	I	0.7868	0.7881	0.5756	0.7741	0.7359	0.7409	0.7421	0.5394
		II	0.7608	0.8075	0.5767	0.7965	0.7377	0.7746	0.7551	0.5544
	June	I	0.7878	0.8007	0.5724	0.7686	0.7537	0.7254	0.6902	0.5166
		II	0.8302	0.8329	0.6044	0.8537	0.7785	0.7801	0.7636	0.5556

highest in the first fortnight of May (20.025) and the lowest in the first fortnight of June (13.395).

Minimum variation was observed in case of Brillouin diversity index based on ordinal, generic, familial and species level between the sprayed and unsprayed cabbage (Table 2).

The Shannon –Weiner index was calculated based on the four taxonomic levels (Table 2). The index values based on ordinal, generic, familial and species levels in sprayed cabbage were lower than unsprayed field.

Simpson's diversity indices at ordinal, family, generic and species level

The Simpson's index was calculated based on ordinal level revealed maximum during the second fortnight of June (4.3064) and minimum during the second fortnight of April (3.5229) in unsprayed cabbage. In sprayed cabbage, the maximum was during the second fortnight of June (5.1852) and minimum during the first fortnight of April (3.1437). Analysis of values based on generic level showed that the value was the highest during the first fortnight of April and lowest during the second fortnight of April both in unsprayed cabbage field (Table 2).

McIntosh index also showed no clear variation among the values on the four taxonomic levels in both sprayed and unsprayed cabbage (Table 2).

Berger Parker diversity index was calculated based on the four taxonomic levels. The index value was higher in unsprayed cabbage than sprayed field and no variation in generic level and species level in sprayed and unsprayed field, respectively (Table 2).

Evenness indices (Equitability J) also observed clear variation in the values of Familial level the maximum (0.83015) was noticed on second fort night of June in sprayed field but in the unsprayed field noticed maximum (0.82426) at first fortnight of April (Table 2).

The maximum number of arthropods was observed in unsprayed cabbage than sprayed field. The maximum diversity of arthropods occurred in the month of May with most of the diversity indices.

Comparision of abundance and diversity of arthropods in cabbage ecosystem

Arthropods are frequently used as ecological indicators because they represent more than 80 per cent of the global species richness. They fulfil essential roles in ecosystem such as pollination, soil structure and function, decomposition and nutrient recycling, natural enemies of pest species, prey for highly valued vertebrate, etc., (Pettersson *et al*., 1995). They have short generation times and respond quickly to ecological changes. Further, various arthropod taxa have been used to detect anthropogenic impact on ecosystems including agriculture and climate change (Buddle *et al*., 2000). The results of the present study revealed that arthropod diversity was greater in case of unsprayed cabbage compared to sprayed cabbage field. Biodiversity is a measurement of ecological complexity, and is expected to be higher in less disturbed ecosystems; overall, biodiversity is highly threatened by modern agriculture documented by Amman (2005).

Agricultural intensification through use of pesticides is significantly correlated to reduction in various taxonomic levels. Arthropod diversity in agricultural landscapes was found to be higher in less intensely cultivated habitats as observed by Amman (2005). Biodiversity of arthropod fauna assessed in brassicaceous ecosystems by Firake *et al.* (2012) Three species of aphids *viz., Lipaphis erysimi* Kaltenbach, *Brevicoryne brassicae* Linnaeus and *Myzus persicae* Sulzer, and large white cabbage butterfly (*Pieris brassicae* Linnaeus) were recorded as major pests of brassicaceous plants in Meghalaya region.

The investigation yielded 2866 individuals of arthropods belonging to 26 families and eight orders in both sprayed and unsprayed cabbage fields. Under Insecta, endopterygotes were the largest group represented by four orders, while exopterygotes represented by three orders. Among endopterygotes, maximum individuals were from Lepidoptera while Hemiptera was predominant in terms of individuals of exopterygota. Totally, six families of Lepidoptera were collected with the majority of individuals falling under the family Plutellidae and Pyralidae in both sprayed and unsprayed cabbage fields. The four families of hemipterans were collected and the majority of the individuals were from Aphididae and Pentatomidae followed by Pseudococcidae. Amoung Aphididae, with majority individuals of *Myzus persicae* Sulzer were collected from unsprayed cabbage. Orthoptera was represented by three families *viz*., Gryllidae, Pyrgomorphidae and Tettigoniidae with majority of individuals from unsprayed cabbage field. The single family represented under the order Mantodea was Mantidae with major individuals of *Mantis religiosa* Linnaeus from unsprayed field. The order Hymenoptera was represented by four families. The maximum number of individuals belonged to family Braconidae, followed by Ichneumonidae, Tenthredinidae and Apidae in both sprayed and unsprayed cabbage. Studies on diversity and abundance of DBM parasitoids in Thailand revealed that *C. plutellae* was dominant during early crop stages as reported by Haseeb *et al.* (2005) and Upanisakorn *et al.* (2011).

Diptera was represented by three families with majority of individuals collected falling under Syrphidae followed by Tachnidae and Tipulidae. Majority of species under Tachinidae belonged to the genus *Exorista*. Under Coleoptera three families were collected with majority of individuals belonging to Coccinellidae. Only 27 individuals of Curculionidae were collected. Earlier studies with spiders of the family Oxyopidae susceptible to insecticides such as the pyrethroid alphamethrin, but less so than to other insecticides such as endosulfan was reported by Vandenberg *et al*. (1990).

Biodiversity indices

Biodiversity is a function of species present (species richness), the evenness which individuals are distributed among these species (species evenness) and the interaction component of richness and evenness as documented by Ludwig and Reynolds (1988). Measures of diversity are frequently seen as indicators of the well being of any ecosystem. They also serve as a measure of the species diversity in the ecosystem. As complete counts of organisms are impractical, indirect solutions that are practical, rapid and inexpensive are necessary and hence, diversity indices have gained importance. In the study, the data on the arthropods collected were subjected to alpha or within habitat diversity and beta or between habitat diversity of sprayed and unsprayed cabbage fields. Margelef's D value based on generic level varied between a minimum of 4.5213 during the first fortnight of April and maximum of 6.1451 during first fortnight of May in sprayed cabbage. In unsprayed cabbage, the index value was the highest during the second fortnight of June (6.6195) and the lowest during the first fortnight of April (5.9322). Similar results were earlier reported by Stanley (2007) that the overall species richness indicated by Margelef index was 2.60 for sprayed and 2.03 for unsprayed clumps for eight sprays of diafenthiuron at 0.08 per cent.

In the study, alpha diversity was estimated based on species number, Fishers alpha, Margelef's D, Q statistic, Brillouin and Shannon-Weiner while dominance was based on Simpson's, McIntosh and Berger parker. In both instances, the analysis was subjected to four levels of classification *viz.,* based on order, family, genus and species. The use of higher taxa typically families as surrogate for species has been suggested by Williams and Gaston (1994). Hughes (1978) concluded that the taxonomic level of identification is one of the most important factors influencing the value of the Shannon index.

The species richness indices based on species number, Fishers Alpha index, Margalef's D index, Q Stastistic, Brillouin diversity index and Shannon - Weiner index was higher in unsprayed cabbage. The different dominance indices *viz.*, Simpson's, McIntosh and Berger Parker, expressed higher arthropods diversity in unsprayed cabbage field and lower was observed in sprayed field. The study was supported by Stanley (2007) who reported that diafenthiuron did not have any adverse effect on the pest, pollinator and natural enemy diversity which was measured by using indices of species richness, diversity and evenness.

CONCLUSION

Species richness of insects and spiders were found to be abundant during the study period. Considering the species diversity indices and species evenness indices, it was recorded that the maximum value was observed during the month of April. The biodiversity indices in cabbage was not reported earlier and henceforth the sudy is a ground research in the biodiversity of arthropods in cabbage ecosystem.

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GENETIC VARIABILITY IN MUTANT CONFECTIONARY SUNFLOWER (*Helianthus annuus* L.)

K. SAI PHANINDRA*, V.N. TOPROPE and N.R. THAKUR
Department of Genetics and Plant Breeding, College of Agriculture,
Vasantrao Naik Marathwada *Krishi Vidyapeeth*, Latur - 413 512

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ABSTRACT

Genetic variability was induced in confectionary sunflower (*Helianthus annuus* L.) genotypes *viz.,* EC 625693, EC 318761 and SCG 62 with sodium azide (NaN_3) at concentrations of 100 ppm, 200 ppm and 300 ppm in distilled water for four hours along with control, respectively. The analysis of variances revealed significant differences between treatments for all ten characters under study. There was a close correspondence between GCV and PCV for all characters. High GCV, PCV, heritability and genetic advance as per cent of mean were exhibited by seed filling percentage, 100 grain weight, sugar content and seed yield plant^{-1}. The 300 ppm showed high genetic parameters for head diameter, seed filling percentage, seed yield plant^{-1}, 100 ppm for 100 grain weight. On the basis of *per se* performance, EC 625693 of 100 ppm showed positive shift in mean for seed yield plant^{-1} compared to control, while other genotypes showed negative response to mutagenic treatment. The material generated can be effectively improved only after attaining homogeneity among characters.

INTRODUCTION

Sunflower (*Helianthus annuus* L.*,* 2n=34) is a native of southern USA and Mexico, which includes 20 genera with 67 species. It is an important oilseeds crop among the four major oilseeds crop cultivated in the world *viz.,* soybean, brassica, sunflower and groundnut. Sunflower is rich source of edible oil (40%-52%) and it is good for heart patients due to presence of PUFA *i.e.,* linoleic acid (55% to 60%) and oleic acid (25 to 30%). Two types of sunflower are grown *viz.,* oil seed purpose and non- oil seed sunflower for commercial market.

Non-oilseed sunflower is known as confectionery sunflower, and is usually white striped and/or comes in large-seeded varieties. They generally have a relatively heavy hull that remains loosely attached to the kernel, permitting more complete dehulling. Seed of the non-oil seed hybrids generally is larger than that of the oilseed types and has a lower oil percentage with high protein and sugar content. The kernels of confectionary type also used in bakery products in European countries. USA leads in production of confectionary sunflower followed by Argentina. The nutritional composition of confectionary sunflower constitutes 900 g kg^{-1} of dry matter, 235 g kg^{-1} of dry protein, 760 g kg^{-1} of total digestible nutrients, 250 g kg^{-1} of oil, 241 g kg^{-1} of crude fibre, 38 g kg^{-1} of ash, 3 g kg^{-1} of calcium and 6 g kg^{-1} of phosphorous The varieties cultivated for confectionary purpose are known as *Helianthus annuus macrocarpus* L. The main aim of confectionary sunflower breeding is to develop lines with low hull content, low oil content, high yielding ability and self- fertile lines. Mutation, spontaneous or induced, is an important source for creating genetic variability. Mutations are the tools being used to study the nature and function of genes, there by producing raw materials for genetic improvement of economic crops. A desired mutation can be recovered in a homozygous stage in the M_4 or M_5 generation as compared with the F_6 or F_7 generation in the case of conventional breeding methods. Chemical mutagens were more efficient than physical ones in inducing viable and total number of mutations. Sodium azide (NaN_3) is considered as safe and it creates point mutations in the genome of plants through metabolite and thus produced protein in

***Corresponding Author E-mail:** saiphani899@gmail.com

mutant plants has different function compared to the normal plants. Hence, the study was undertaken to induce genetic variability in confectionary sunflower through mutation breeding.

MATERIAL AND METHODS

The dry seeds of sunflower genotypes *viz.,* EC 625693, EC 318761 and SCG 62 were exposed to different concentrations of freshly prepared sodium azide solution (100 ppm, 200 ppm, 300 ppm) for 4h. The seeds of control were also soaked in distilled water for four hours. After treatment with sodium azide, the seeds were thoroughly washed under running tap water for 10 minutes to remove excess exudates, chemicals and other materials from seeds. The treated seeds and control (a total of 12 treatments) were sown for raising M_1 generation allowing for selfing during *Rabi,* 2016-17 by dibbling method with a population size of 50 plants for each treatment at Experimental farm, College of Agriculture, Latur. For raising M_2 generation the seed of each treatment were sown during *Kharif (*rainy) season*, 2017*-18 in two replicates of Randomized Block Design (RBD) with a population size of 100 plants for each treatment except for control (40 plants only). Sowing was carried out at the spacing of 60 cm x 30 cm between the rows and plants, respectively by dibbling method. The recommended cultural practices including plant protection measures were followed to maintain healthy crop upto maturity. The data obtained from respective characters was subjected to analysis of variance (Panse and Sukhatme, 1985), calculation of variability component (Burton and Devane,1953), heritability (Allard, 1960) and genetic advance (Burton, 1952). Data on days to 50% flowering, days to maturity, plant height, head diameter, seed filling percentage, hull content, 100 grain weight, oil content, seed yield plant^{-1}, sugar content was recorded.

RESULTS AND DISCUSSION

The ANOVA (Table 1) revealed significant difference in mutant population indicating the presence of considerable amount of genetic variability in M_2 generation for all characters (Cvejic *et al*., 2011; Cvejic *et al*., 2015).

Relative comparision of the magnitude of genotypic coefficient of variation and phenotypic coefficient of variation for different traits revealed that induced genotypic and phenotypic coefficient of variations were higher over the control for most of the characters.

The phenotypic coefficient of variations and genotypic coefficient of variations (Table 2) were higher for seed filling percentage, 100 grain weight, seed yield plant^{-1} and sugar content indicating that greater amount of variability was induced in mutant populations. Similar findings were also reported by Kalukhe *et al*. (2010), Kumar *et al*. (2011), Makane *et al*. (2011), Hassan *et al*. (2012), Neelima *et al*. (2012) and Natikar *et al*. (2013) in sunflower for seed yield plant^{-1}.

The traits such as plant height, head diameter and oil content exhibited moderate PCV and GCV parameters. Kumar *et al*. (2011), Hassan *et al*. (2012), Natikar *et al*. (2013), Sudrik *et al*. (2014) and Rani (2016) in sunflower reported similar findings for head diameter and oil content. Whereas, for plant height the results were in conformity with findings of Neelima *et al*. (2012) in sunflower.

Low genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) values were exhibited for days to 50 % flowering, days to maturity and hull content indicating the narrow range of variability for these characters and restricts the phenotypic selection. These results were in agreement with Kalukhe *et al*. (2010) and Sudrik *et al*. (2014) in sunflower for days to 50% flowering, days to maturity and hull content. Whereas, for days to 50 % flowering and days to maturity results were in conformity with Makane *et al*. (2011), Natikar *et al*. (2013), Rani (2016) in sunflower and Kulmi *et al*. (2017) in linseed.

Table 1. Analysis of variance between treatments for yield and yield contributing characters in M_2 generation of confectionary sunflower

Source of variation	D.F.	Mean sum of squares									
		Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100 grain weight (g)	Oil content (%)	Sugar content (%)	Seed yield plant^{-1} (g)
Replication	1	0.42	0.02	10.57	1.11	9.82	0.06	0.08	0.62	0.01	2.15
Treatment	11	6.02***	6.27***	338.18***	4.22***	464.94***	6.98***	4.20***	10.65***	0.08***	22.15***
Error	11	0.43	0.14	16.94	0.31	6.50	0.27	0.06	0.86	0.002	0.98

*,** Significant at 5 and 1 percent level, respectively

Table 2. Estimates of range, mean, shift in mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance between treatments for yield and yield contributing characters in M_2 generation of confectionary sunflower

S. No.	Parameters	Range	Mean	GCV (%)	PCV (%)	Heritability (B.S) (%)	Genetic advance	Genetic advance as % of mean
1.	Days to 50% flowering	62.10-68.37	63.50	2.63	2.82	86.60	3.20	5.04
2.	Days to maturity	88.63-94.16	92.02	1.91	1.95	95.60	3.53	3.83
3.	Plant height (cm)	146.18-181.31	162.50	7.80	8.20	90.50	24.83	15.28
4.	Head diameter (cm)	13.92-18.89	16.31	8.57	9.23	86.10	2.67	16.40
5.	Seed filling (%)	34.56-80.42	58.30	27.13	27.51	97.24	30.75	55.10
6.	Hull content (%)	39.22-45.00	42.23	4.34	4.51	92.52	3.63	8.60
7.	100-grain weight (g)	6.16-9.75	8.05	17.88	18.12	97.31	2.92	36.32
8.	Oil content (%)	25.13-32.04	29.31	7.55	8.18	85.06	4.20	14.34
9.	Sugar content (%)	1.40-1.95	1.65	12.00	12.30	94.60	0.40	23.97
10.	Seed yield plant^{-1} (g)	16.30-27.79	23.45	13.88	14.50	91.50	6.41	27.33

Heritability in broad sense is the ratio of genotypic variance to the phenotypic variance. Heritability value coupled with genetic advance as percent of mean showed a better approach for selection. Therefore, the characters with high heritability is of better selection at phenotypic level and breeding values together with low genetic advance was an indication of non-additive gene action.

High heritability coupled with high genetic advance as percent of means was noticed for seed filling percentage followed by 100 grain weight, seed yield plant^{-1}, sugar content (Table 1) indicating the presence of additive gene action and improvement of the above characters could be made possible by simple phenotypic selection in mutant populations. Sudrik *et al*. (2014) for 100 grain weight in sun-flower and Rani (2016) for seed filling percentage in sunflower and Wadikar *et al*. (2018) for sugar content in sweet sorghum showed similar results.

Head diameter, plant height and oil content showed high heritability with moderate genetic advance as percent of mean which suggested that improvement of these characters is not possible by simple phenotypic selection. The findings were in agreement with the results of Kalukhe *et al*. (2010) and Rani (2016) for head diameter in sunflower. Whereas, for plant height similar findings were reported by Kalukhe *et al*. (2010); Rani (2016); Kalukhe *et al*. (2010) and Makane *et al*. (2011). Similar findings for oil content in sunflower were reported by Hassan *et al*. (2012) and Rani (2016).

High heritability with low genetic advance as percent of mean was reported for hull content, days to 50% flowering and days to maturity indicating non-additive interaction. Similar results were recorded by Makane *et al*. (2011), Kumar *et al*. (2011), Neelima *et al.* (2012), Mahmoud (2012) Rani (2016) in sunflower and Kulmi *et al*. (2017) in linseed for days to maturity.

CONCLUSION

The findings revealed that the characters 100 grain weight, seed filling percentage and seed yield plant^{-1} showed high heritability with high genetic advance. Hence, selection for these characters enhances genetic improvement.

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EVALUATION OF NEWER INSECTICIDES IN THE MANAGEMENT OF THRIPS AND LEAFHOPPERS IN GROUNDNUT

G. V. SUNEEL KUMAR* and M. SUNIL KUMAR

Acharya N. G. Ranga Agricultural University, Agricultural Research Station, Darsi – 523 247

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ABSTRACT

Evaluation of the bio-efficacy of newer insecticides against thrips and leafhoppers in groundnut was carried out through experiments conducted in Randomized Block Design with ten treatments and three replications during *Kharif* (rainy) seasons of 2014, 2015 and 2016. The pooled efficacy of two sprays against thrips showed that fipronil 80% WG and fipronil 5% SC were significantly superior with 62.0 and 57.6 per cent reduction in thrips foliage damage over control followed by diafenthiuron 50% WP and bifenthrin 10% EC with 51.2 and 50.9 per cent reduction of thrips damage over control, respectively. Thrips population also followed the same trend with 68.3, 64.0, 55.9 and 55.8 per cent reduction over control by fipronil 80% WG, fipronil 5% SC, diafenthiuron 50% WP and bifenthrin 10% EC, respectively. Diafenthiuron 50% WP and bifenthrin 10% EC were significantly superior over rest of the treatments in reducing the leafhopper population over control after two sprays with mean efficacy of 62.8 and 59.4 per cent, respectively. Highest dry pod yield of 2152.8 kg ha^{-1} was recorded with fipronil 80% WG significantly followed by fipronil 5% SC (1861.1 kg ha^{-1}), diafenthiuron 50%WP (1708.3 kg ha^{-1}) and bifenthrin 10% EC (1611.1 kg ha^{-1}) which were at par. However, highest ICBR was recorded with fipronil 5% SC (29.7), followed by bifenthrin 10% EC (26.6), acephate 95% SG (23.3), buprofezin 25% EC (22.2) and diafenthiuron 50% WP (16.6).

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the principal oilseed crop grown in eleven states in India in an area of 4.56 million hectares with a production of 6.67 million tonnes and an average productivity of 1486 kg per hectare. Six states *viz*., Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan and Tamil Nadu account for about 90 per cent of the total groundnut area of the country. Andhra Pradesh and Gujarat contribute more than 55 per cent of the total area and production of groundnut (Directorate of Economics and Statistics, 2016). Despite of its high production potential (4000 kg ha^{-1}) the actual yield in farmers' field is quite low (860 kg ha^{-1}), largely because of rainfed cultivation, which may suffer due to either mid season or late season drought and also insect pests and diseases (Subhash, 2011). Four genera of thrips *viz*., *Scirtothrips dorsalis*, *Frankliniella schultzei*, *Thrips palmi*, *Caliothrips indicus* and leaf hopper, *Empoasca kerri* are the major sucking pests of importance on groundnut crop cause severe damage to the crop in initial stage mainly by direct feeding and indirectly by acting as a vector.

The current concern of groundnut growers is the role of thrips in the transmission and spread of bud necrosis disease caused by tomato spotted wilt virus. A higher incidence of disease was observed in rainy season than in the post rainy season. The disease affected 2,25,000 ha in Anantapur district during *Kharif (*rainy*)* season of the year 2000 and the crop losses were estimated to exceed 3 billion rupees (Prasad Rao *et al.,* 2003). Sole dependence on either indigenous materials or botanicals or conventional insecticides did not result in effective management of pests. Scientific and judicious use of new molecules is still the best method of plant protection from the yield and economic point of view. Added to this some of the new molecules in an integrated approach being originated from microbial source are eco-friendly as well. In the light of the above, the investigation was carried out to find out the effective and economical insecticides against sucking insect pests of groundnut.

*** Corresponding Author E-mail:** suneelkumar.gonam@gmail.com

MATERIAL AND METHODS

Field experiments were carried out during *Kharif* seasons of 2014, 2015 and 2016 at Agricultural Research Station, Darsi, with ten treatments including untreated control replicated thrice in a Randomized Block Design. Groundnut variety K-6 was sown at a spacing of 30 cm x 10 cm having gross and net plot size of 5.0 m × 2.4 m and 4.0 m x 1.8 m, respectively. All the agronomical practices as per package of practices of ANGRAU were followed in raising the crop. The test insecticides were applied twice during the cropping period based on the pest incidence which started from 25 days after crop emergence and subsequent second spray was applied after 25 days interval with the help of manually operated knapsack sprayer.

Observations were recorded on the population of thrips per five terminal buds and population of leafhoppers on top three leaves for both the sprays. Pre-treatment observation was made a day before application, while post-treatment observations made after 5 and 10 days after application and per cent reduction of both thrips and leafhoppers was worked out. The percentage foliar damage caused by thrips was also counted based on total leaves count from randomly selected five plants in each treatment plot and per cent reduction in damage over untreated check was worked out. When the crop matured, the pods yield was recorded separately on mean ten plants later converted to kg ha^{-1} and statistically analysed by Duncan's Multiple Range Test (DMRT).

The economics of different treatments were worked out based on the pod yield and cost of protection. The cost and sale price of the pods of respective treatment was considered to calculate gross profit. Based on the cost of treatment and the gross profit in different treatments, net profit was calculated. Incremental benefit was calculated by taking the difference in gross profit from the respective treatments over the control. Further, the Incremental Benefit Cost (IBC) ratio was obtained by taking the ratio of incremental benefit to the cost of treatment.

RESULTS AND DISCUSSION

Pooled data indicated that significantly low foliage damage caused by thrips was recorded in all the insecticide treatments over control (Table 1). Thrips feed on young unopened bud leave causing dull yellowish-green patches on upper surface and dark-brown necrotic patches on lower leaf surface as well curling of leaves. The mean foliage damage after two sprays was found varying from 4.2 % to 11.2 %. Significantly low foliage damage by thrips (4.2 per cent) was recorded in the treatment of fipronil 80% WG and it was at par with fipronil 5% SC (4.7 per cent). Diafenthiuron 50% WP and bifenthrin 10% EC were also found effective in their order in reduction of thrips foliage damage (5.4 per cent). Maximum mean foliage damage of 11.2 per cent was recorded in untreated control. The pooled efficacy of the two sprays against thrips showed that fipronil 80% WG and fipronil 5% SC were significantly superior treatments with 62.0 % and 57.6 % reduction in thrips foliage damage over control followed by diafenthiuron 50% WP and bifenthrin 10% EC with 51.2 and 50.9 per cent reduction of thrips damage over control, respectively.

Pooled data indicated that significantly low population of thrips was recorded in all the treatments over control (Table 2). However, significantly low population of thrips (4.5 thrips terminal bud^{-1}) was recorded in the treatment of fipronil 80% WG and it was at par with fipronil 5% SC, diafenthiuron 50% WP and bifenthrin 10% EC with the overall mean thrips populations of 5.1 and 6.3 thrips terminal bud^{-1}, respectively. Maximum thrips population (14.3 thrips terminal bud^{-1}) was recorded in control. The maximum reduction in thrips population was observed in fipronil 80% WG (68.3 per cent), followed by fipronil 5% SC (64.0 per cent), diafenthiuron 50% WP (55.9 per cent) and bifenthrin 10% EC (55.8 per cent). The remaining insecticidal treatments were also found effective in reduction of thrips population after two sprays but were significantly different. Similar results on the efficacy of fipronil 80% WG and fipronil 5% SC against thrips in groundnut were reported by Khanpara *et al.* (2016) and Jayewar *et al*. (2017); in blackgram by Sireesha (2012); in chilli by Samota *et al*. (2017) and Satish and Ashwani Kumar (2017); and in onion by Indu Bala (2015) which showed significant reduction.

The mean leafhopper population before first spray was ranging from 3.3 hoppers leaves^{-3} plant^{-1} to 5.2 hoppers leaves^{-3} plant^{-1} suggesting uniform distribution among treatments and was non-significant (Table 3). The overall mean leafhopper population from all the treatments after two sprays ranged from 1.4 hoppers leaves^{-3} plant^{-1} to 3.9 hoppers leaves^{-3} plant^{-1} and it differed significantly within the treatments. The lowest overall mean leafhopper population (1.4 leaves^{-3} plant^{-1}) was recorded in the treatment, diafenthiuron 50% WP followed by bifenthrin 10% EC which were at par with each other and differed significantly with that of rest of the chemical treatments and untreated control (3.9 hoppers leaves^{-3} plant^{-1}). The treatments which showed on par results with the former were buprofezin 25% EC and acephate 50% + imidacloprid 1.8% SP with the overall mean leafhopper populations of 1.9 and 2.0 leaves^{-3} plant^{-1}, respectively. Mean per cent reduction in leafhopper population was varying from 32.6 to 62.8 per cent, highest per cent reduction was observed in case of diafenthiuron 50% WP (62.8) followed by bifenthrin 10% EC (59.4 per cent), buprofezin 25% EC (50.8 per cent) and acephate 50% + imidacloprid 1.8% SP (49.8 per cent). The efficacy of diafenthiuron in controlling the leafhoppers and thrips is in conformity with the observations recorded on cotton by Bajya *et al*. (2016). Earlier observations made by Ramesh Babu and Santharam (2002); Jyothirmai *et al.* (2002); Bhadane *et al.* (2007); Sutaria *et al.* (2010) and Subhash (2011) on the efficacy of imidacloprid in reducing the population of leafhopper under field conditions confirming the above results.

Pooled pod and haulm yield data (Table 4) indicated that all the treatments gave significantly the highest pod and haulm yields over control. However, significantly, highest pod yield (2152.8 kg ha^{-1}) and haulm yield (7243.2 kg ha^{-1}) was recorded in the treatment of fipronil 80% WG and it was followed by fipronil 5% SC (1861 kg ha^{-1} and 7007 kg ha^{-1}, respectively), diafenthiuron 50% WP (1708.3 kg ha^{-1} and 6936.9 kg ha^{-1}, respectively) and bifenthrin 10% EC (1611 kg ha^{-1} and 6998.8 kg ha^{-1}, respectively) which were at par. The remaining treatments, *viz.,* acephate 95% SG and buprofezin 25% EC were the next best treatments in pod (1541.7 and 1513.9 kg ha^{-1}, respectively) and haulm yield (5909.8 kg ha^{-1} and 6565.2 kg ha^{-1}, respectively). The lowest pod and haulm yield were recorded in the control (791.7 kg ha^{-1} and 5234.2 kg ha^{-1}, respectively).

Considering the cost effectiveness of various treatments, fipronil 80% WG registered higher net returns (Rs. 44829 ha^{-1}) followed by fipronil 5% SC (Rs. 36171 ha^{-1}), diafenthiuron 50% WP (Rs. 30148 ha^{-1}), bifenthrin 10% EC (Rs. 27601 ha^{-1}), acephate 95% SG (Rs. 25125 ha^{-1}) and buprofezin 25% EC (Rs. 24140 ha^{-1}). These results were contrary to the findings of Khanpara *et al.* (2016) who observed less net returns with fipronil 80% WG. This difference could be due to significantly less pod yield that was obtained with this treatment at that particular place. Although fipronil 80% WG proved to be the most effective treatment in the investigation, due to higher cost, it could record lower ICBR of 17.0 than the fipronil 5% SC which recorded highest ICBR of 29.7 followed by bifenthrin 10% EC (26.6), Acephate 95% SG (23.3), buprofezin 25% EC (22.2) and diafenthiuron 50% WP (16.6). Lower net returns (Rs.15190 ha^{-1}) and ICBR (7.6) was obtained by thiacloprid 21.7% SC.

Table 1. Bio-efficacy of new insecticides against thrips damage in groundnut (Pooled data of *Kharif*, 2014-2016)

Treatments	Dose	Thrips foliage damage (%)							Mean % reduction Over control
		First spray (25 DAE)			Second spray (50 DAE)			Mean of two sprays	
		PTC	5 DAT	10 DAT	PTC	5 DAT	10 DAT		
Imidacloprid 70% WG	125 g ha^{-1}	6.4 (14.6)	2.1 (8.4)^{ef}	6.1 (14.1)^{bc}	8.9 (17.4)	9.8 (18.2)^{bc}	8.9 (17.2)^{bcde}	6.7 (15.0)^{bcd}	40.7 (39.6)^{cd}
Fipronil 80% WG	100 g ha^{-1}	6.3 (14.4)	1.8 (7.6)^{f}	4.4 (12.0)^{c}	9.2 (17.7)	5.8 (13.9)^{e}	5.0 (12.9)^{g}	4.2 (11.9)^{f}	62.0 (51.9)^{a}
Acephate 50% + Imidacloprid 1.8% SP	1000 g ha^{-1}	7.2 (15.5)	4.1 (11.6)^{b}	6.4 (14.6)^{bc}	9.3 (17.8)	9.1 (17.6)^{bc}	9.4 (17.8)^{bc}	7.2 (15.5)^{bc}	35.5 (36.5)^{d}
Fipronil 5% SC	1000ml ha^{-1}	8.3 (16.7)	2.6 (9.3)^{cdef}	4.4 (12.0)^{c}	9.7 (18.1)	6.5 (14.8)^{de}	5.4 (13.5)^{fg}	4.7 (12.6)^{ef}	57.6 (49.4)^{ab}
Diafenthiuron 50% WP	625 g ha^{-1}	5.9 (14.1)	2.5 (9.0)^{cdef}	4.4 (12.0)^{c}	9.8 (18.3)	8.2 (16.6)^{bcd}	6.8 (15.0)^{defg}	5.4 (13.5)^{de}	51.2 (45.7)^{abc}
Buprofezin 25% EC	825ml ha^{-1}	6.0 (14.0)	3.6 (10.8)^{bc}	6.6 (14.5)^{bc}	9.0 (17.5)	10.1 (18.5)^{b}	10.5 (18.9)^{b}	7.7 (16.1)^{b}	31.7 (34.1)^{d}
Thiacloprid 21.7% SC	625 ml ha^{-1}	6.8 (15.1)	3.3 (10.3)^{bcd}	7.5 (15.8)^{ab}	9.8 (18.3)	10.3 (18.6)^{b}	9.0 (17.4)^{bcd}	7.5 (15.9)^{b}	33.4 (35.2)^{d}
Bifenthrin 10% EC	25 ml 6 ha^{-1}	6.4 (14.6)	2.4 (8.9)^{def}	4.9 (12.8)^{c}	9.0 (17.5)	7.8 (16.2)^{cd}	6.6 (14.9)^{efg}	5.4 (13.5)^{de}	50.9 (45.5)^{bc}
Acephate 95 % SG	625 g ha^{-1}	6.7 (15.0)	2.8 (9.7)^{cde}	5.7 (13.4)^{bc}	9.7 (18.2)	8.1 (16.6)^{bcd}	7.2 (15.6)^{cdef}	6.0 (14.1)^{cde}	47.2 (43.4)^{bc}
Untreated control	—	6.2 (14.4)	9.0 (17.4)^{a}	9.5 (18.0)^{a}	0.51 (18.9)	12.7 (20.9)^{a}	13.7 (21.7)^{a}	11.2 (19.6)^{a}	0.0 (1.6)^{e}
CV%		11.2	10.3	12.3	3.5	7.3	9.0	6.1	9.6

DAE – Days After crop Emergence
PTC - Pre Treatment Count
DAT – Days After Treatment
Values in parentheses are arcsine values
Figures followed by the same letter in the same column did not differ significantly by DMRT

Table 2. Bio-efficacy of new insecticides against thrips population in groundnut

Treatments	Dose	Average no. of Thrips / terminal bud							* Mean % reduction Over control
		First spray (25 DAE)			Second spray (50 DAE)			Mean of two sprays	
		PTC	5 DAT	10 DAT	PTC	5 DAT	10 DAT		
Imidacloprid 70% WG	125 g ha^{-1}	9.8 (3.1)	7.6 (2.7)^{bc}	9.5 (3.1)^{cd}	12.6 (3.6)	8.5 (2.9)^{bc}	7.7 (2.8)^{d}	8.3 (2.9)^{cd}	41.4 (40.0)^{cd}
Fipronil 80% WG	100 g ha^{-1}	9.2 (3.0)	4.0 (2.0)^{f}	5.0 (2.2)^{f}	11.1 (3.3)	4.6 (2.1)^{f}	4.4 (2.1)^{e}	4.5 (2.1)^{f}	68.3 (55.8)^{a}
Acephate 50%+ Imidacloprid 1.8% SP	1000 g ha^{-1}	1.11 (3.3)	6.9 (2.6)^{cd}	10.2 (3.2)^{bcd}	14.7 (3.8)	9.3 (3.1)^{bc}	10.4 (3.2)^{c}	9.2 (3.0)^{c}	35.3 (36.4)^{d}
Fipronil 5% SC	1000 ml ha^{-1}	9.9 (3.1)	4.0 (2.0)^{f}	5.4 (2.3)^{ef}	12.5 (3.5)	5.1 (2.3)^{ef}	6.1 (2.5)^{d}	5.1 (2.3)^{f}	64.0 (55.1)^{a}
Diafenthiuron 50% WP	625 g ha^{-1}	10.1 (3.2)	6.0 (2.4)^{de}	5.8 (2.4)^{ef}	12.1 (3.5)	6.3 (2.5)^{de}	7.1 (2.7)^{d}	6.3 (2.5)^{e}	55.9 (48.4)^{b}
Buprofezin 25% EC	825 ml ha^{-1}	10.5 (3.2)	8.8 (3.0)^{b}	12.0 (3.5)^{ab}	14.4 (3.8)	10.3 (3.2)^{b}	1.81 (3.4)^{bc}	10.7 (3.3)^{b}	24.8 (29.7)^{e}
Thiacloprid 21.7% SC	625 ml ha^{-1}	12.5 (3.5)	8.1 (2.8)^{bc}	11.5 (3.4)^{abc}	14.1 (3.8)	9.6 (3.1)^{bc}	13.5 (3.7)^{ab}	10.7 (3.3)^{b}	25.3 (30.1)^{e}
Bifenthrin 10% EC	625 ml ha^{-1}	11.8 (3.4)	5.0 (2.2)^{ef}	6.6 (2.6)^{e}	13.9 (3.7)	6.6 (2.6)^{de}	6.9 (2.6)^{d}	6.3 (2.5)^{e}	55.8 (48.3)^{b}
Acephate 95 % SG	625 g ha^{-1}	12.6 (3.5)	7.8 (2.8)^{bc}	8.9 (3.0)^{d}	13.0 (3.6)	7.8 (2.8)^{cd}	7.4 (2.7)^{d}	8.0 (2.8)^{d}	44.0 (41.5)^{c}
Untreated control	—	11.8 (3.4)	13.4 (3.6)^{a}	13.9 (3.7)^{a}	14.7 (3.8)	15.1 (3.9)^{a}	14.6 (3.8)^{a}	14.3 (3.8)^{a}	0.0 (1.6)^{f}
CD ($P \leq 0.05$)		NS	0.3	0.3	NS	0.3	0.4	0.2	4.4
CV%		8.7	6.1	6.8	6.7	7.1	7.1	3.7	6.7

PTC – Pre Treatment Count, DAT – Days After Treatment
DAE – Days After crop Emergence
Values in parentheses are SQRT transformed values
*Values in parentheses are arcsine values
Figures followed by the same letter did not differ significantly

Table 3. Bio-efficacy of new insecticides against leafhopper population in groundnut (Pooled data of *Kharif*, 2014-2016)

Treatments	Dose	Average Number of leafhoppers leaves^{-3} plant^{-1}							*Mean % reduction Over control
		First spray (25 DAE)			Second spray (50 DAE)			Mean of two sprays	
		PTC	5 DAT	10 DAT	PTC	5 DAT	10 DAT		
Imidacloprid 70% WG	125 g ha^{-1}	3.7 (10.9)	1.6 (7.1)^{bc}	2.0 (7.9)^{bc}	3.6 (10.8)	3.5 (10.8)^{ab}	2.4 (9.0)^{bc}	2.3 (8.8)^{bc}	39.2 (38.7)^{de}
Fipronil 80% WG	100 g ha^{-1}	3.6 (10.9)	1.5 (6.9)^{c}	1.8 (7.6)^{bc}	3.7 (11.0)	3.0 (9.9)^{b}	2.3 (8.7)^{bc}	2.2 (8.4)^{cd}	44.2 (41.6)^{cd}
Acephate 50%+ Imidacloprid 1.8% SP	1000 g ha^{-1}	4.1 (11.6)	2.0 (8.0)^{b}	2.2 (8.6)^{b}	3.8 (11.2)	1.8 (7.8)^{cd}	1.9 (7.8)^{cde}	2.0 (8.0)^{cd}	49.8 (44.9)^{bcd}
Fipronil 5% SC	1000 ml ha^{-1}	4.2 (11.8)	1.9 (8.0)^{b}	2.3 (8.7)^{b}	3.9 (11.3)	3.4 (10.5)^{ab}	2.9 (9.8)^{b}	2.6 (9.3)^{b}	32.6 (34.8)^{e}
Diafenthiuron 50% WP	625 g ha^{-1}	3.9 (11.4)	1.2 (6.4)^{c}	1.3 (6.6)^{c}	3.9 (11.4)	1.6 (7.0)^{d}	1.5 (7.1)^{de}	1.4 (6.9)^{f}	62.8 (52.5)^{a}
Buprofezin 25% EC	825 ml ha^{-1}	3.3 (10.3)	1.3 (6.5)^{c}	1.8 (7.6)^{bc}	3.5 (10.8)	2.6 (9.3)^{bc}	2.0 (8.1)^{cd}	1.9 (7.9)^{de}	50.8 (45.5)^{bc}
Thiacloprid 21.7% SC	625 ml ha^{-1}	4.0 (11.5)	1.3 (6.6)^{c}	2.3 (8.7)^{b}	4.2 (11.8)	3.0 (9.9)^{b}	2.3 (8.7)^{bc}	2.2 (8.6)^{bcd}	2.4 (40.6)^{cde}
Bifenthrin 10% EC	625 ml ha^{-1}	4.9 (12.8)	1.2 (6.3)^{c}	1.9 (7.8)^{bc}	4.1 (11.7)	1.9 (7.8)^{cd}	1.4 (6.7)^{e}	1.6 (7.2)^{ef}	59.4 (50.4)^{ab}
Acephate 95% SG	625 g ha^{-1}	5.2 (13.1)	1.4 (6.8)^{c}	2.0 (8.1)^{bc}	4.0 (11.5)	3.0 (10.0)^{b}	2.9 (9.7)^{b}	2.3 (8.7)^{bcd}	0.2 (39.3)^{cde}
Untreated control	—	3.4 (10.6)	2.8 (9.6)^{a}	3.7 (11.1)^{a}	3.6 (10.9)	4.6 (12.3)^{a}	4.5 (12.2)^{a}	3.9 (11.4)^{a}	0.0 (1.6)^{f}
CD ($P \leq 0.05$)		NS	1.0	1.7	NS	1.9	1.2	0.8	6.2
CV%		10.4	8.0	11.8	4.2	11.8	8.2	5.7	9.3

DAE – Days After crop Emergence

PTC – Pre Treatment Count

DAT – Days After Treatment

Values in Parentheses are SQRT transformed values

*Values in Parentheses are arcsine values

Figures followed by the same letter did not differ significantly

Table 4. Yield and economics of new insecticides against thrips and leafhoppers in groundnut (Pooled data of *Kharif,* 2014-2016)

Treatments	Dose	Pod yield (kg ha^{-1})	Haulms (kg ha^{-1})	Additional pod yield over control (kg ha^{-1})	Cost of treatment with labour charges (Rs. ha^{-1})	Additional returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	ICBR
Imidacloprid 70% WG	125 g ha^{-1}	1375.0 $(37.1)^{def}$	6269.3 $(79.2)^{abcd}$	583.3	1605	20417	18812	12.7
Fipronil 80% WG	100 g ha^{-1}	2152.8 $(46.4)^{a}$	7243.2 $(85.1)^{a}$	1361.1	2810	47639	44829	17.0
Acephate 50% + Imidacloprid 1.8% SP	1000 g ha^{-1}	1319.4 $(36.3)^{ef}$	5869.3 $(76.4)^{cd}$	527.8	1610	18472	16862	11.5
Fipronil 5% SC	1000 ml ha^{-1}	1861.1 $(43.1)^{b}$	7007.0 $(83.6)^{ab}$	1069.4	1260	37431	36171	29.7
Diafenthiuron 50% WP	625 g ha^{-1}	1708.3 $(41.3)^{bc}$	6936.9 $(83.3)^{abc}$	916.7	1935	32083	30148	16.6
Buprofezin 25% EC	825 ml ha^{-1}	513.91 $(38.9)^{cde}$	6565.2 $(80.8)^{abc}$	722.2	1138	25278	24140	22.2
Thiacloprid 21.7% SC	625 ml ha^{-1}	1291.7 $(35.9)^{f}$	5830.0 $(76.3)^{cd}$	500.0	2310	17500	15190	7.6
Bifenthrin 10% EC	625 ml ha^{-1}	1611.1 $(40.1)^{c}$	6998.8 $(83.6)^{ab}$	819.4	1080	28681	27601	26.6
Acephate 95 % SG	625 g ha^{-1}	1541.7 $(39.3)^{cd}$	5909.8 $(76.8)^{bcd}$	750.0	1125	26250	25125	23.3
Untreated control	—	791.7 $(28.1)^{g}$	5234.2 $(72.3)^{d}$					
CD ($P \leq 0.05$)		2.9	7.0					
CV%		4.4	5.1					

Values in parentheses are SQRT transformed values

Figures followed by the same letter did not differ significantly

ICBR - Incremental Cost Benefit Ratio

CONCLUSION

Scientific and judicious use of new molecules is still the best method of plant protection from the yield and economic point of view. Two sprayings (25 DAE and 50 DAE) at peak infestations of thrips and leafhoppers were considered for effective management with higher yield. Among different insecticides, fipronil 5% SC and fipronil 80% WG were found to be effective in reducing the thrips and diafenthiuron 50% WP and bifenthrin 10% EC were effective against leafhopper population with maximum pod yield. Thus, incorporation of newer chemistry molecules in integrated pest management programme for sucking pests in groundnut may prove effective.

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EFFECT OF INITIAL IRRIGATION TIME AND WEED MANAGEMENT ON GROWTH AND YIELD OF CHICKPEA

SAHAJA DEVA* and S.S.KOLHE

Department of Agronomy, Indira Gandhi *Krishi Vishwavidyalaya*, Raipur, Chhattisgarh -492012

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ABSTRACT

Studies were carried out during *Rabi* (winter) season for two years in chick pea and the results revealed that the highest crop stand was found in irrigation after sowing (pooled mean of 16.91). Among weed management practices, crop stand was the maximum in control (pooled mean of 17.71). Hand weeding twice was superior in obtaining maximum plant height, number of nodules, nodule dry weight, seed yield (pooled mean of 17.94 q ha^{-1}), haulm yield (pooled mean of 19.33 q ha^{-1}), harvest index (pooled mean of 48.07%), agronomic efficiency (pooled mean of 17.94), production efficiency (pooled mean of 15.87 kg ha^{-1} day^{-1}) and lowest weed density. Among herbicides, pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} was superior in producing maximum plant height, nodule number, nodule dry weight, seed yield (pooled mean of 15.82 q ha^{-1}), haulm yield (pooled mean of 17.34 q ha^{-1}), agronomic efficiency (pooled mean of 15.82), production efficiency (pooled mean of 14.00 kg ha^{-1} day^{-1}) and lowest weed density.

INTRODUCTION

Pulse crops are, in general, rich in protein and are contributing to the major protein dietaries especially for vegetarian communities. India is the largest producer (~25 per cent of world production) and consumer (~30 per cent of world consumption) of pulses. Chickpea is one of the best sources of pulse in India. It is nutritionally rich crop and contains 20 per cent protein, 61.5 per cent carbohydrates, 4.5 per cent fat and 4%-10% oil. It also contains 50% oleic and 40% linolic acid and good source of vitamins B6, vitamin C, niacin, zinc, calcium, iron and has medicinal importance too. It is the third important pulse crop of the world after french bean and field pea, with an area, production and productivity of 11.15 mha, 9.2 mt and 826 kg ha^{-1}, respectively (FAO, 2009). In India, chickpea area, production and productivity are 8.56 mha, 7.35 mt and 859 kg ha^{-1}, respectively which contribute highest share in area (65.3%) and production (67.2%) in the world (AICRP, 2010; FAO, 2009). In Chhattisgarh state, chickpea is one of the important pulse crop and occupies an area of 375.76 thousand ha with production and productivity of 402.06 thousand ton and 1070 kg ha^{-1}, respectively.

Chickpea is a poor competitor to weeds because of initial slow growth rate and limited leaf area development. Yield losses to the tune of 40%-80% have been reported, if weeds are not controlled within critical growth period of crop. The prevailing practice of manual weeding no doubt is effective measure of weed management. Owing to migration of farm labourers, urbanization, industrialization, the availability of farm labourers is shrinking day by day. Further, manual weeding is tedious, time consuming and therefore in many instances may not be profitable. Introduction of herbicides has made it possible to control wide spectrum of weed species in pulses effectively. Proper use of herbicides may manage weeds during critical crop-weed competition period and thereby help in enhancing the productivity of crops. Information on chemical weed management in chickpea is not available in Chhattisgarh state and hence, there is need to develop suitable weed management in chickpea.

In rice- chickpea cropping system, irrigation is applied either after harvest of rice to facilitate ease of field preparation and sowing of chickpea or after field preparation and sowing of chickpea. The impact of application of irrigation before or after sowing of

***Corresponding Author E-mail:** sahajareddy.deva@gmail.com

chickpea has not been evaluated by researchers. Hence, there was a need to know the correct time of irrigation *i.e.* before sowing or after sowing of chickpea. Further, weeds are major problem in chickpea. With increased labour wages and non-availability of labour there was a need to identify the suitable herbicide in chickpea. In light of those mentioned above, the field experiment was carried out to find out the suitable herbicide and time of irrigation.

MATERIAL AND METHODS

The investigation was carried out during *Rabi* (winter) seasons of 2013-14 and 2014-15 at the Research Farm, Raipur located between 21°4' N latitude and 81°39' E longitude with an altitude of 298 m above MSL having sub-tropical humid climate. The experimental soil was clayey (vertisol) with values of pH 7.12, EC 0.20 m mhos m^{-1}, low in available nitrogen (212.6 kg N ha^{-1}), medium in available phosphorus (12.50 kg P ha^{-1}), high in available potassium (300.3 kg K ha^{-1}) and organic carbon (0.48 %). The rainfall received during the cropping season of *Rabi* 2013-14 and 2014-15 was 112.8 mm and 66.7 mm, respectively. The mean maximum temperature ranged from 27.7 ^{0}C to 38.5 ^{0}C and 25.0 ^{0}Cto 39.1^{0}C during *Rabi* season of 2013-14 and 2014-15, respectively. The mean minimum temperature ranged from 9.8 ^{0}C to 23.4 ^{0}C and 8 ^{0}C to 24.6 ^{0}C during *Rabi* season of 2013-14 and 2014-15, respectively. The experiment was laid out in strip plot design with three replications with a plot size of 3.5 m x 4.5 m. Vertical strip consisted of irrigation time *viz.,* (i) irrigation before sowing, and (ii) irrigation after sowing. Horizontal strip consisted of seven weed management practices *viz.,* (1) Pre- emergence application of Pendimethalin 1.0 kg ha^{-1}, (2) Pre-emergence application of Imazethapyr 0.04 kg ha^{-1}, (3) Pre- emergence application of Oxyfluorfen 0.3 kg ha^{-1}, (4) Pre- emergence application of Metribuzin 0.4 kg ha^{-11}, (5) Pre- emergence application of Sulfentrazone 0.3 kg ha^{-1}, (6) Hand weeding twice at 20 and 40 DAS and (7) Control. Test variety selected was 'JG-226'. Chickpea seed was treated with carbendazim @ 2 g kg^{-1} seed and *Trichoderma* species @ 10 g kg^{-1} seed. Treated seeds were sown manually in lines with 30 cm spacing between rows**.** Sowing was done during December and crop was harvested during April. A seed rate of chickpea @100 kg ha^{-1} was used in all the treatments. A fertilizer dose of 20 kg N, 50 kg P_2O_5, 30 kg K_2O ha^{-1} were applied. Irrigations were given as per treatments. First irrigation was given four days before sowing in one strip and another irrigation two days after sowing in one strip in main plot. Remaining irrigations were given at critical stages. At each irrigation time 40 mm water was applied. Different weed management practices were performed as per the treatment, in all the experiments. Pre-emergence herbicides were applied one DAS in irrigation before sowing (IB) and 3 DAS in irrigation after sowing (IA), respectively. Hand weeding was done at 20 DAS and 40 DAS. Natural growth of weeds was allowed throughout the crop growth period in control in all the experiments. One row from the either side of each plot and 40 cm from other two ends was harvested separately as border. The produce of each net plot was tied into bundle and allowed for sun drying in respective plots. Germination of plants in 1m was recorded at five random places in each plot at 14 DAS and was averaged. For plant height in each plot, five randomly selected plants were tagged and the plant height was measured with the help of metre scale from base of the plant to the tip of the top most leaf and was averaged. The number of nodules was recorded from three randomly selected plants in each plot. The root zone of the plants was wetted with water repeatedly until soil became loose. With the help of hand hoe carefully plants were removed and the roots of the plant were washed in sieve with running water and effective root nodules were separated and counted. The counted nodules were dried at 60^{o}C for 48 hours in hot air oven and thereafter dry weight of nodules was recorded and average dry weight of nodule plant$^-$

^{1} was worked out. Microbiological estimations with respect to rhizobial count in the soil samples were done by dilution plate method (Subba Rao, 1988). Seed yield of the net plot was recorded. The harvested produce from each net plot was tied in bundles separately. Haulm yield of plot was recorded after subtraction of seed yield from bundle weight. Bundle weight of net plot was converted in q ha^{-1} with the help of appropriate multiplication factor. The weed density of different weed species was studied at 15 DAS, 45 DAS and 75 DAS and at harvest. The weed study in each plot was made at random from three selected spots and for this purpose quadrate (0.25 m^{2}) was used. Only green weeds sample was taken and total population of weeds was worked out in m^{-2}. Agronomic efficiency and production efficiency was calculated. All observations on growth, yield and weed dynamics were statistically analysed as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth Parameters

Crop stand was significantly influenced by irrigation time as well as weed management practices. However, there was no significant difference due to irrigation time on plant height, number of nodules and nodule dry weight (Table 1).The highest crop stand was found in irrigation after sowing (IA) with mean values of 15.90 and 17.92 during 2013-14 and 2014-15, respectively with pooled mean of 16.91. The lowest crop stand was obtained in IB with mean values of 13.76 and 14.71 during 2013-14 and 2014-15, respectively with pooled mean of 14.17.

Among weed management practices, crop stand was the maximum in control with mean values of 17.17 and 18.25 during 2013-14 and 2014-15, respectively with a pooled mean of 17.71. However, comparable crop stand was also observed with hand weeding twice with mean values of 16.83 and 17.72 during 2013-14 and 2014-15, respectively with pooled mean of 17.28 and pre-emergence application of imazethapyr 0.04 kg ha^{-1} with 16.67 during 2014-15. The minimum crop stand was noted under pre- emergence application of metribuzin 0.4 kg ha^{-1}, during both the years and on mean data basis. The maximum plant height, number of nodules and nodule dry weight was observed under hand weeding twice during both the years as well as on pooled data basis. Pre-emergence application of oxyfluorfen 0.3 kg ha^{-1}, metribuzin 0.4 kg ha^{-1} and hand weeding twice were at par in respect to plant height. The lowest plant height, no. of nodules and nodule dry weight was under control, during both the years as well as on mean data basis.

Among herbicides, pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} produced the maximum plant height, no. of nodules and nodule dry weight. Pre- emergence application of metribuzin 0.4 kg ha^{-1} and pre- emergence application of sulfentrazone 0.3 kg ha^{-1} were found comparable to that of pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} in enhancing plant height, number of nodules and nodule dry weight of chickpea. There was no much variation due to irrigation time on days to branching. Among weed management practices, there was no much variation in days of initiation but early branching was under hand weeding twice. Among herbicides, pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} showed early vegetative growth.

The interaction between irrigation time and weed management practices and interaction between weed management practices and irrigation time was found non-significant on crop stand, plant height, number of nodules plant^{-1} and nodule dry weight.

Lower crop stand in irrigation before sowing of chickpea might be due to the less availability of moisture for germination of chickpea. Singh *et al.* (2011) also reported lower crop stand under irrigation before sowing. The chickpea plant height, number of nodules and nodule dry weight had remained unchanged under irrigation applied before or after sowing of chickpea. The plausible reason was that there was no moisture stress during crop growth which resulted in better crop performance under these treatments. The higher plant height, no. of nodules and nodule dry weight in pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} and hand weeding twice treatments might be due to the favourable growing conditions in view of low crop-weed competition. Similarly, Kaushik *et al.* (2014) observed that plant height was highest in the treatment of hand weeding and lowest in control at Satna. The increase in number of nodules and dry weight probably due to increased aeration of rhizosphere in soil condition. These results supported the findings of Mirjha *et al*. (2014) who reported that hand weeding at 20 DAS and 40 DAS recorded the maximum number of nodules and their dry weight $plant^{-1}$.

Rhizobium population (x 10^6 g^{-1} soil)

Rhizobium population (x 10^6 g^{-1} soil) in soil of chickpea field was counted (Table 1) and there was no significant influence of irrigation time on rhizobium population, throughout the period of study.

Among weed management practices, significantly maximum rhizobium population was observed under control and it was comparable with hand weeding twice pre-emergence application of imazethapyr 0.04 kg ha^{-1} and pendimethalin 1.0 kg ha^{-1} w.r.t rhizobium population. The minimum rhizobium population was observed under pre-emergence application of oxyfluorfen 0.3 kg ha^{-1}, during both the years and on mean data basis. The interaction between irrigation time and weed management practices and interaction between weed management practices and irrigation time was found non-significant on rhizobium population.

Rhizobium population had not shown significant change due to irrigation applied before sowing or after sowing. It might be due to the fact that the soil environment w.r.t moisture content during chickpea germination to harvest was similar under both the treatments. Patel and Anahosur (1998) reported that irrigation levels did not show significant influence on rhizosphere microflora. Maximum rhizobium population under control was due to herbicide free conditions.

Yield attributes

Irrigation applied before or after sowing did not bring appreciable change in yield and harvest index of chickpea (Table 2).There was no much variation due to irrigation time on days to 50% flowering and pod initiation. Among weed management practices, early flowering and pod initiation was under hand weeding twice. Among herbicides, pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} showed early reproductive growth. Weed management practices exerted significant impact on yield and harvest index of chickpea. The highest seed yield with mean values of 16.20 q ha^{-1} and 19.67 q ha^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 17.94 q ha^{-1} and haulm yield with mean values of 18.15 q ha^{-1} and 20.50 q ha^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 19.33 q ha^{-1} and harvest index with mean values of 47.16% and 48.97% during 2013-14 and 2014-15, respectively with pooled mean of 48.07% was produced in hand weeding at 20 and 40 DAS and it was significantly higher than that of other weed management practices. On the contrary, the lowest seed yield with mean values of 8.95 q ha^{-1} and 10.01 q ha^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 9.48 q ha^{-1} and haulm yield with mean values of 11.98 q ha^{-1} and 13.21 q ha^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 12.60 q ha^{-1} and harvest index with mean values of 42.72% and 42.84% during 2013-14 and 2014-15, respectively with pooled mean of 42.78% was observed under control.

Among the herbicidal treatments, pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} exhibited the maximum seed yield with mean values of 13.42 q ha^{-1} and 18.22 q ha^{-1} during 2013-14 and

Table 1. Effect of irrigation time and weed management on crop stand, plant height, nodules and rhizobium population of chickpea

Treatments	Crop stand (per m row)			Plant height (cm)			Nodules (no. plant^{-1})			Nodule dry weight (mg plant^{-1})			Rhizobium population (x 10^6 g^{-1} soil)		
				75 DAS			45 DAS			45 DAS			45 DAS		
Irrigation time / Year	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
IB	13.76	14.71	14.17	33.24	37.51	35.38	24.62	29.19	26.91	85.25	87.83	86.54	53.05	57.19	55.12
IA	15.90	17.92	16.91	33.46	37.66	35.56	26.14	29.67	27.91	85.59	89.06	87.33	52.86	57.67	55.27
CD ($P \leq 0.05$)	2.90	2.39	2.65	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	14.27	11.02	12.59	-	-	-	-	-	-	-	-	-	-	-	-
Weed management															
W_1	14.50	16.00	15.25	33.90	36.10	35.00	24.50	29.00	26.75	82.07	84.42	83.25	56.00	60.67	58.34
W_2	14.67	16.67	15.67	29.00	32.88	30.94	20.83	24.83	22.83	75.96	76.91	76.44	58.00	62.67	60.34
W_3	14.17	15.50	14.84	36.28	40.93	38.61	29.17	33.00	31.09	92.29	96.93	94.61	45.17	48.83	47.00
W_4	13.33	15.00	14.17	35.33	39.62	37.48	27.67	31.50	29.59	90.97	93.22	92.10	50.33	55.00	52.67
W_5	13.67	15.06	14.37	34.28	38.17	36.23	27.50	31.07	29.29	85.98	91.13	88.56	53.00	57.00	55.00
W_6	16.83	17.72	17.28	37.13	42.55	39.84	29.83	33.33	31.58	94.78	101.00	97.89	47.50	52.17	49.84
W_7 (Control)	17.17	18.25	17.71	27.50	32.85	30.18	20.83	24.67	22.75	75.88	76.61	76.25	60.67	65.67	63.17
CD ($P \leq 0.05$)	1.45	2.04	1.24	3.11	3.20	2.16	2.69	2.03	1.87	6.83	5.82	5.47	5.96	5.91	5.88
CV (%)	7.52	9.96	6.25	6.79	6.78	4.63	8.43	6.10	5.74	6.36	5.23	5.00	8.95	8.18	8.48
I X W	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
W X I	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

IB: Irrigation before sowing *i.e.* four days before sowing, IA: Irrigation after sowing *i.e.* two days after sowing

$W_{1:}$ Pre- emergence application of Pendimethalin 1.0 $^{kg\ ha-1}$; $W_{2:}$ Pre- emergence application of Imazethapyr 0.04 $^{kg\ ha-1}$; W_3: Pre- emergence application of Oxyfluorfen 0.3 kg ha^{-1}; W_4: Pre- emergence application of Metribuzin 0.4 kg ha^{-1}; $W_{5:}$ Pre- emergence application of Sulfentrazone 0.3 kg ha^{-1}; $W_{6:}$ Hand weeding twice (20 and 40 DAS); W_7: Control

I x W: interaction of irrigation time and weed management

S: significant, NS: non-significant

2014-15, respectively with pooled mean of 15.82 q ha^{-1} and haulm yield with mean values of 15.68 q ha^{-1} and 19.00 q ha^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 17.34 q ha^{-1} and harvest index with mean values of 46.05% and 48.95% during 2013-14 and 2014-15, respectively with pooled mean of 47.50% which was at par with pre-emergence application of metribuzin 0.4 kg ha^{-1} which produced chickpea seed yield with mean values of 12.42 q ha^{-1} and 16.80 q ha^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 14.61 q ha^{-1} haulm yield with mean values of 14.72 q ha^{-1} and 18.00 q ha^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 16.36 q ha^{-1}. The interaction between irrigation time and weed management practices and interaction between weed management practices and irrigation time was found non-significant on yield and harvest index.

Irrigation applied before or after sowing did not show any appreciable yield and harvest index. It was due to the fact that there was no water stress during crop growth period because number and time of irrigations were same to all the treatments except initial irrigation. Higher yield and harvest index under hand weeding twice and pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} was due to the weed managed at critical period and better early crop growth. Gautam (1999) at IARI, New Delhi reported that grain yield and harvest index were significantly enhanced in weed free conditions. Chaudhary *et al.* (2005) reported that hand weeding at 20 DAS and 40 DAS produced significantly highest grain yield. Trimurtulu *et al.* (2015) reported that with the application of oxyfluorfen the yield of crop was significantly increased and increase in seed and haulm yield was 14.7% and 13.8% with oxyflourfen over control.

Agronomic efficiency (yield kg^{-1} nutrient) and Production efficiency (kg ha^{-1} day^{-1})

There was no significant influence on agronomic efficiency and production efficiency of chickpea due to irrigation time (Table 2).

Weed management practices showed significant impact on agronomic efficiency and production efficiency. The highest agronomic efficiency with mean values of 16.20 and 19.67 during 2013-14 and 2014-15, respectively with pooled mean of 17.94 and production efficiency with mean values of 14.34 kg ha^{-1} day^{-1} and 17.40 kg ha^{-1} day^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 15.87 kg ha^{-1} day^{-1} was observed with hand weeding at 20 and 40 DAS and it was significantly higher than rest of the treatments of weed management. Among the herbicide treatments, pre- emergence application of oxyfluorfen 0.3 kg ha^{-1} exhibited the maximum agronomic efficiency with mean values of 13.42 and 18.22 during 2013-14 and 2014-15, respectively with pooled mean of 15.82 and production efficiency with mean values of 11.87 and 16.13 kg ha^{-1} day^{-1} during 2013-14 and 2014-15, respectively with pooled mean of 14.00 kg ha^{-1} day^{-1} and it was at par with pre- emergence application of metribuzin 0.4 kg ha^{-1} The lowest agronomic efficiency of chickpea with mean values of 8.95 and 10.01 during 2013-14 and 2014-15, respectively with pooled mean of 9.48 was noted under control. The interaction between irrigation time and weed management practices and interaction between weed management practices and irrigation time was found non-significant on agronomic and production efficiency.

Irrigation time showed non-significant influence on agronomic efficiency and production efficiency which was due to fact that there was no moisture stress during crop growth period. Among weed management practices hand weeding twice and pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} showed maximum agronomic efficiency and production efficiency. It might be due to fact that these treatments showed higher seed yield per kg of nutrients applied and higher seed yield per day.

Total weed density

Total weed density as affected by different irrigation time and weed management practices was

Table 2. Effect of irrigation time and weed management on yield, harvest index, agronomic efficiency and production efficiency of chickpea

Treatments	Seed yield (q ha^{-1})			Haulm yield (q ha^{-1})			Harvest Index (%)			Agronomic efficiency (yield kg^{-1} nutrient)			Production efficiency (kg ha^{-1} day^{-1})		
Irrigation time	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
IB	11.32	15.07	13.19	13.79	16.36	15.07	44.80	47.61	46.21	11.32	15.07	13.19	10.01	13.34	11.68
IA	12.36	15.21	13.79	14.27	16.76	15.52	46.21	47.36	46.79	12.36	15.21	13.79	10.94	13.46	12.20
CD (P≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed management															
W_1	10.41	14.54	12.48	13.10	16.26	14.68	44.28	47.21	45.74	10.41	14.54	12.48	9.21	12.87	11.04
W_2	9.17	11.14	10.16	11.87	13.74	12.81	43.55	44.77	44.16	9.17	11.14	10.16	8.11	9.86	8.99
W_3	13.42	18.22	15.82	15.68	19.00	17.34	46.05	48.95	47.50	13.42	18.22	15.82	11.87	16.13	14.00
W_4	12.42	16.80	14.61	14.72	18.00	16.36	45.66	48.34	47.00	12.42	16.80	14.61	10.99	14.87	12.93
W_5	11.33	15.64	13.48	13.70	16.76	15.23	45.18	48.28	46.73	11.33	15.64	13.48	10.02	13.84	11.93
W_6	16.20	19.67	17.94	18.15	20.50	19.33	47.16	48.97	48.07	16.20	19.67	17.94	14.34	17.40	15.87
W_7 (Control)	8.95	10.01	9.48	11.98	13.21	12.60	42.72	43.44	43.08	8.95	10.01	9.48	7.92	8.85	8.39
CD (P≤0.05)	1.34	1.42	1.00	1.44	2.08	0.99	2.84	3.11	1.39	1.34	1.42	1.00	1.18	1.26	0.78
CV (%)	9.02	7.45	5.87	8.08	9.99	5.16	5.00	5.21	2.40	9.02	7.45	5.87	9.02	7.45	5.67
I X W	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
W X I	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS : Non Significant

Table 3. Effect of irrigation time and weed management on total weed density of chickpea

Treatments	Total weed density (m^{-2})											
	15 DAS			75 DAS			75 DAS			At harvest		
	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean	2013-14	2014-15	Mean
Irrigation time												
IB	5.92 (52.43)	5.81 (47.29)	5.87 (49.86)	8.32 (90.43)	8.15 (87.24)	8.23 (88.83)	9.21 (101.90)	8.83 (94.33)	9.02 (98.12)	9.47 (105.95)	9.01 (97.10)	9.24 (101.52)
IA	5.75 (49.33)	5.80 (47.10)	5.78 (48.22)	8.24 (86.05)	7.97 (79.71)	8.10 (82.88)	9.25 (102.90)	8.57 (89.67)	8.91 (96.28)	9.20 (100.10)	8.71 (89.43)	8.96 (94.76)
CD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	-	-	-	-	-	-	-	-	-	-	-	-
Weed management												
W_1	9.07 (81.33)	8.76 (76.00)	8.92 (78.67)	11.82 (139.33)	11.51 (132)	11.66 (135.67)	12.27 (150.00)	11.69 (136.00)	11.98 (143.00)	12.47 (154.83)	11.87 (140.17)	12.17 (147.50)
W_2	9.47 (89.17)	9.16 (83.83)	9.31 (86.50)	13.21 (174.17)	12.87 (165.33)	13.04 (169.75)	13.78 (189.17)	13.00 (168.17)	13.39 (178.67)	13.62 (184.67)	12.98 (167.67)	13.30 (176.17)
W_3	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	3.86 (14.00)	3.68 (12.67)	3.77 (13.33)	4.92 (23.33)	4.45 (18.83)	4.68 (21.08)	5.05 (24.67)	4.68 (21.00)	4.87 (22.84)
W_4	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	7.03 (48.67)	6.03 (38.67)	6.53 (43.67)	8.79 (76.50)	8.24 (67.17)	8.51 (71.83)	8.62 (74.00)	8.12 (65.33)	8.37 (69.67)
W_5	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	7.37 (53.50)	7.11 (49.67)	7.24 (51.58)	8.60 (73.00)	8.31 (68.17)	8.45 (70.58)	8.73 (75.33)	8.40 (69.67)	8.57 (72.50)
W_6	9.70 (93.17)	9.19 (83.67)	9.45 (88.42)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	2.03 (3.50)	1.62 (2.00)	1.82 (2.75)	2.62 (6.00)	2.36 (4.67)	2.49 (5.33)
W_7 (Control)	9.61 (92.50)	9.36 (86.83)	9.49 (89.67)	13.67 (188.00)	13.21 (176.00)	13.44 (182.00)	14.22 (201.33)	13.58 (183.67)	13.90 (192.50)	14.23 (201.67)	13.61 (184.33)	13.92 (193.00)
CD ($P \leq 0.05$)	0.55	0.66	0.41	0.91	0.64	0.70	1.09	0.80	0.65	1.13	1.26	1.15
CV (%)	7.46	9.31	5.71	8.78	6.34	6.84	9.36	7.30	5.74	9.63	11.28	10.01
I X W	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
W X I	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Values in parantheses are original. Data transformed to square root transformation $\sqrt{X+1}$

recorded (Table 3). *Medicago denticulata, Melilotus indica, Chenopodium album* were the major weeds observed in the field. Irrigation time showed non-significant effect on total weed density.

Among weed management practices, the maximum density of weeds was observed under control, throughout growth period. At 15 DAS, there were no weeds in pre-emergence application of oxyfluorfen 0.3 kg ha^{-1}, metribuzin 0.4 kg ha^{-} and sulfentrazone 0.3 kg ha^{-1}. While, the weed density under pre-emergence application of pendimethalin 1.0 kg ha^{-1}, imazethapyr 0.04 kg ha^{-1}, hand weeding twice and control were comparable to each other. At 45 DAS till harvest hand weeding at 20 and 40 DAS proved to be the best over rest of the treatments in minimizing weed density. Similarly, among herbicides, the minimum weed density was noted in pre-emergence application of oxyfluorfen 0.3 kg ha^{-1} which was significantly superior to other herbicide treatments and control.

Interaction between irrigation time and weed management practices and weed management and irrigation time on weed density of chickpea was not significant. Lower weed density in handweeding and pre emergence application of oxyfluorfen was due to effective control of weeds compared to other treatments. Tamang *et al*. (2014) observed that hand weeding resulted in significantly lower weed density and dry weight in greengram.

CONCLUSION

Initial irrigation has no impact on growth, yield and weed density. Hand weeding twice at 20 DAS and 40 DAS found the best treatment in giving higher growth and yield and reducing weeds. Among herbicides, pre emergence application of Oxyfluorfen 0.3 kg ha^{-1} proved to be effective in reducing weeds and giving higher yield.

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CORRELATION STUDIES IN HALF SIB FAMILIES OF THIRD CYCLE OF RECURRENT SELECTION IN SAFFLOWER (*Carthamus tinctorius* L.)

N.A. NAGRE, V.L. GAWANDE*, R. D. RATNAPARKHI and S.S. NICHAL
Department of Botany Dr. Panjabrao Deshmukh *Krishi Vidyapeeth*, Akola - 444 104

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ABSTRACT

The investigation was undertaken to study the association of various characters for half sib families to yield and yield attributing traits with an aim to select genotypes for developing population in next generation. Sixty plants having sufficient seeds were selected for evaluation and sown in augmented block design with AKS 207, Bhima, PBNS-12, A-1 and PKV Pink as checks. Observations were recorded on days to 50 % flowering, days to maturity on plot basis and plant height (cm), number of primary branches plant^{-1}, number of capitula plant^{-1}, number of seeds per capitulum, 100 seed weight (g), seed yield plant^{-1} (g) and oil content (%) on plant basis. The correlation between days to 50% flowering and seed yield plant^{-1} was negative and significant indicating breaking of linkages. It also indicated that unfavourable gene combination can be broken by recurrent selection methods. In the study, in the safflower random mating population, seed yield plant^{-1} was significantly correlated with plant height (0.422**), no. of primary branches plant^{-1} (0.585**), number of capitula plant^{-1} (0.523**) and number of seeds per capitulum (0.27*). This indicated the importance of these traits while developing population for next generation.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an important *Rabi (*winter*)* oilseed crop of India. India is the largest producer of safflower in the world. Safflower is cultivated in more than 60 countries, but more than half is produced in India, mainly for vegetable oil market (Patil *et al.,* 1999). The largest acreage of safflower is in the south-central India. In India, safflower is mainly grown as a rain-fed crop. It has a long taproot system, which allows the plant to thrive well in lighter soils and can easily adapt with saline alkaline conditions. It gives better option to farmers in dry land area for crop rotation and can give more yields under protective irrigation condition (Nimbkar, 2002).

In India, 17 high yielding varieties *viz*., A-1, K-1, S-144, Manjira, Type-65, Co-1, Bhima, JSF-1, Sagarmuthyalu, Nira, HUS-305, Girna, Sharda, JSI-7, A-2, JSI-73 and NARI-6 released under AICRP (Safflower) and four safflower hybrids *viz*., DSH-129, MKH-11, NARISH-1 and PH-6 were released in last five decades. These varieties have the genetic potential to give yield of 15-20 q per ha with oil content of about 30 *per cent* under optimal condition. However, attempts to further improve the yield and oil content were not successful for the last four decades

The recurrent selection experiments are mainly designed and conducted for improving seed yield plant^{-1}. However, it does not mean that other traits are unimportant. Selection for high yield, to some extent, is indirect selection for disease and insect resistance and for traits correlated with yield (Gardner, 1978). The relationship between two or more quantitative characters is of great interest and carries much practical significance. Correlation is a measure of the degree to which characters are associated with yield or among themselves (Burton, 1972). However, if selection is for high seed yield alone undesirable correlated response may occur in other traits as pointed out by Doggett (1972) but emphasis on positively correlated trait is most important while developing population in recurrent selection. Therefore, the investigation was conducted to study the association between seed and other traits in 3rd cycle half sib's families for recurrent selection of safflower developed by using GMS lines.

***Corresponding Author E-mail:** vlgawande@yahoo.co.in

MATERIAL AND METHODS

New random mating population using new GMS line *i.e.,* HUS-MS-305, has been developed in collaboration with two safflower AICRP centres, *viz*., Akola and Solapur. The population was developed by crossing GMS line HUS-MS-305 with 47 male parents *viz.,* NARI-SPS-34-46, NARI-SPS-50-1, AKS/S 41, GMU-2924, AKS-NS-1, PBNS-33, PBNS-58, GMU-148, GMU 2914-2, GMU 4811, PBNS-40, AKS-207, N-7, AKS-310, AKS 311, SSF 674, Bhima, A-1, JSI 99, GMU 3293, GMU 3420, PI-SPS-21-8, GMU 2724, C-2829-5-39-6, MMS, IVT 07-1, IVT 07-6, SSF 687, SSF 674, SSF 710, SSF 714, SSF 678, NARI 42, SSF 682, SSF 679, SSF 33, NARI 36, SSF 698, SSF 648, 99-1-1, 97-12—B, 11-17-2, 8-10-4-10, 6-9-2, 8-1-4, AV 98933, SSF 625 and SSF 24. The F_1 s seeds of all these crosses were mixed together in equal quantity and sown for the first cycle recombination during 2010-11. Second cycle of recombination was conducted during 2012-13 and third recombination cycle during 2015-16. From which 60 male sterile plants were selected. All these 60 plants had sufficient seeds and their progenies were selected and sown in Augmented Block Design in three replications along with five checks (AKS-207, Bhima, A-1, PBNS-12 and PKV Pink) for third cycle evaluation keeping remnant seeds during *rabi* 2016-17 at Oilseeds Research Unit, Dr. PDKV, Akola. Each entry was of four meter length and 25 entries in each block along with checks. Sowing was completed with dibbling method with spacing of 45 cm X 20 cm between rows and plants. All standard agronomical and plant protection practices were provided (PDKV, 2016). Observations were recorded on days to flowering, days to 50 % flowering, days to maturity on plot basis and plant height (cm), number of primary branches plant^{-1}, number of capitula plant^{-1}, number of seeds capitulum^{-1}, 100 seed weight, seed yield plant^{-1} and oil content on plant basis. Data was subjected to analysis of variance as per the procedure given by Federer (1961), and correlations between various traits were estimated as per Burton (1972).

RESULTS AND DISCUSSION

The mean squares due to half-sib families were significant for all the characters except days to flowering, days to maturity, number of primary branches plant^{-1}, number of capitula plant^{-1} and seed yield plant^{-1} indicating substantial genetic variability existed among the half-sib families after third cycle of recurrent selection (Table 1).

The mean performance of 60 half-sib families recorded was 98.5 for days to 50 % flowering (Table 2), 142.93 for days to maturity, 94.83 cm for plant height, 9.71 for no. of primary branches plant^{-1}, 31.61 for no. of capitula plant^{-1}, 34.59 for no. of seed capitulum^{-1}, 33.44 g for seed yield plant^{-1}, 3.783 g for 100 seed weight, and 27.65 *per cent* for oil content in third cycle of recurrent selection.

In case of the safflower random mating population, seed yield plant^{-1} was significantly correlated with plant height (0.422**), number of primary branches plant^{-1} (0.585**), number of capitula plant^{-1} (0.523**) and number of seeds capitulum^{-1} (0.27*) (Table 3). The results of the investigation are in agreement with the observations in safflower true breeding lines by Reddi (2002) and Mummaneni (2003). The correlation between days to 50 % flowering and seed yield plant^{-1} was negative and significant indicating breaking of linkages. Reddi (2002) also reported negative and significant correlation between seed yield and days to 50 % flowering (-0.377**) indicating that unfavourable gene combination can be broken by recurrent selection methods.

These results indicated that half-sib families behaved in a similar way as pureline behaved due to continuous selection of fertile plants. Thirteen half-sib families were selected which have given superior performance over A-1, AKS-207, PKV Pink, Bhima and PBNS-12 for the trait seed yield plant^{-1}. These selected 13 half-sib families may be planted for next

Table 1. Analysis of variance for various characters in half-sib families of safflower

Sources of variation	d.f.	Days to flower-ing	Days to 50% flow ering	Days to maturity	Plant height (cm)	No. of Primary branches plant^{-1}	No. of capitulas plant^{-1}	No. of seeds per capitulum	100 seed weight (g)	Oil content (%)	Seed yield plant^{-1} (g)
Block	2	33.653	68.81*	96.04*	111.41*	29.05*	364.50	249.35*	0.74**	39.32**	488.60
Entries (Treatments)	64	59.213	36.12*	13.31	92.09*	8.84	221.44	164.81**	1.29**	47.83**	417.07
Checks	4	27.9	9.73	7.23	15.12	1.17	77.93	240.69**	3.18**	7.31*	227.04
Checks + half sib vs. half-sib	60	61.301	37.87*	13.72	97.22*	9.35	231.01	159.75**	1.17**	50.53**	429.73
Error	8	33.601	8.78	6.43	20.20	3.97	158.38	31.38	0.07	1.64	304.91
Block eliminating (check+ half-sib)	2	74.594	40.87*	31.26*	5.06	34.62*	698.13	91.03	0.05	0.32	15.31
Entries	64	57.934	36.99*	15.34	95.41*	8.67	211.02	169.76**	1.31**	49.05**	431.86
Checks	4	27.9	9.73	7.23	15.12	1.17	77.93	240.69**	3.18**	7.31*	227.04
Half-sib	59	60.857	38.83*	16.00	97.72*	8.98	219.86	163.70**	1.18**	52.50**	452.71
Checks vs. half-sib	1	5.603	37.45	9.01	280.26*	20.59	221.74	243.18*	2.08**	12.54*	20.99
Error	8	33.601	8.78	6.43	20.20	3.97	158.38	31.38	0.07	1.64	304.91

d.f.: Degrees of freedom

Table 2. Mean performance of selected half-sib families for yield contributing characters

Details	Day to 50% flowering	Days to maturity	Plant height (cm)	No. of Primary branches plant^{-1}	No. of capitulas plant^{-1}	No. of seeds per capitula	100 seed weight (g)	Oil content (%)	Seed yield plant^{-1} (g)
Half-sibs									
Maximum	112.00 (HS-51)	151.00 (HS-42, HS-51)	120.20 (HS-20)	16.80 (HS-39)	83.20 (HS-1)	65.00 (HS-51)	6.53 (HS-25)	32.24 (HS-2)	101.20 (HS-41)
Minimum	88.00 (HS-12)	133.00 (HS-12)	68.00 (HS-23)	2.60 (HS-13)	3.80 (HS-13)	10.00 (HS-10,HS-11)	2.00 (HS-6, HS-8, HS-13, HS-24)	18.82 (HS-43)	2.33 (HS-28)
Mean (HS)	98.50	142.93	94.83	9.71	31.61	34.59	3.78	27.65	33.44
Check varieties									
A-1	95.00	141.00	88.53	10.86	37.13	23.66	4.83	26.82	38.58
AKS-207	96.33	141.33	87.33	10.53	32.86	20.10	5.16	25.77	21.53
PKV Pink	95.66	140.66	90.93	10.40	29.13	40.71	3.00	29.72	31.70
Bhima	99.66	144.33	93.16	11.90	37.96	28.00	3.16	28.34	44.60
PBNS-12	97.00	143.00	90.06	11.40	42.46	38.00	4.83	26.69	37.40
General Mean	98.14	142.76	93.87	9.97	32.47	33.69	3.86	27.62	33.70
SE(M)±	2.41	2.07	3.66	1.62	10.27	4.57	0.21	1.04	14.25

Table 3. Association among yield and its contributing traits for the half-sib selection of safflower

Character	Days to 50% flowering	Days to maturity	Plant height	No. of Primary branches plant^{-1}	No. of capitula plant^{-1}	No. of seeds per capitulum	100 seed Weight	Oil content	Seed yield plant^{-1}
Days to 50% flowering	1	0.847**	-0.035	-0.441**	-0.476**	-0.260*	-0.207	-0.229	-0.253*
Days to maturity		1	0.146	-0.261*	-0.306*	-0.204	-0.124	-0.174	-0.121
Plant height (cm)			1	0.212	0.144	0.256	0.161	0.035	0.422**
No. of primary branches plant^{-1}				1	0.843**	0.299*	0.250	0.052	0.585**
No.of capitulas plant^{-1}					1	0.248	0.232	0.126	0.523**
No. of seeds capitulum^{-1}						1	-0.323*	0.310*	0.270*
100 seed weight							1	-0.283*	0.246
Oil content								1	-0.034
Seed yield plant^{-1}									1

recombination cycle for further improvement of the concerned random mating population. For improvement of seed yield, positively associated traits with seed yield should be considered during the subsequent generation of selection cycles.

CONCLUSION

There is good scope for selection and genetic improvement for various traits in the random mating population studied. Selection for earliness decreases the half sibs for seed yield plant^{-1}. Hence, for effective genetic improvement of seed yield plant^{-1}, selection of half sibs for plant height, number of primary branches, number of capitula plant^{-1} and number of seeds capitulum^{-1} may be considered in the further selection cycles.

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INFLUENCE OF IRRIGATION SCHEDULES AND NITROGEN MANAGEMENT ON MOISTURE USE EFFICIENCY AND YIELD IN *RABI* MAIZE

P. HARI KRISHNA, N. VENKATA LAKSHMI*, K. CHANDRASEKHAR and P. PRASUNA RANI

Department of Agronomy, Advanced Post Graduate Centre, Lam, Guntur - 522 034

Date of Receipt: 02.04.2018 Date of Acceptance: 07.05.2018

ABSTRACT

Moisture use efficiency and yield of maize in response to different irrigation schedules and nitrogen levels were studied during *rabi,* 2016. The experiment was laid out in split-plot design with three irrigation schedules as main plots and three nitrogen levels as subplots in three replications. The results revealed that maximum moisture use efficiency was recorded with I_2 0.8 IW/CPE (16.0 kg ha-mm^{-1}), and it was found on a par with $I_3$0.6IW/CPE (15.7 kg ha-mm^{-1}). It was recorded that irrigation scheduled at 1.0 IW/CPE (I_1) has the lowest moisture use efficiency (13.2 kg ha-mm^{-1}). The highest kernel yield was recorded with application of N_3 *i.e*. 100% Recommended Dose of Nitrogen (RDN) through urea + 50% RDN through FYM (7017kg ha^{-1}) and was significantly superior over application of 100% RDN through urea + 25% RDN thorugh FYM (6797 kg ha^{-1}) and 100 % RDN through urea (6503 kg ha^{-1}).

INTRODUCTION

Maize is cultivated in India in all the states in an area of 9.5 million ha, with annual production of 23.3 million tonnes and 2452 kg ha^{-1} of productivity (DACNET, 2014). In Andhra Pradesh it is grown in an area of 7.9 lakh ha with a production of 4.14 million tonnes and productivity of 5260 kg ha^{-1}. In India, maize has been widely cultivated as a rainfed crop during *kharif* season but it is also being successfully grown during *Rabi* under irrigated conditions with higher productivity (Patel *et al.,* 2006). Maize responds relatively better to management factors especially irrigation and nitrogen. Hence, proper irrigation scheduling is essential for efficient use of water and crop production. Maize has maximum nitrogen use efficiency of about 50 per cent, however, under poor management, its efficiency varies from 30 %-40 % (Patel *et al.,* 2006). Considering the above facts, the experiment was planned to study the influence of different irrigation schedules and nitrogen levels on yield and moisture use efficiency of maize (*Zea mays* L.) in *rabi* season during the year 2016.

MATERIAL AND METHODS

The field experiment was conducted during *Rabi*, 2016 (winter season) at Agricultural Research Station, Jangamaheswarapuram, Guntur district. The soils of the experimental plot was sandy loam in texture, alkaline in soil reaction (pH 8.51), low in organic carbon (0.38 per cent) and low in available nitrogen (150 kg ha^{-1}), medium in available phosphorus (18 kg ha^{-1}) and available potassium (225 kg ha^{-1}). The experiment was laid out in a split plot design with three irrigation schedules *i.e.,* I_1 - Irrigation at 1.0 IW/CPE, I_2 - Irrigation at 0.8 IW/CPE, I_3 - Irrigation at 0.6 IW/CPE as main plots and three nitrogen levels N_1– 100% Recommended Dose of Nitrogen (200 kg N ha^{-1}) through urea, N_2– 100% RDN through urea + 25 % RDN through FYM, N_3–100% RDN through urea + 50% RDN through FYM as subplots in three replications. Nitrogen was applied in three equal splits one each at planting, knee-high stage and at tasseling by hill placement as per the treatments. A common dose of 80 kg P_2O_5 ha^{-1} was applied through Single Super Phosphate at the time of sowing and 80 kg K_2O ha^{-1} was applied through

***Corresponding Author E-mail:** venkatalakshmee@gmail.com

Muriate of Potash in two equal splits one each at the time of sowing and at tasseling stage.

The irrigation scheduling was done based on pan evaporation replenishment. The irrigations were given on the basis of pan evaporation (PE) data measured from the USWB open pan evaporimeter from the meteorological observatory of Agricultural Research Station, Jangamaheswarapuram. Irrigation water was applied in the main plots based on pan evaporation readings and scheduled at 1.0 IW/CPE ratio, 0.8 IW/CPE ratio and 0.6 IW/CPE ratio. Irrigation was given when the total evaporation reached 50 mm, 62.5 mm and 83.3 mm for 1.0IW/CPE ratio, 0.8IW/CPE ratio and 0.6 IW/CPE ratios, respectively. A total of 7, 5 and 4 irrigations were provided for I_1, I_2 and I_3 treatments, respectively, with uniform depth of 5 cm per each irrigation. Maize hybrid 'Pioneer 3396' was sown by adopting a spacing of 60 cm x 20 cm.

RESULTS AND DISCUSSION

Influence of irrigation schedules and nitrogen management on yield parameters and yield

Irrigation scheduled at IW/CPE ratio of 1.0 recorded the highest cob length (22.9 cm) which was significantly superior to IW/CPE ratio of 0.8 (21.7 cm) and IW/CPE ratio of 0.6 (20.5 cm). Similar cob length was recorded with IW/CPE ratio of 0.8 and IW/CPE ratio of 0.6. This might be due to more vigorous and luxuriant vegetative growth, which in turn favoured a better partitioning of assimilates from source to sink. Among the nitrogen managements tested, N_3 – 100% RDN through urea + 50% RDN through FYM recorded the maximum cob length (22.2 cm) and was significantly superior over the other treatments (N_2 and N_1). The lowest cob length (21.2 cm) was recorded with N_1– 100% RDN through urea. The increase in the size of cob might be due to positive effect of nitrogen on plant height, dry matter accumulation, nutrient uptake and increased translocation of photosynthates from source to sink. Om *et al.* (2014) also reported that length of the cob showed a significant improvement due to application of highest nitrogen dose of 240 kgha^{-1}over 80 kg ha^{-1}and was on a par with the recommended N level of 160 kg ha^{-1}.

The number of kernels cob^{-1} was significantly influenced by different irrigation schedules and nitrogen management (Table 1). Interaction between irrigation schedules and nitrogen management could not reach the level of significance. Maximum number of kernels cob^{-1} was recorded when irrigations were scheduled at IW/CPE ratio of 1.0 (603.3), and was significantly higher than the irrigation schedules 0.8IW/CPE (513.2) and 0.6 IW/CPE (412.9). This might be due to availability of moisturein the soil that caused better pollination and consequently better filling of cobs, better partitioning and translocation of photosynthates to the sink, which finally resulted in more number of kernels cob^{-1}. Reddy *et al.* (2012) reported that significantly more number ofkernels were recorded when irrigations were scheduled at an IW: CPE of 1.0 (480 and 483) which was superior to 0.6 ratio (445 and 448) and 0.8 ratio (457 and 461) during 2007-08 and 2008-09, respectively. The lowest number of kernels cob^{-1}(412.9) was recorded with I_3 (IW/CPE ratio of 0.6).

Regarding nitrogen management, the maximum number of kernels cob^{-1}were recorded with N_3– 100% RDN through urea + 50% RDN through FYM (536.9) over N_2 and $N_1$was on a par with N_2 – 100% RDN through urea + 25% RDN through FYM (517.8). Lowest number of kernels cob^{-1} were recorded with N_1– 100% RDN *i.e.*200 kg N ha^{-1}(474.6). Higher drymatter accumulation and efficient translocation of photosynthates to reproductive parts due to adequate supply of nitrogen might be responsible for realizing more number of kernels cob^{-1} in N_3. Reddy *et al.* (2012) reported that application of 240 kg N ha^{-1} was found to increase the number of kernels cob^{-1} (481 and 483) compared to 180 (458 and 462) and 120 kg N ha $^{-1}$ (443 and

447) during both the years of experimentation *i.e.* 2007-08 and 2008-09.

Test weight of maize was significantly influenced by different irrigation levels and nitrogen management(Table 1), however, not by their interaction.The maximum test weight was recorded with I_1 - IW/CPE ratio of 1.0 (17.1 g) which was significantly superior over IW/CPE ratio of 0.8 (16.4 g) and IW/CPE ratio of 0.6 (15.4 g). The maximum test weight was recorded with N_3(16.8 g) which was significantly superior over N_2 (16.4 g).The minimum test weight was recorded with N_1 (15.8 g). The highest test weight under higher nitrogen level might be due to synergistic effect of externally added nitrogen and higher biomass production coupled with increased sink capacity. Bakht *et al.* (2006) also observed significant effect of various nitrogen levels on test weight.Similarly, the highest shelling percentage was recorded with N_3– 100% RDN through urea + 50% RDN through FYM (83.9%), which was significantly superior over N_2 – 100% RDN through urea + 25% RDN through FYM (82.0%) and N_1– 100% RDN (81.4%).

Among the irrigation levels tried, higher shelling percentage was recorded with more frequent irrigations applied *i.e.* IW/CPE ratio of 1.0 (85.1%) which was significantly superior over the other treatments (I_2 and I_3) tested. Regarding irrigations under crtitcal stages, under I_1regime, adequate turgidity that must have prevailed inside the plant helped in better root and shoot development. This process acted as active source backup even during the photosynthates translocation to sink which further strengthen the explanation that active translocation of photosynthates must have existed for longer period to fill the sink to achieve higher capacity as is evident from higher shelling percentage (Aulakh*et al*., 2013).

The maximum kernel yield (7827 kg ha^{-1}) was recorded with 1.0 IW/CPE which was significantly superior to 0.8 IW/CPE ratio (6871 kg ha^{-1}) and 0.6 IW/CPE (5619 kg ha^{-1}). The kernel yield increased by 12.2 per cent and 28.2 per cent with 1.0 IW/CPE and0.8 IW/CPE, respectively. This might be due to adequate moisture availability and increase in nutrient uptake throughout the crop growth stages, having beneficial effect on yield contributing factors. The lowest kernel yield was obtained with I_3 (5619 kg ha^{-1}) due to less availability of moisture to the crop. Low irrigation at I_3 resulted in marginal reduction in kernel yield. Similar findings were reported by Shivakumar*et al.* (2011) in baby corn. Nivedhitha and Nagavani (2016) also reported that higher grain yield was recorded with the 1.0 IW/CPE, which was, however, comparable with IW: CPE ratio of 0.8 but significantly higher than IW: CPE ratio of 0.6, which has resulted in lowest yield.

The highest kernel yield and stover yield (Table 1) was recorded with 1.0 IW/CPE and it was significantly superior to other irrigation levels tested. Among the nitrogen management, maximum kernel yield was recorded with N_3-100% RDN through urea + 50% RDN through FYM, and was significantly superior over N_2, and N_1. This might be due to adequate moisture availability and increase in nutrient uptake throughout the crop growth stages, having beneficial effect on yield contributing factors. The lowest kernel yield(6503 kg ha^{-1}) was recorded with N_1due to water scarce situations under irrigation at I_3resulted in marginal reduction in kernel yield. Similar findings were reported by Shivakumar*et al.* (2011)and Niveditha and Nagavani (2016). No significant differences were found in stover yield among the nitrogen levels tried.

Moisture Use Efficiency (kg ha-mm^{-1})

The moisture use efficiency recorded with I_2 - 0.8 IW/CPE (16.0 kg ha-mm^{-1}) and I_3 - 0.6 IW/CPE (15.7 kg ha-mm^{-1}) were similar. The lowest moisture use efficiency (13.2 kg ha-mm^{-1}) was recorded with 1.0 IW/CPE, where more number of irrigations were applied (Table2). This might be due to the fact that with increased water supply, the rate of

Table 1. Yield attributes, consumptive use, moistur use efficiency and moisture use rate of *rabi* maize as influenced by different irrigation schedules and nitrogen management

	Treatments	Cob length (cm)	No. kernels cob^{-1}	Test weight (g)	Shell-ing %	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Consum-ptive use of water (mm)	Moisture use effi-ciency (kgha-mm^{-1})	Moisture use rate (mm day^{-1})
Irrigation schedules (I)										
I_1	1.0 IW/CPE	22.9	603.3	17.1	85.1	7827	9558	593.6	13.2	5.2
I_2	0.8 IW/CPE	21.7	513.2	16.4	82.4	6871	8569	429.9	16.0	3.9
I_3	0.6 IW/CPE	20.5	412.9	15.4	79.8	5619	7419	358.2	15.7	3.4
	CD ($P \leq 0.05$)	2.1	65.4	0.8	2.6	754.08	978.11	2.3	1.8	0.02
	CV (%)	7.3	9.8	3.5	2.4	8.50	8.77	1.2	9.0	0.5
Nitrogen levels (N)										
N_1	100% RDN through urea	21.2	474.6	15.8	81.4	6503	8342	450.2	14.7	4.2
N_2	100% RDN through urea+ 25%RDN through FYM	21.7	517.8	16.4	82.0	6797	8478	458.6	15.1	4.2
N_3	100% RDN through urea + 50% RDN through FYM	22.2	536.9	16.8	83.9	7017	8727	472.9	15.1	4.2
	CD ($P \leq 0.05$)	0.3	65.4	0.4	0.2	194.50	NS	7.3	0.4	0.04
	CV (%)	1.3	9.8	2.2	2.1	2.79	4.41	0.5	3.0	1.1
Interaction										
	I x N									
	CD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS	4.0	NS	NS
	N x I									
	CD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS	6.9	NS	NS

I x N – To compare two sub plot treatment means at a given main plot treatment

N x I - To compare two main plot treatment means at each level of sub plot treatment

RDN: Recommended dose of nitrogen- (200 kg N ha^{-1}); FYM: Farm yard manure evapotranspiration was proportionately higher than the increase in yield upto certain limit. Similarly, Mahajan *et al*. (2007) recorded that water use efficiency was not much affected by irrigation levels, further decreased at 1.2 ETc. Reddy *et al*. (2012) observed highest water use efficiency with 0.6 IW/ CPE compared to 0.8 IW/ CPE and 1.0IW/ CPE. Moisture use efficiency of maize was significantly influenced by irrigation levels and nitrogen management but not by their interaction.

Consumptive Use of Water (mm)

The maximum consumptive use of water (593.6 mm) was recorded with 1.0 IW/CPE ratio which was significantly superior over 0.8 IW/CPE (429.9 mm) and 0.6 IW/CPE (358.2 mm). The lowest consumptive use of water (358.2 mm) was recorded with I_3 irrigation regime (IW/CPE ratio of 0.6). Among the nitrogen levels tested, highest consumptive use of water (472.9 mm) was recorded with N_3 (100% RDN through urea + 50% RDN through FYM), which was significantly superior to N_2 and N_1. The lowest consumptive use (450.2 mm) was recorded with N_1 which received 100% RDN *i.e.* 200 kg N ha^{-1}. The interaction was found significant with irrigation levels and nitrogen levels tested in maize. The I_1N_3 plot which received irrigations at 1.0 IW/CPE ratio and 100% RDN through urea + 50% RDN through FYM recorded the highest consumptive use of water for more accumulation of dry matter and yield. This might be due to optimum soil moisture availability and adequate nutrient supply to the crop which in turn helped in better growth and yield attributes. Similarly, lower consumptive use of water under irrigation at 100 CPE was also reported by Meena*et al*. (2015).

Moisture Use Rate (mm day^{-1})

Data pertaining to moisture use rate (Table 1) revealed that the maximum moisture use rate (5.2 mm day^{-1}) was recorded with irrigation scheduled at 1.0 IW/CPE ratio which was significantly superior to irrigation scheduled at 0.8 IW/CPE (3.9 mm day^{-1}) and irrigation scheduled at 0.6 IW/CPE (3.4 mm day^{-1}).The influence of N levels on moisture use rate was found non- significant.

Economics

Gross returns, net returns and B:C ratio were calculated by considering the cost of inputs used and prevailing market price of the produce . The data revealed that though the highest gross returns (Rs.1,05,638 ha^{-1}) were obtained with I_1N_3, the highest net returns (Rs. 65,572 ha^{-1}) and B:C ratio (2.02) were noticed with I_1 along with the application of N_1 (100% RDN) followed by I_1N_2. This might be due to higher yield obtained with these treatments. The lowest B:C ratio (0.55) was obtained with I_3N_3, which might be due to moisture stress conditions in I_3 which resulted in lower yields and net returns.

CONCLUSION

Maize crop can be irrigated at an IW/CPE ratio of 1.0 along with application of 100 % RDN through urea + 50 % RDN through FYM to realize higher kernel yield, more net returns and B:C ratio during *Rabi* season.

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METEROGLYPH ANALYSIS FOR MORPHOLOGICAL VARIATION IN CHICKPEA (*Cicer arietinum* L.)

N. R. THAKUR*, V. N. TOPROPE and K. SAI PHANINDRA

Department of Genetics and Plant Breeding,

College of Agriculture, *Vasantrao Naik Marathwada* Agricultural University, Latur-413 512

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ABSTRACT

Hundred chickpea lines including seven checks were evaluated to study the morphological variation for eleven characters by Meteroglyph analysis and index score method. These lines were grouped into six complexes *viz*., 25 small seeded with medium number of pods plant^{-1} (Complex I), three small seeded with high number of pods plant^{-1} (Complex II), 13 medium seeded with low number of pods plant^{-1} (Complex III), 52 medium seeded with medium number of pods plant^{-1} (Complex IV), four medium seeded with high number of pods plant^{-1} (Complex V) and three bold seeded with medium number of pods plant^{-1} (Complex VI). The scatter diagram, index scoring and ray pattern showed that beside test weight and number of pods plant^{-1}, the *Kabuli* genotypes, HK 08-206, PG 0749, PKV Kabuli 4, BDNGK 807, Virat and ICC 15105 and *Desi* genotypes, ICC 1058, ICC 101, ICC 4958, ICC 110 Digvijay, Vijay and BDNG 797 showed higher morphological variation for more number of traits. Thus, the use of these genotypes in future breeding programme is suggested.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most important *Rabi* pulse crop in India. Chickpea is good source of protein and carbohydrate. Chickpea protein quality is better than other legumes such as pigeon pea, black gram and green gram (Kaur and Singh, 2005). Chickpea seed contain 17.7% protein, 0.49% lysine, 0.11% methionine, 56.6% carbohydrates, considerable amount of calcium, phosphorus, iron and vitamin B. Genetic variability is the basic requirement for crop improvement as it provides wider scope for selection. The success of plant breeding for improving a trait of interest and depends on the availability of diverse germplasm, precise selection procedure and crossing programme. Several methods are utilized for the assessment of genetic diversity and grouping of genotypes. Meteroglyph analysis initially given by Anderson (1957) was useful mainly for establishing relationship among races and biotypes of crop plants.

Meteroglyph analysis has been used to access the genetic variability not only in chickpea but also in several crop species across the genus. Dewan *et al*. (1992) in Indian mustard; Chandra *et al*. (1997) in turmeric; Laiju *et al*. (2002) in *Hordeum* species; Ghafoor and Ahmad (2005) in black gram; Bhargava *et al*. (2009) in *Chenopodium*; Khan *et al*. (2007) in seven cotton cultivars; Rashid *et al*. (2007) in basmati rice mutants; Kang *et al*. (2013) in sugarcane cultivar; Jha *et al*. (2011) in chickpea and Datta *et al*. (2013) in maize used this method to assess the morphological variations. Thus, the experiment was conducted with an aim to evaluate the genetic potential of hundred chickpea genotypes for yield and yield component characters by Meteroglyph analysis and to develop a selection criterion.

MATERIAL AND METHODS

The experimental material comprising 100 genotypes of chickpea (75 *Desi* and 25 *Kabuli*, were grown during *Rabi* 2016-2017 in a Randomized Complete Block Design with two replications at the Experimental Farm, College of Agriculture, Latur (Table 1). Data was recorded on five randomly tagged plants for plant height (cm), number of primary branches, number of secondary branches, total

***Corresponding Author E-mail:** niranjan.thakur95@gmail.com

number of pods plant^{-1}, 100 seed weight (g), seeds pod^{-1}, seed yield plant^{-1} (g), biological yield (g) and harvest index (%). Whereas, for characters such as days to 50% flowering and days to maturity data was recorded on plot basis. Data was subjected to the analysis of variance followed by Anderson's Meteroglyph technique to study the patterns of morphological variations in different genotypes. Twenty-Five *Kabuli* genotypes were represented by closed glyph and seventy-five *Desi* genotypes were represented by open glyph. Two most variable characters, test weight and number of pods plant^{-1} were selected for Y and X axis, respectively. Except these traits, other traits were represented as rays on the glyph, where each glyph represented a genotype, thus, forming a scatter diagram.

Table 1. List of genotypes

S.No.	Genotypes	S. No.	Genotypes	S. No.	Genotypes	S. No.	Genotypes
1	ICC 110	26	GNG 2064	51	Virat	76	Digvijay
2	ICC 101	27	GNG 0904	52	PKV Kabuli 4	77	BDNG 797
3	ICC 111	28	JG 23	53	PKV Kabuli 2	78	Vijay
4	ICC 104	29	JG 11	54	BDNG 798	79	ICC 113
5	ICC 4958	30	JG 25	55	No. 115	80	Green Chana
6	ICC 85	31	PBC 37-2	56	G 20	81	IC 22
7	ICC 0918	32	PBC 37-1	57	G 94	82	IC 261
8	ICC 5034	33	PBC 1103-1	58	JGK 1	83	IC 1142
9	ICC 7117	34	PBC 1103-2	59	RVSGS 11	84	G 87
10	ICC 107	35	GJG 0814	60	IPCK 08-130	85	G 45
11	ICC 5003	36	GJG 0906	61	GK 23	86	G 97
12	ICC 1058	37	IPCK 0762	62	HK 06-163	87	G 84
13	ICC 932	38	BGD 1070	63	HK 171	88	G 57
14	ICC 8111	39	RKG 153	64	HK 08-206	89	B 24
15	ICC 11775	40	RSG 143-1	65	PG 0749	90	B 768
16	ICC 11027	41	GCP 101	66	PG 12310	91	B 611
17	ICC 14333	42	JS 06	67	PG 09305	92	B 49
18	ICC 16-348	43	BG 3023	68	ICC 117	93	B 45
19	ICC 1433	44	BCG 85	69	ICC 33103	94	BCG 36
20	ICC 867	45	BCG 19-17	70	IC 2444	95	BCG 10-1
21	ICC 12654	46	BCG 13-16	71	ICC 33229	96	BCG 54-1
22	ICC 13812	47	BCG 10-4	72	ICC 1696	97	BCG 78
23	ICC 45033	48	BCG 75	73	ICC 15105	98	BCG 64
24	ICC 14346	49	BCG 79	74	ICC 303	99	BCG 10-11
25	GNG 2058	50	BCG 902	75	No. 115	100	BCG 15-44

RESULTS AND DISCUSSION

The analysis of variance indicated significant variation among the hundred lines for eleven characters. The scatter diagram revealed that six complexes could be distinguished on the basis of morphological variation (Table 2 and Fig.1). Table 3 represents the index scores and signs used for nine characters for Meteroglyph analysis.

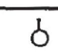
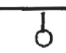
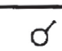
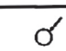
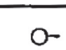
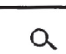
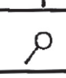
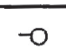
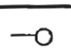
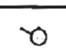
Complex I was characterized by small seeded with medium number of pods per plant and low seed yield per plant. This group comprised 25 lines which includes two kabuli lines. The Complex

Table 2. Complex constellation based on Meteroglyph analysis.

Complex	Name of complex	No. of lines	Name of lines
I	Small seeded with medium number of pods plant^{-1}	25	G 57, JS 06, G 84, ICC 932, No. 115, G 45, G 20, ICC 14333, B 24, IC 1142, ICC 113, ICC 14346, ICC 16-348, IC 261, BGC 10-1, Green Chana, JG 11, GCP 101, ICC 8111, ICC 12654, BCG 1316, G 87, ICC 45033, RSG 143-1 and BDNG 797
II	Small seeded with high number of pods plant^{-1}	03	ICC 13812, ICC 107 and BCG 15-44
III	Medium seeded with low number of pods plant^{-1}	13	ICC 303, ICC 33103, ICC 104, ICC 1696, IPCK 0762, BCG 75, ICC 1433, BCG 36, BCG 902, ICC 0918, ICC 7117, PG 09305 and ICC 11027.
IV	Medium seeded with medium number of pods plant^{-1}	52	ICC 33229, IPCK 08-130, ICC 117, PG 12310, PKV Kabuli 2, HK 06-163, B 45, B 768, BCG 78, BGD 1070, PBC 1103-1, PBC 37-1, RKG 153, BCG 1917, GJG 0814, B 49, G 97, ICC 11775, ICC 5034, BCG 64, JG 23, BCG 85, ICC 85, Digvijay, GJG 0906, ICC 110, BCG 79, G 94, RVSGS 11, GNG 0904, IC 22, GNG 2064, IC 2444, BCG 54-1, ICC 867, GNG 2058, VIJAY, JGK 1, B 611, HK 06-171, PBC 1103-2, BG 3023, GNG 0904, ICC 5003, ICC 101, ICC 4958, ICC 111, JG 25, BCG 10-11, GK 23, BDNG 798 and BCG 10-4
V	Medium seeded with high number of pods plant^{-1}	04	BDNGK 807, Virat, ICC 1058 and ICC 15105
VI	Bold seeded with medium number of pods plant^{-1}	03	PKV Kabuli 4, HK 08-206 and PG 0749

II was containing three lines and characterized by small seeded with high number of pods per plant and low seed yield per plant. Medium seeded with low number of pods per plant lines were included in complex III, which comprised of 13 lines including four *Kabuli* lines. More than fifty *per cent* (52) lines were grouped into complex IV. This complex was characterized by medium seeded with medium number of pods per plant and medium to high seed yield plant^{-1}. The checks Vijay, Digvijay and PKV Kabuli 2 were included in this complex. Out of 52 lines, thirteen lines were of *Kabuli* types. Complex V consisted of four lines with three kabuli lines characterized by medium seeded with high number of pods plant^{-1} and high seed yield. The check Virat was included in this complex. The complex VI was characterized by bold seeded with medium number of pods plant^{-1} and high seed yield plant^{-1}. All three lines in Complex VI were *Kabuli* types including PKV Kabuli 4. Jha *et al*. (2011) reported eight groups of 30 chickpea genotypes on the basis of morphological variation like high pods and early days to 50 per cent flowering, medium grain yield and low primary branches, medium grain yield and medium primary branches, medium grain yield and high primary branches, late days to 50 per cent flowering, 100 seed weight and pods plant^{-1}, high seed weight and days to maturity, medium grain yield and medium primary branches.

Table 3. Index scores and signs used for nine characters under Meteroglyph analysis

Character	Score 1	Sign	Score 2	Sign	Score 3	Sign
	Value <		*Value from - to*		*Value >*	
Days to 50% Flowering	43.833	O	43.833-54.666		54.666	
Days to maturity	105.5	O	105.5-113		113	
Plant Height	36.931	O	36.931-47.462		47.462	
Number of Primary branches	2.766	O	2.766-3.632		3.632	
Number of Secondary branches	4.013	O	4.013-8.026		8.026	
Number of seeds/pod	1.1433	O	1.1433-1.351		1.351	
Seed yield/plant	7.033	O	7.033-10.666		10.666	
Biological Yield	14.586	O	14.586-22.462		22.462	
Harvest index	46.818	O	46.818-55.191		55.191	

The frequency diagram revealed that the index scores ranged from 13 to 27 (Fig. 2).

Fifteen genotypes recorded index score of 19 followed by 14, 12, 10 and 9 with an index score of 17, 21, 23 and 20, respectively. Minimum frequency of genotypes (1) occurred for index score of 14 and 27. Highest index score of 27 recorded by only one line, HK 08-206 followed index score of 25, 24 and 23 by four, seven and ten lines, respectively. Jha *et al*. (2011) earlier reported minimum frequency of genotypes (1) for index score 14, 15 and 18 in chickpea.

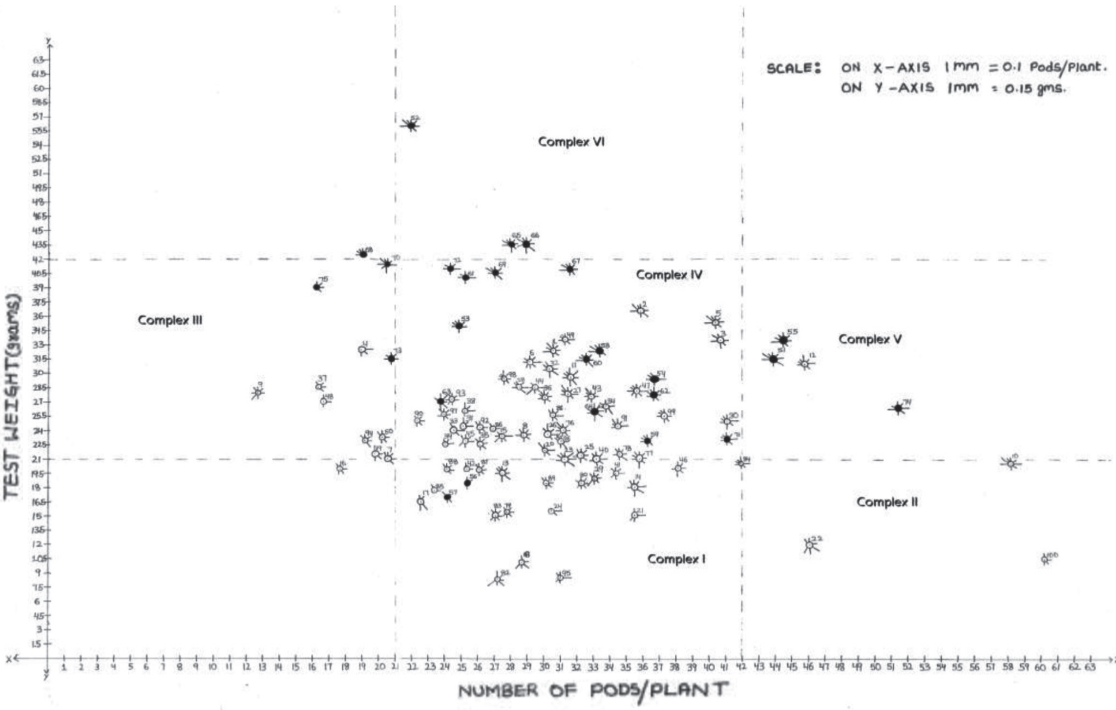


Fig.1. Scatter diagram of Meteroglyph analysis for 100 chickpea line

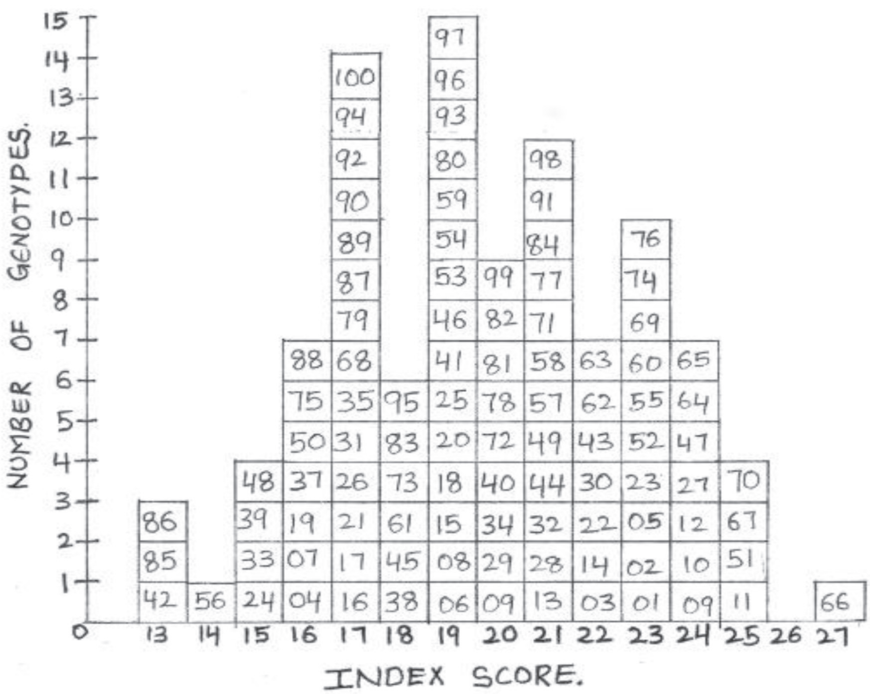


Fig. 2. Frequency diagram

CONCLUSION

The scatter diagram, index scoring and ray pattern showed that besides test weight and number of pods plant^{-1}, the *Kabuli* genotypes, HK 08-206, PG 0749, PKV Kabuli 4, BDNGK 807, Virat and ICC 15105 and *Desi* genotypes, ICC 1058, ICC 101, ICC 4958, ICC 110 Digvijay, Vijay and BDNG 797 showed higher morphological variation for more number of traits. Thus, the use of these genotypes in future breeding programme is suggested.

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INFLUENCE OF SPACING ON INCIDENCE OF MAJOR INSECT PESTS IN RAINFED COTTON

M.S. MAHALAKSHMI* and N.V.V.S.D. PRASAD
Regional Agricultural Research Station,
Acharya N.G. Ranga Agricultural University, Lam, Guntur- 522 034

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ABSTRACT

The field trial to study the influence of plant spacing on incidence of major insect pests on cotton was conducted for two consecutive seasons (*Kharif*, 2015-16 and 2016-17) at Lam, Guntur. The incidence of sucking pests especially leafhoppers and thrips was slightly higher in close spacing *i.e.* under high density planting system (HDPS) when compared to recommended spacing. The incidence of bollworms was almost similar in both close and recommended spacing. The study indicated that statistically there are no significant differences between close spacing and recommended spacing regarding the incidence of insect pests, except for leafhoppers.

INTRODUCTION

Cotton is an important commercial crop and is mostly grown under rainfed conditions in Andhra Pradesh. It is highly prone to insect pest attack at various stages of crop growth. In India, about 162 insect pest species have been recorded which cause yield loss to an extent of 2,87,000 million annually (Dhawan *et al*., 2008). Hence, farmers mostly rely on insecticides to combat the insect pest damage. Cotton consumes about 48 per cent of pesticides used in India and 22.5 per cent of the world (Saiyed *et al*., 2003). Extensive and indiscriminate use of insecticides in cotton not only increased the cost of plant protection but also lead to development of resistance to insecticides besides environmental pollution. At this juncture, Bt cotton with Cry 1 Ac gene was introduced during 2002 and stacked Bt cotton hybrids with Cry 1 Ac + Cry 2 Ab genes were introduced during 2006 which is a breakthrough in cotton cultivation. Incidence of major bollworms was kept under check by transgenic Bt cottons, but sucking pests need to be taken care through insecticides or by alternative measures.

The productivity of cotton was increased after introduction of Bt cotton and India stood second after China in recent past though occupied first position in acreage (AICCIP, 2018). Stagnation in the productivity was observed from last 4-5 years despite heavy use of inputs and insecticides against sucking pests in BG II cotton hybrids necessitates the search of alternative measures to increase the productivity. Adoption of high density planting system or narrow or closed spacing is one of such alternative which derived attention at global level. Manipulation of row spacing, plant density and the spatial arrangements of cotton plants for obtaining higher yield have been attempted by agronomists for several decades in many countries. The concept of high density planting system (HDPS), more popularly called as Ultra Narrow Row (UNR) cotton was initiated by Briggs *et al*. (1967). UNR cotton has row spacing as low as 20 cm and plant population in the range of 2 lakh plants ha^{-1} to 2.5 lakh plants ha^{-1}, while conventional cotton is planted in rows at 90 cm to 100 cm apart and has a plant population of about 100,000 plants ha^{-1}. However in India, the recommended plant density for cotton seldom exceeded 55000 plants ha^{-1}. The obvious advantage of this system is earliness, since UNR needs less bolls/plant to achieve the same yield as conventional cotton and the crop does not have to maintain the late formed bolls to mature (Rossi *et al*., 2004). The other advantages include better light interception, efficient

*** Corresponding Author E-mail:** msmlaxmi@gmail.com

leaf area development and early canopy closure which will shade out the weeds and reduce their competitiveness. The early maturity in soils that do not support excessive vegetative growth can make this system ideal for shallow to medium soils under rainfed conditions, where conventional late maturity hybrids experience terminal drought. Therefore, the high density planting system is now being considered as an alternate production system having a potential for improving the productivity and profitability. Recent research on closed spacing or high density planting offered encouraging results (Venugopalan *et al*., 2013; Singh *et al*., 2014). Plant spacing significantly affects the growth and development of the crop as well as microclimatic condition of the crop ecosystem for multiplication of the pest (Jain and Bhargava, 2007). Despite yield and economic advantages of HDPS in cotton, especially in rainfed and marginal soils, the adoption of closer spacing and high plant density may create congenial condition for build-up of pest population (Mohite and Utamsamy,1997; Singh *et al*., 2015). Many reports are available on influence of closer spacing on yield and yield components in cotton. However, studies on the effect of narrow spacing or high density planting system on incidence of insect pests across agro ecological systems was found to be scanty. Hence, the study was taken up to investigate the impact of HDPS on pest incidence in cotton.

MATERIAL AND METHODS

The experiment was conducted at Regional Agricultural Research Station, Lam, Guntur for two successive seasons *i.e. Kharif,* 2015-16 and *Kharif,* 2016-17. The variety Suraj (non- Bt) was sown in July second fortnight at two different spacings *i.e.* at 75 cm X 10 cm as closer spacing or HDP system and at 105 cm X 60 cm as recommended spacing, each in 1000 sq.m area. The crop was maintained completely under unprotected conditions throughout the season for recording the incidence of insect pests. The number of sucking pests such as leafhoppers, thrips, aphids and whiteflies was recorded from three leaves (top, middle and bottom) per plant from twenty randomly selected plants per plot. The larval population of bollworms, *H.armigera* and *S.litura* and fruiting body damage due to *H.armigera* was recorded on whole plant basis. The larval population of pink bollworm and locule damage was recorded by collecting 50 green bolls randomly from each plot and larval population and damage was recorded through destructive sampling *i.e.* by cutting the green bolls in the laboratory. The data was recorded at weekly intervals from both HDPS plot and recommended spacing plot and subjected to statistical analysis.

RESULTS AND DISCUSSION

Incidence of sucking pests

The incidence of sucking pests such as leafhoppers, thrips, aphids and whiteflies was observed throughout the crop growth period in both closed spacing and recommended spacing. The population of leafhoppers was observed from middle of August itself till the end of crop growth which was ranged from 2.7 to 10.03/ 3 leaves with two population peaks. The first peak was observed during 38th standard week (17th-23rd September) with a population of 10.03/ 3 leaves and the second peak was observed with a population of 9.14/3 leaves during 48th standard week (26th November – 2nd December) under HDPS. Though the trend was similar in recommended spacing, the population was slightly low under recommended spacing when compared to closed spacing (Fig.1). The seasonal mean population of leafhoppers was 6.67±2.02/3 leaves (mean ±SD) in HDPS as against 5.30±2.08/3 leaves that was recorded in recommended spacing. The computed t-statistic for differences between the above two mean values is statistically different (t= 2.20; critical = 2.01; p= <0.05), indicating that the leafhopper population was significantly higher in closed spacing than that of recommended spacing (Table 1).

The incidence of thrips was high upto 90 days after sowing which declined later towards the end of crop growth. The population of thirps was high from the end of September (39th standard week) to first week of November (44th standard week). The population of thrips was slightly higher under HDPS than in recommended spacing but statistically there are no significant differences between closed spacing and recommended spacing (Table1 and Fig.2).

The incidence of aphids was low initially with a gradual increase and population was high from third week of October to third week of December (42nd to 51st standard week) and declined thereafter. The population of aphids ranged from 0.0 to 31.95/ 3 leaves in closed spacing *i.e.* under high density planting system, while it was 0.0 to 26.15/ 3 leaves in recommended spacing. The peak population of aphids was observed at the end of November (48th standard week) which was slightly higher in HDPS (31.95/3 leaves) when compared to recommended spacing (26.1/ 3 leaves) (Table 1 and Fig.3). Though the population was slightly higher in HDPS, it was statistically at par with recommended spacing.

The population of whiteflies was low upto the end of November in both closed and recommended spacing without much difference. However, the population of whiteflies has increased from the month of December in closed spacing, while it declined from December and nil during January in recommended spacing (Fig.4). However, the seasonal mean for two years and t-statistic revealed that there is no significant influence of plant spacing on incidence of whiteflies (Table 1).

Incidence of Bollworms

The incidence of *H.armigera* was observed from first week of October (40th standard week) to the end of December (52nd standard week) with a peak population during first week of November (45th standard week) in both close and recommended spacing without statistical differences between seasonal mean population. The fruiting body damage due to *H.armigera* was almost similar in both close spacing and recommended spacing without significant differences (Table 2 and Fig. 5).

The larval population of *S.litura* was observed from October to December months with a peak population during the month of November, *i.e.* during 46th standard week in close spacing (6.6/plant) and during 45th standard week in recommended spacing (4.5/plant). Though the seasonal mean larval incidence of *S.litura* was numerically higher in close spacing (2.2/plant), it was statistically on a par with recommended spacing (1.8/plant) (Table 2 and Fig. 5).

The destructive sampling of green bolls revealed that the incidence of pink bollworm commenced from the end of November which progressed gradually and peak larval population was recorded during the month of January irrespective of spacing. The larval population of pink bollworm ranged from 1.4 to 10.9/ 10 green bolls in HDPS, while it was 2.1 to 10.1 / 10 bolls in normal spacing with slightly higher locule damage in green bolls in closed spacing (Fig.6). The seasonal mean population of pink bollworm larvae was slightly higher, *i.e*. 6.36 ± 3.15/10 green bolls (mean ±SD) in HDPS as against 5.90 ± 2.48/10 green bolls in recommended spacing. But statistically there were no significant differences between the closed and recommended spacing (t=0.34, t tab=2.12) indicating that the plant spacing had no significant influence on larval incidence of pink bollworm (Table 2).

The results of the field trials revealed that there were no significant differences between closed spacing and recommended spacing regarding the incidence of both sucking pests and bollworms in cotton except for leafhoppers. The results agree with Anand *et al*. (2017) who reported non-significant differences between HDPS and normal spaced crop with respect to pest population in cotton in Dharwad, Karnataka. The population of leafhoppers was higher in closed spacing than in normal spacing and the

Table 1. Influence of spacing on incidence of sucking pests in cotton (Pooled data of 2015-16 and 2016-17)

Particulars	No./ 3 leaves/plant							
	leafhoppers		Thrips		Aphids		Whitefly	
	HDPS	Normal	HDPS	Normal	HDPS	Normal	HDPS	Normal
Mean	6.67	5.30	7.02	7.41	9.12	9.33	1.77	1.18
SD (±)	2.02	2.08	6.04	5.39	8.89	7.88	1.55	1.03
t cal	2.20*		0.22		0.08		1.47	

*** Significantly different at $p < 0.05$; df = 42; critical value (t tab) = 2.01**

Table 2. Influence of spacing on incidence of bollworms in cotton (Pooled data of 2015-16 and 2016-17)

Particulars	***H.armigera***				***S.litura* larva/plant**		**Pink bollworm**			
	Larva/ plant		**Fruiting body damage**				**Larva/ 10 green bolls**		**% locule damage**	
	HDPS	Normal	HDPS	Normal	HDPS	Normal	HDPS	Normal	HDPS	Normal
Mean	0.5	0.5	6.0	6.2	2.2	1.8	6.36	5.90	33.28	32.46
SD (±)	0.41	0.42	5.19	5.25	2.05	1.52	3.15	2.48	17.56	17.37
t cal	0.14		0.08		0.61		0.34		0.10	

$p < 0.05$; df =24 ; critical value (t tab) = 2.06 (*H.armigera* and *S.litura*)

$p < 0.05$; df =16 ; critical value (t tab) = 2.12 (pink bollworm)

results are in accordance with Priyanka (2016) who reported that in case of closer spacing(111111 plants ha^{-1}) aphids and leaf hoppers population crossed Economic Threshold Level(ETL) in cotton. Butter *et al*. (1992) reported that the population of jassids and incidence of bollworms were higher at closer spacing (75x15 cm) when compared to wider spacing (75 cm x30 cm) in cotton. Mohite and Uthamasamy (1997); Muhammad *et al*. (2006); Kalaichelvi (2008) and Shwetha *et al*. (2009) also reported the higher population of sucking pests in cotton grown at the closer spacing. The population of jassid, whitefly and thrips was significantly affected by plant spacing and decreased with the increase in plant spacing and vice versa (Arif *et al*., 2006). The population of bollworms such as *H.armigera*, *S.litura* and *P.gossypiella* were similar in both closed spacing and normal spacing without significant differences in the study. However, the results are in divergence with Singh *et al*. (1991) who reported that closer spacings (60 cm x15 cm and 67.5 cm x15 cm) harboured higher population of diapausing pink bollworm larvae in arboreum cotton under unprotected conditions. Anand *et al*.(2008) also recorded

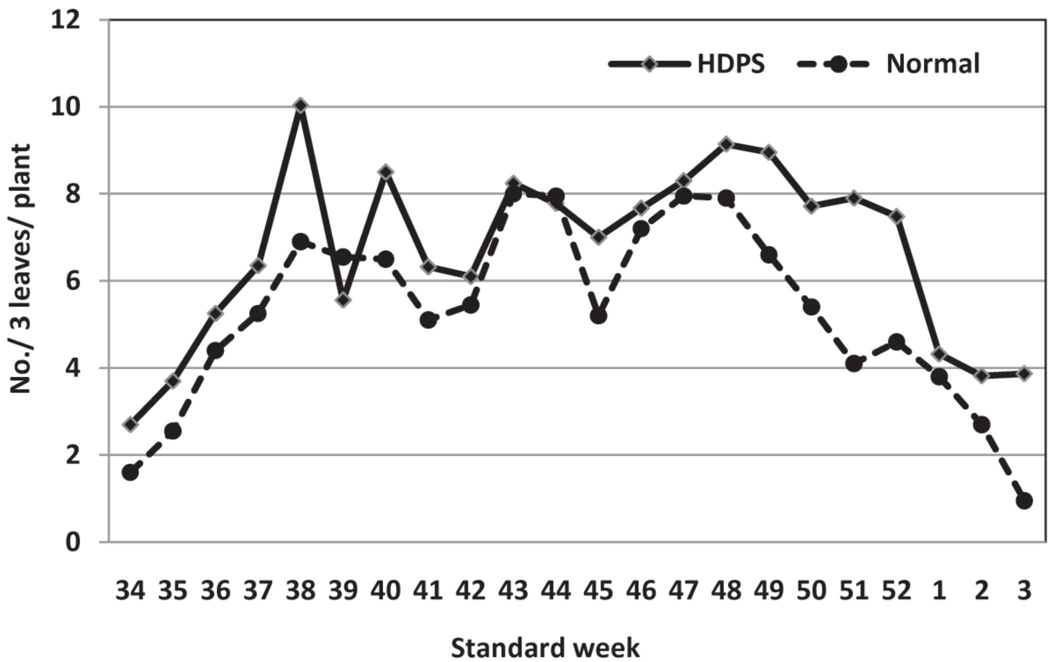

Fig.1. Mean incidence of leafhoppers in cotton at different spacings under unprotected conditions

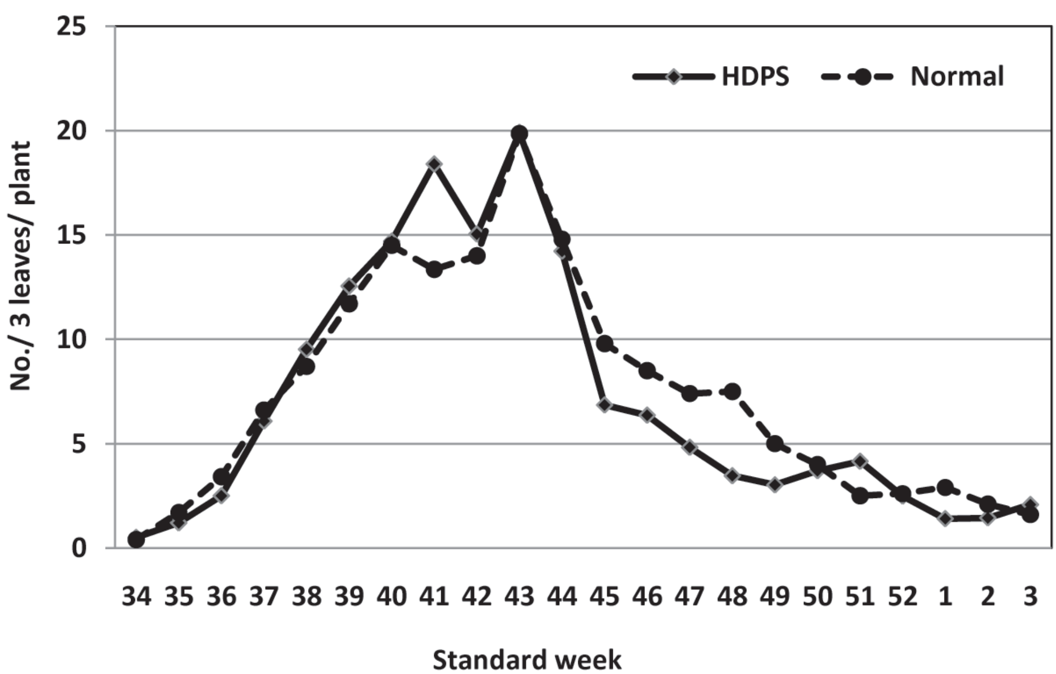

Fig.2. Mean incidence of thrips in cotton at different spacings under unprotected conditions

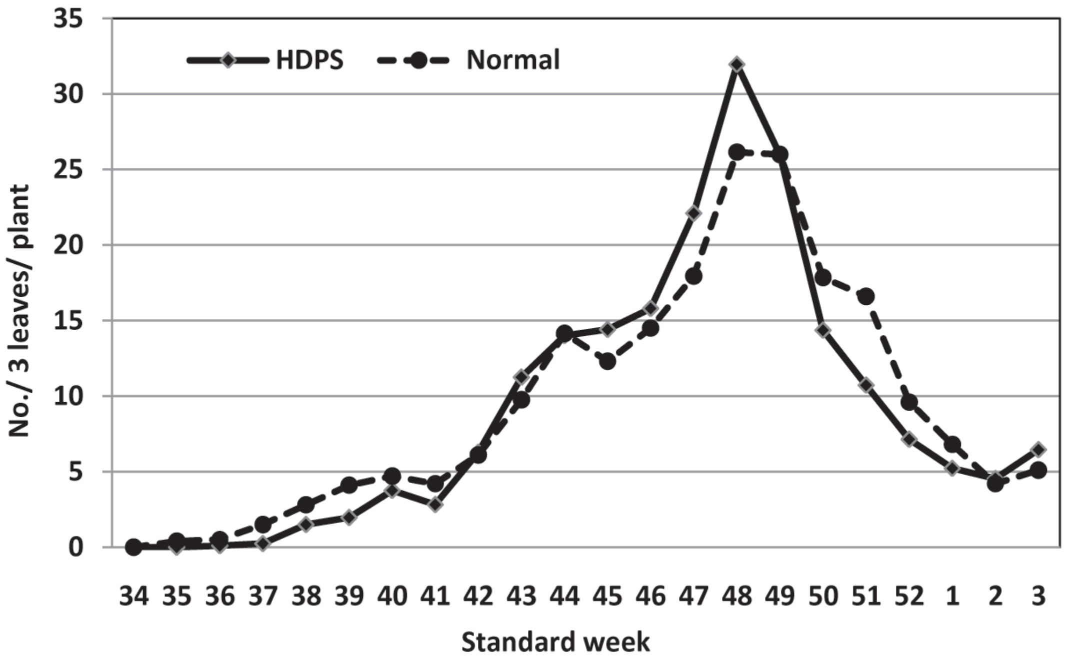

Fig.3. Mean incidence of aphids in cotton at different spacings under unprotected conditions

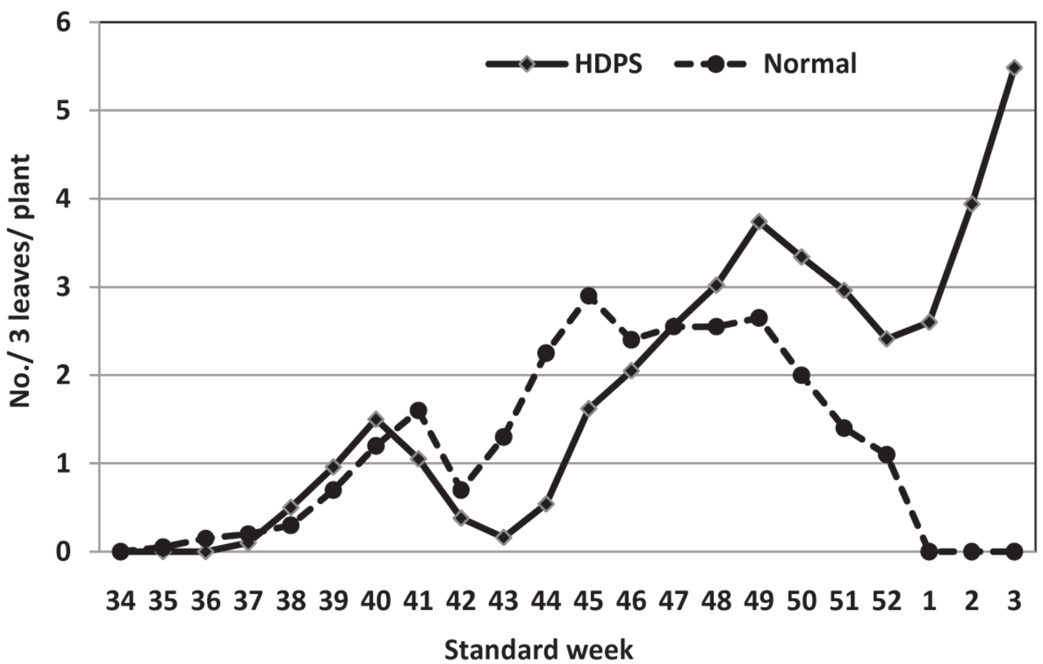

Fig.4. Mean incidence of whiteflies in cotton at different spacings under unprotected conditions

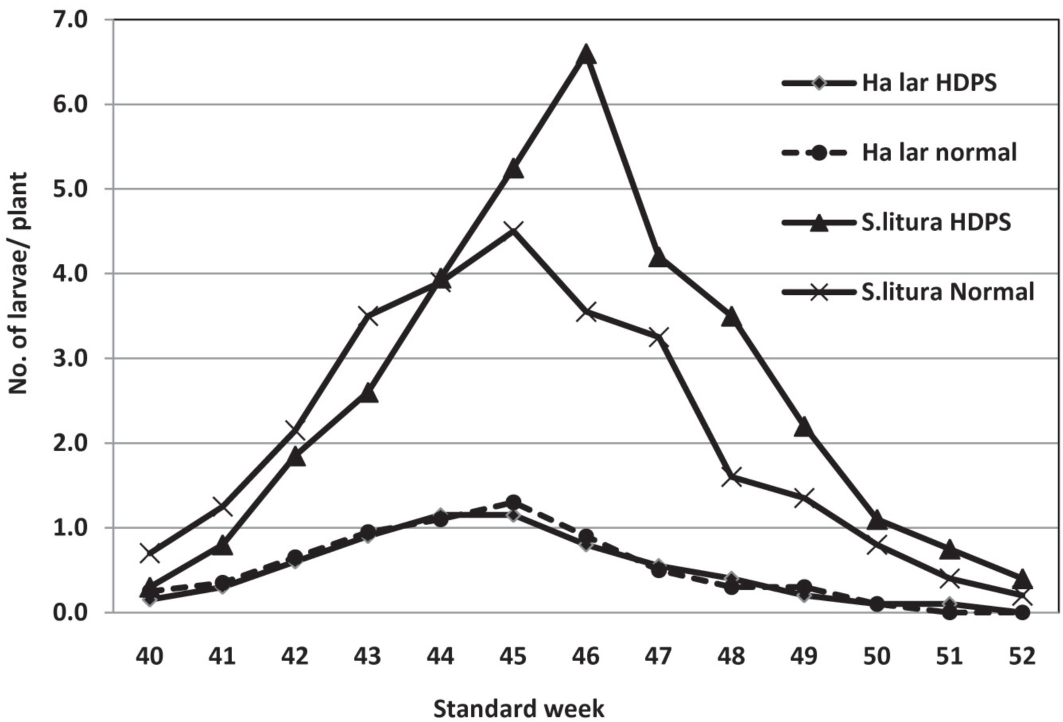

Fig.5. Mean larval incidence of *H.armigera* and *S.litura* in cotton at different spacings under unprotected conditions

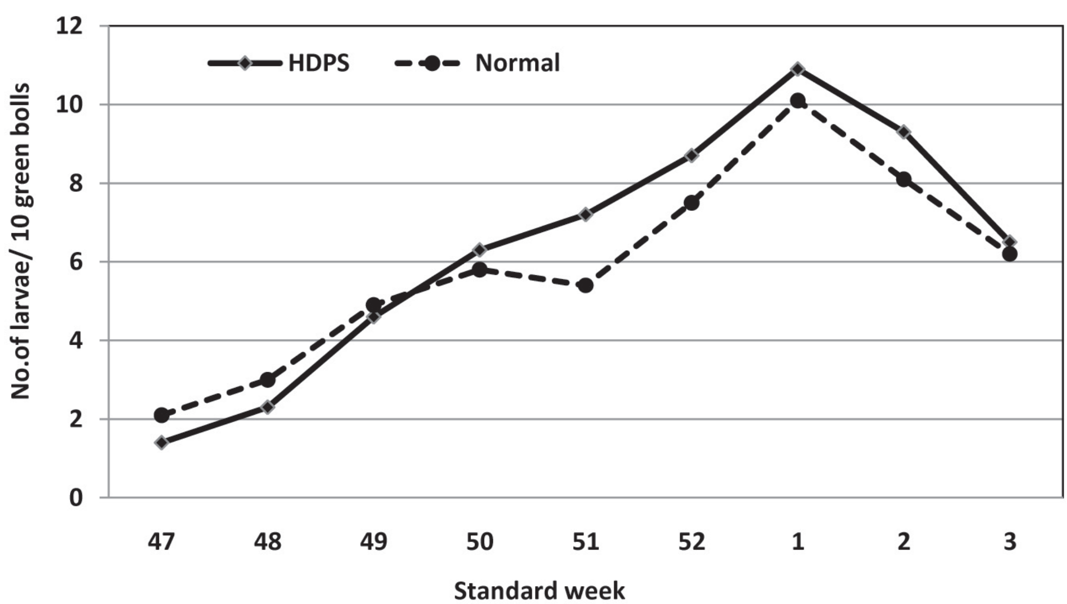

Fig.6. Mean larval incidence of pink bollworm in cotton at different spacings under unprotected conditions

significantly higher bollworms per plant at a spacing of 75 cm x30 cm when compared to sowing at 90 cm x60 cm spacing in cotton.

CONCLUSION

The incidence of both the sucking pests and bollworms was statistically similar in both high density planting system and recommended spacing except for leafhoppers. High density planting system (HDPS) in cotton needs to be studied thoroughly in Indian context for its adaptability and feasibility in terms of yield per ha, B:C ratio and location specificity.

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MINIMUM GUARANTEE PRICE FIXATION FOR FCV TOBACCO IN ANDHRA PRADESH USING BULK-LINE COST APPROACH

D. V. S. RAO, G. RAGHUNADHA REDDY*, K. UMA DEVI and M. CHANDRASEKHAR REDDY

Department of Agricultural Economics

Acharya N. G. Ranga Agricultural university, Guntur - 522 101

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ABSTRACT

The paper provides insights about fixing of the Minimum Guaranteed Price (MGP) for FCV tobacco based on bulk-line cost concept, which could be helpful in retaining majority of the farmers in cultivation, who contribute to majority of total production. A total sample size of 1,126 tobacco growers (NLS-373, SLS-378 and SBS-375) were selected for the study spread over 11 auction platforms in three districts of Andhra Pradesh. The methodology used by CACP (Commission for Agricultural Costs and Prices) was adopted to calculate cost of cultivation and income measures. The negative net returns with -0.13 return on rupee invested was realised by the total respondents. To make the tobacco cultivation economically viable there is a need to fix up MGP to be received by the farmers, at remunerative level to maximum number of growers. When the MGP was fixed based on bulk-line cost method all the FCV growers in all the soil regions obtained positive gross returns and net returns.

INTRODUCTION

In India, tobacco is grown on 0.45 million ha of area producing 750 million kg and FCV tobacco accounts for one-third of total tobacco production. Andhra Pradesh stands first in FCV tobacco area and production. The crop is grown in four distinctive soil zones in A.P *viz.,* Northern light soil (NLS), Southern light soils (SLS), Northern black soils (NBS) and Southern black soils (SBS) covering five districts.

During 2014-15, the FCV growers faced distress situation by producing more quantity (> 40% of total) of NOG (No Grade) tobacco coupled with declined international demand, lead to very low prices in auctions. It was reported that, eight FCV tobacco growers of Andhra Pradesh resorted to the extreme act of committing suicides during 2014-15. The Tobacco Board had fixed the crop size as 172 million kg for 2014-15 season, which was now reduced to 120 million kg for 2016-17 season.

At present price, risk of FCV tobacco is not been guarded by the MGS system of the government. In the recent times the returns realized by the FCV growers showed negative profits which signifies the importance of fixing MGP for the crop at remunerative level. Bulk-line cost was recommended in fixing the MGP which covers 85 per cent of production and is calculated on Cost C3 concept (Anil Kumar Chagar, 2002). In this context, the article provides insights about fixing of the Minimum Guaranteed Price for FCV tobacco based on bulk-line cost concept.

MATERIAL AND METHODS

Multi-Stage sampling technique was employed to select the respondents. The study covered three soil regions *viz.,* northern light soils (NLS), southern light soils (SLS) and black soils (BS) of Andhra Pradesh where most of the FCV tobacco is grown. Based on the probability proportion of tobacco farmer's population in each soil region, the sample is decided in each region. All the auction platforms were covered. The divisions of auction platforms, the villages from each division and the growers from each village were selected based on probability proportion of the respective component. A total sample size of 1,126 tobacco growers (NLS-373, SLS-378 and SBS-375) were selected with 5 per cent margin of error and 95 per cent confidence level out of total 47,195 FCV growers. The primary data about cost of cultivation and curing was collected through survey method with the help of pre-tested schedules in three spells of the crop period *i.e.,* mid-

*** Corresponding Author E-mail:** raghunadhareddy88@gmail.com

crop season, harvesting season and post-harvest curing season during 2014-15.

The Bulk-Line Cost concept was proved to be more appropriate for fixing a stable producers price which envelops about 75 per cent of total cost (Bhagavat Mishra, 1985). The methodology used by Commission for Agricultural Costs and Prices was adopted to calculate cost of cultivation and income measures.

RESULTS AND DISCUSSION

Profitability of Tobacco crop (per acre)

Northern Light Soils (NLS): The average cost of cultivation including curing costs was Rs.1,44,679/- per acre(0.4 ha). The average gross income realised was Rs. 1,12,205/- per acre with an average yield of 8.69 q/acre and average price of Rs. 12883/- per q. The gross profit over Cost –A_1 (*i.e.* gross income minus cash expenses) was positive with Rs. 35399/- per acre, whereas, the gross profit over Cost-A_2 (*i.e.* gross income minus working expenses & leased-in land and barn rentals) was negative at -Rs.17218/- per acre. The net profit (gross income minus Cost C_3) was also negative with a loss of Rs. 32474 /- per acre, hence, the benefit-cost ratio was also negative by 0.22 per rupee of investment (Table 1).

Southern Light Soils (SLS): The average cost of cultivation was Rs. 76052/- per acre. The average gross income was Rs.64899/- per acre with an average yield of 5.88q and average price of Rs.11045 per q. The gross profit over Cost A_1 was Rs. 11279/- per acre and the gross profit over Cost A_2 was negative *i.e.* Rs.- 2177. The net profit estimated was also negative *i.e.* Rs. -11153 per acre. The income per rupee of investment was -0.15.

Black Soils (BS): The average cost of cultivation was Rs. 89928/- per acre. The gross return realised was Rs. 88785/- per acre with a yield of 8.06q and price of Rs. 10972/q. The gross profit over Cost A_1 and Cost A_2 were positive, whereas, net profit was negative with a loss of Rs. 1142/- per acre.

Table 1. Profitability of Tobacco crop (2014-15) (Rs./acre)

S. No.	Particulars	NLS	SLS	BS	Average
1	Cost A_1	76806	53620	59712	63379
2	Cost A_2	129423	67076	80162	92282
3	Cost C_3(Total cost of cultivation)	144679	76052	89928	103553
5	Yield (q.)	8.69	5.88	8.06	7.54
6	Cost of Production (Rs./kg)	166.49	129.34	111.57	137.33
7	Price/q	12883	11045	10972	11606
8	Gross Income (GI)	112205	64899	88786	88630
9(i)	Gross Profit (GI-Cost A_1)	35399	11279	29074	25251
9(ii)	Gross Profit (GI-Cost A_2)	-17218	-2177	8624	-3590
10	Net Profit (GI-Cost C_3)	-32474	-11153	-1142	-14923
11	Net Return on rupee invested	-0.22	-0.15	-0.01	-0.13

The average measure of the total sample also followed the same trend of negative net returns with -0.13 return on rupee invested.

Bulk-line cost analysis

To make the tobacco cultivation an economically viable activity in the backdrop of rising prices of input costs (manpower, diesel, fertilizer, machine power, pesticides, etc.,) there was a need to fix up minimum guarantee price at remunerative level to maximum number of growers. The Bulk -line cost concept which was used for determining such prices of agricultural produce, which could be helpful in retaining the majority of farmers in cultivation, who contribute majority of total production, was adopted for determining the MGP (Lehman B Fletcher, 1983)

The average cost of production per kg. was Rs.166.49/- for NLS; Rs.129.34/- for SLS and Rs. 111.57/- for BS. At this average cost level only 75 per cent of producers and 79 per cent of production was covered in NLS. It is concluded that still there were 25 per cent of growers producing at higher cost than the average cost of production. In case of SLS region, at average cost of Rs. 129.34, twenty per cent of producers are producing 18 per cent of production and remaining 80 per cent of producers are producing 82 per cent of production at higher than the average cost. In case of SBS region, at an average cost of Rs. 111.57, 22 per cent of producers are producing 21 per cent of production and the remaining 78 per cent of producers are producing 79 per cent of production at higher than the average cost of production.

Table 2. Cumulative percentage of production and producers covered for different levels of unit cost for Northern Light Soils (n=373)

S. No.	Cost range (Rs./kg.)	No. of producers covered	Production covered (kg)	% of No. of producers covered	% of Production covered	Cumulative percentage of	
						Producers covered (%)	Production covered (%)
1	97-106	5	4852	1.34	1.48	1.34	1.48
2	107-116	12	10457	3.22	3.19	4.56	4.67
3	117-126	30	28546	8.04	8.71	12.60	13.37
4	127-136	38	36251	10.19	11.06	22.79	24.43
5	137-146	61	56565	16.35	17.25	39.14	41.68
6	147-156	56	51809	15.01	15.80	54.16	57.48
7	157-166	55	49360	14.75	15.05	68.90	72.53
8	167-176	45	36459	12.06	11.12	80.97	83.65
9	177-186	35	26459	9.38	8.07	90.35	91.72
10	187- Above	36	27152	9.65	8.28	100.00	100.00
	Total	**373**	**327909**	**100**	**100**	-	-

The number of FCV tobacco farmers covered and their respective level of production at different unit cost ranges for SLS region was presented in the Table 3 and Fig. 2. The bulk-line cost analysis showed that 85 per cent of total production was obtained at Rs.160/kg covering 85 per cent of producers.

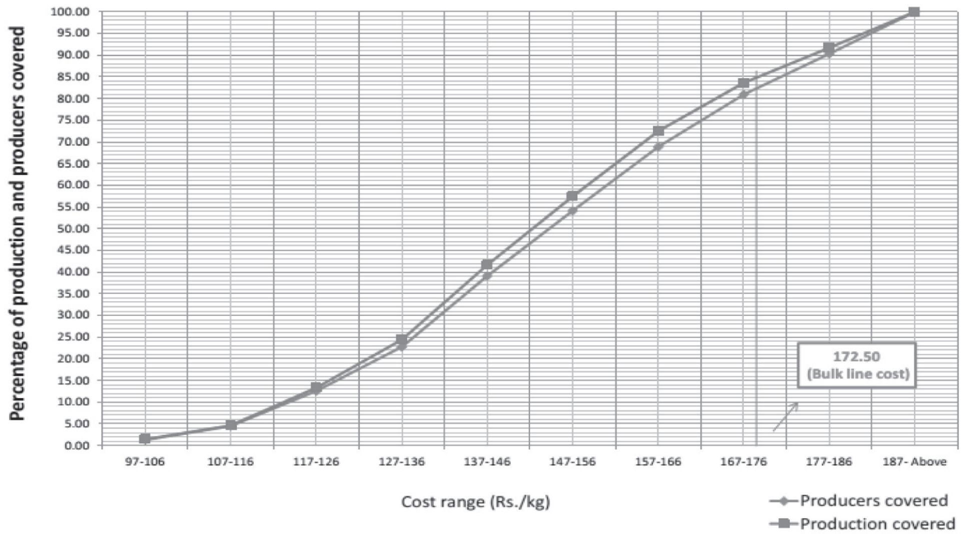

Fig.1 : Cumulative percentage of production and producers covered under different levels of unit costs (Rs./kg) and Bulk line cost - Northern Light Soils (NLS)

When the Bulk-line production was considered at 85 per cent level of production and the cost is fixed at this level of production, it is implied that the farmers not only recover their paid out costs but also get rewarded for use of their own resources such as land, family labour and fixed capital (Anil Kumar Chagar, 2002). In the study, the bulk-line cost analysis examined the cost of tobacco production by the last sample producer making the bulk at 85 per cent level of production. In order to retain the majority of the producers in FCV production, the price can be fixed for NLS farmers at Rs.172.50/- per kg, SLS at Rs.160/- per kg and SBS at Rs.158.50/- per kg, which were arrived through the Bulk-line cost concept (making the bulk at 85 per cent level of production).

The number of FCV growers covered and their respective level of production at different unit cost ranges for NLS region was presented in the Table 2 and Fig. 1. The bulk-line cost analysis showed that 85 per cent of total production was obtained at Rs. 172.50/kg in NLS region which has covered 80 per cent of producers.

Profitability of FCV tobacco at Bulk-line Cost Price (MGP)

The profitability of tobacco crop production was worked out based on average price received by the cultivators from the auction platforms. It was observed that the net profit realised was negative in all the soil regions, whereas, the gross profit was positive in all the soil regions and with all categories of farmers, except in BS region. However, an attempt was made to work out the profitability based on the bulk-line cost price which can be recommended as Minimum Guarantee Price to tobacco. The alternate scenario of profitability based on the bulk-line cost price is presented in Table 5. Based on this price all FCV growers in all the soil regions obtained positive gross profits and net profit. The margins are more in black soils followed by SLS and NLS.

Comparision of Average Cost of production/kg and Bulk-line Cost price

Table 6 shows the comparision of bulk-line cost price with that of average cost price incurred by the farmers during 2014-15 season. The bulk-line cost price was higher by 3.48 per cent in NLS region, 19.16 per cent in SLS region and 29.61 per cent in BS region, which makes 82 per cent, 84 per cent and 83 per cent of farmers profitable in tobacco cultivation, respectively in the three soil regions.

Table 3. Cumulative percentage of production and producers covered for different levels of unit cost for Southern Light Soils (n=378)

S. No.	Cost range (Rs./kg.)	No. of producers covered	Production covered (kg)	% of No. of producers covered	% of Production covered	Cumulative percentage of	
						Producers covered (%)	Production covered (%)
1	97-106	4	2825	1.06	1.27	1.06	1.27
2	107-116	15	9565	3.97	4.30	5.03	5.57
3	117-126	23	15175	6.08	6.83	11.11	12.40
4	127-136	35	22137	9.26	9.96	20.37	22.36
5	137-146	74	45542	19.58	20.49	39.95	42.86
6	147-156	94	56255	24.87	25.31	64.81	68.17
7	157-166	81	42656	21.43	19.19	86.24	87.36
8	167-176	34	18599	8.99	8.37	95.24	95.73
9	177-186	13	6535	3.44	2.94	98.68	98.67
10	187- Above	5	2956	1.32	1.33	100.00	100.00
	Total	**378**	**222246**	**100**	**100**	-	-

The number of FCV tobacco farmers covered and their respective level of production at different unit cost ranges for BS region was presented in the Table 4 and Fig. 3. The bulk-line cost analysis showed that 85 per cent of total production was obtained at Rs.158.50/kg covering 84 per cent of producers.

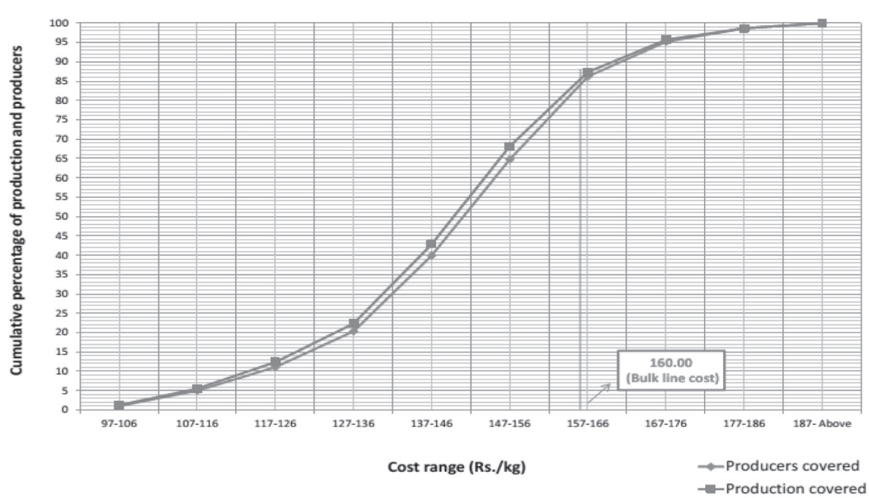

Fig. 2 : **Cumulative percentage of production and producers covered under different levels of unit costs (Rs./kg) and Bulk line cost - Southern Light Soils (SLS)**

Table 4. Cumulative percentage of production and producers covered for different levels of unit cost for Black Soils (n=375)

S. No.	Cost range (Rs./kg.$^{-1}$)	No. of producers covered	Production covered (kgs)	% of No. of producers covered	% of Production covered	Cumulative percentage of	
						Producers covered (%)	Production covered (%)
1	80-89	4	3215	1.07	1.06	1.07	1.06
2	90-99	29	25426	7.73	8.41	8.80	9.47
3	100-109	30	24351	8.00	8.05	16.80	17.52
4	110-119	32	24565	8.53	8.12	25.33	25.64
5	120-129	35	29856	9.33	9.87	34.67	35.51
6	130-139	49	41253	13.07	13.64	47.73	49.15
7	140-149	59	49586	15.73	16.39	63.47	65.55
8	150-159	62	49586	16.53	16.39	80.00	81.94
9	160-169	36	26522	9.60	8.77	89.60	90.71
10	170-179	21	15425	5.60	5.10	95.20	95.81
11	180-above	18	12666	4.80	4.19	100	100
	Total	**375**	**302451**	**100**	100	-	-

The number of FCV tobacco farmers covered and their respective level of production at different unit cost ranges for BS region was presented in the Table 4 and Fig. 3. The bulk-line cost analysis showed that 85 per cent of total production was obtained at Rs.158.50/kg covering 84 per cent of producers.

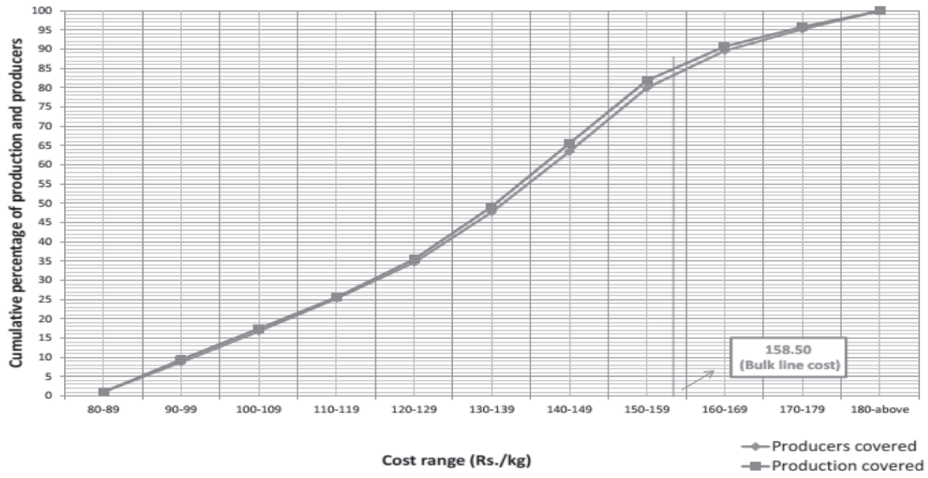

Fig.3 : **Cumulative percentage of production and producers covered under different levels of unit costs (Rs./kg) and Bulk line cost - Black Soils (BS)**

Table 5. Profitability of tobacco crop as per MGP (at 85 % bulk-line cost) (Rs/acre)

S.No.	Particulars	NLS	SLS	BS	Average
1	Cost C_3 (Total cost of cultivation)	144679.00	76052.00	89928.00	103553.00
2	Yield (q.)	8.69	5.88	8.06	7.54
3	Price/q. as per the MGP	17250.00	16000.00	15850.00	16366.67
5	Gross Income (GI)	149902.50	94080.00	127751.00	123911.17
6	Gross Profit (GI-Cost A_1)	73096.50	40460.00	68039.00	60531.83
7	Gross Profit (GI-Cost A_2)	20479.50	27004.00	47589.00	31690.83
8	Net Profit (GI-Cost C_3)	5223.50	18028.00	37823.00	20358.17
9	Net Return on rupee invested at A_1	0.51	0.53	0.76	0.60
10	Net Return on rupee invested at A_2	0.14	0.36	0.53	0.34
11	Net Return on rupee invested at C_3	0.04	0.24	0.42	0.23

Table 6. Comparision of average cost of production, average price received in 2014 season and bulk-line cost price (Rs/kg)

S.No.	Particular	NLS	SLS	BS
1	**Average Cost of production (2014)**	166.49	129.34	111.57
2	Per cent of number of producers covered	77.50	20.00	22.00
3	Average price received in 2014 season	128.83	110.45	109.72
4	Price difference between Average price received and Average Cost	-37.66	-18.89	-1.85
5	Per cent difference between average price received and average cost	-29.23	-17.10	-1.69
6	**Bulk-line Cost Price (MGP arrived)**	172.50	160.00	158.50
7	Per cent of number of producers covered	82.00	84.00	83.00
8	Price difference in Bulk-line Cost price over Average Cost Price	6.01	30.66	46.93
9	Per cent increase in Bulk-line Cost price over Average Cost Price	3.48	19.16	29.61
10	Price difference in Bulk-line Cost over Average Price received in 2014	43.67	49.55	48.78
11	Per cent increase in Bulk-line Cost over Average Price received in 2014	25.32	30.97	30.78

Comparision of the bulk-line cost price with the average price received by the farmers during 2014-15 season showed that price was higher by 25.32 per cent in NLS region, 30.97 per cent in SLS region and 30.78 per cent in BS region, which makes 80 per cent, 85 per cent and 84 per cent of farmers profitable in tobacco cultivation, respectively in the three soil regions.

CONCLUSION

The average price received during 2014-15 season was less than the average cost of production incurred by the farmers by 29.23 per cent in NLS region, 17.10 per cent in SLS region and 1.69 per cent in BS region, respectively. The analysis revealed that the MGP can be fixed for NLS farmers at Rs.172.50/- per kg, SLS at Rs.160/- per kg and SBS at Rs.158.50/- per kg, which was arrived through the Bulk-line cost concept (making the bulk at 85 per cent level of production) to retain the majority of the producers in FCV tobacco production. Hence, Government should take care of downward fluctuations in FCV tobacco prices by price support mechanisms especially in the event of slackening of export demand during any particular marketing season.

Policy Option

The study revealed that there was a huge difference in the bulk line cost arrived compared to the average price received by the FCV tobacco farmers and there is a need to increase the average price to match the bulk line cost. Hence, the study suggests for the Government intervention to safeguard the farmers (especially SLS and SBS regions of Prakasam district) by fixing the suggested Minimum Guarantee Price, which can retain majority of the FCV tobacco growers in production.

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STUDY ON FARMERS LEVEL OF KNOWLEDGE TOWARDS VEGETABLE CULTIVATION

H.D. VENU PRASAD*, PREMLATA SINGH and M. VENKATARAMULU
Division of Agricultural Extension, Indian Agricultural Research Institute, New Delhi – 110 012

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ABSTRACT

The study aimed at assessing the knowledge level of vegetable growers in the National Capital Region of Delhi during 2014-15. The total sample size was 200 respondents comprising of 100 retail farmers and 100 non-retail farmers. It was observed that majority of the farmers' (both retail and non-retail) had medium level of knowledge (74 % in case of retail and 76 % in case of non- retail) about vegetable cultivation. However, there was greater variability in the knowledge of the individual farmer from both the groups. It was observed that age, farming experience, income, socio-political participation, mass media exposure and extension contact had a positive and significant relationship with the farmer's knowledge about vegetable cultivation. It was also found that majority of the retail farmers followed the post-harvest operations *viz.,* sorting and grading of vegetables (62%), washing (100 %) and transport of produce to the collection centre (100%).

INTRODUCTION

There is a structural shift in the food basket away from the cereals and pulses towards fruits, vegetables, milk, meat, eggs, fish, etc. This, coupled with the increasing urbanisation, health consciousness, improved education and better marketing arrangements, has resulted in changes in the dietary pattern and food habits of households. Vegetables are common in human diet and form an important component of a balanced diet. Vegetables are an excellent source of vitamins, particularly niacin, riboflavin, thiamin and Vitamin A and Vitamin C. Vegetables also supply minerals such as calcium and iron besides proteins and carbohydrates. Vegetables combat under nourishment and are known to be the cheapest source of natural protective tools. Though the vegetable requirement is 300g/day/ person as recommended by dieticians, Indians are able to meet only about 1/9th of that requirement.

India is the second largest producer of vegetables in the world, next to China. India produces 14 per cent (146.55 million tonnes) of world's vegetables on 15 per cent (8.5 million hectares) of world area under vegetables (Vanitha *et al.*, 2013). India is gifted with a wide range of agro-climatic conditions which enable the production of vegetables throughout the year in one part of the country or the other thereby maintaining a continuous supply of fresh vegetables.

Most of the vegetables, being short duration crops, fit well in the intensive cropping system and are capable of giving high yields and high economic returns to the growers besides providing better health standards to the people. Therefore, a planned development in the field of vegetable production will not only improve the nutritional requirement of population but can also meet the challenge of adequate food supply to the growing population in India. In this context, it was necessary to study the farmer's level of knowledge about vegetable cultivation, so that they provide good quality vegetables to the consumers and also improve their prosperity. The investigation was aimed at measuring of farmers' knowledge about vegetable cultivation and also examined correlates of farmers' knowledge about vegetable cultivation as socio-personal variables play an important role in an individual's knowledge level as well as their predisposition to seek knowledge about a particular subject.

***Corresponding author E-mail**: venu@cwrdm.org; * Part of the PhD Thesis submitted to IARI, New Delhi

MATERIAL AND METHODS

The study was undertaken during the year 2013- 2014 in the National Capital Region (NCR) of Delhi, where *Safal* and *Reliance Fresh* retail companies' collection centres are in operation. Collection centres of both *Safal* and *Reliance Fresh* are located in Bakhtawarpur village of Alipur block in Delhi. Bakhtawarpur village was selected purposively because as it is the only centre in Delhi where the collection centres of both *Safal* and *Reliance Fresh* are functioning. List of all the farmers who are selling their vegetables to the collection centres was collected and from this list a random sample of 100 farmers (retail farmers) were selected. Another sample of 100 farmers (non-retail farmers) who were selling their vegetables directly to Azadpur *mandi* (a local wholesale market for fruits and vegetables) were selected randomly. To assess their knowledge about vegetable cultivation, knowledge test was developed. Post-harvest management practices followed by the retail farmers were also studied. The selected respondents were interviewed personally with the help of a structured interview schedule.

RESULTS AND DISCUSSION

It is clear from Table 1 that 53 per cent of the retail farmers belonged to middle age group, 40 per cent of them were in old age group and the rest were in low age group (7 %). Nearly half of the non-retail farmers (49%) belonged to middle age group, the rest were in old (47 %) and young age group (4 %).

Table 1. Socio-economic and personal profile characteristics of farmers

(n=200)

Sl.No	Socio-personal variables	Retail farmers		Non-retail farmers	
		f	%	*f*	%
A	**Age**				
1	Young (up to 35 years)	7	7	4	4
2	Middle (36-45 years)	53	53	49	49
3	Old (> 45 years)	40	40	47	47
B	**Education**				
1	Illiterate	0	0	0	0
2	Functional literate	8	8	0	0
3	Primary school	11	11	37	37
4	Middle school	23	23	30	30
5	High school	47	47	27	27
6	Pre- college	7	7	4	4
7	College	4	4	2	2
C	**Occupation**				
1	Full time farmer	93	93	88	88
2	Farming +other	7	7	12	12

(Table 1 Continued)

Sl.No	Socio-personal variables	Retail farmers		Non-retail farmers	
		f	%	*f*	%
D	**Family type**				
1	Nuclear	38	38	42	42
2	Joint	62	62	58	58
E	**Land holding**				
1	Landless (Leased in)	8	8	0	0
2	Marginal (0.1-1.0 ha)	11	11	27	27
3	Small (1.1-2.0 ha)	41	41	53	53
4	Semi-medium (2.1-4.0 ha)	33	33	16	16
5	Medium (4.1-10.0 ha)	7	7	4	4
6	Large (>10 ha)	0	0	0	0
F	**Socio-political participation**				
1	Low (<Q_1)	18	18	17	17
2	Medium (Q_1-Q_2)	28	28	34	34
3	High (Q_2-Q_3)	27	27	32	32
4	Very high (>Q_3)	27	27	17	17
G	**Mass media exposure**				
1	Low (<Q_1)	6	6	4	4
2	Medium (Q_1-Q_2)	30	30	26	26
3	High (Q_2-Q_3)	33	33	49	49
4	Very high (>Q_3)	31	31	21	21
H	**Extension contact**				
1	Low (<Q_1)	18	18	21	21
2	Medium (Q_1-Q_2)	45	45	35	35
3	High (Q_2-Q_3)	28	28	32	32
4	Very high (>Q_3)	9	9	12	12
I	**Net income**				
1	Low (<Q_1)	24	24	24	24
2	Medium (Q_1-Q_2)	26	26	26	26
3	High (Q_2-Q_3)	25	25	32	32
4	Very high (>Q_3)	25	25	18	18
J	**Farming experience (in years)**				
1	Low (<10)	6	6	4	4
2	Medium (10-20)	37	37	22	22
3	High (20-30)	34	34	39	39
4	Very high (> 30)	23	23	35	35

f = Frequency; **%** = Percentage

The educational status of the retail farmers revealed that 47 per cent of them were educated up to high school, 23 per cent of them were educated up to middle school, 11 per cent of them were educated up to primary school and 8 per cent of them were functional literate (these farmers were originally from Bihar and settled in Bakhtawarpur village and they have leased in land to cultivate vegetables), 7 per cent of them were educated up to pre-college and 4 per cent of them were educated up to college level. In case of non-retail farmers, 37 per cent of them were primary school educated, 30 per cent of them were middle school educated, 27 per cent of them were high school educated followed by pre-college educated (4%) and college level educated (2%).

Majority of the retail (93 %) and non-retail (88 %) farmers had farming as full time occupation. Similarly, more than half of the retail (62 %) and non-retail (58 %) belonged joint family type. Majority of the retail farmers were small farmers (41 %) and semi-medium farmers (33 %), whereas, in case of non-retail farmers 53 per cent were small farmers followed by marginal farmers (27 %).

The study found that as much as 28 per cent of the retail respondents and 34 percent of non- retail farmers had medium level of social participation. Similarly, 33 per cent retail respondents had high level of mass media exposure, followed by very high level (31 %), medium level (30 %) and low level (6 %) mass media exposure. It was also found that 49 per cent of the non-retail farmers had high level of mass media exposure, followed by medium level (26 %), very high level (21 %) and low level (4 %) mass media exposure. Also, 45 per cent retail respondents had medium level contacts with extension agencies, whereas, 35 per cent of the non-retail respondents had medium level contacts with extension agencies. As far as income is concerned, income of retail farmers were categorised as low (< Rs. 4 lakh), medium (Rs. 4 lakh to Rs. 5.7 lakh), high (Rs. 5.7- Rs. 7.5 lakh) and very high (> Rs.7.5 lakh). Similarly, income of non-retail farmers was categorised into four groups and these are low (< Rs. 2.4 lakh), medium (Rs. 2.4- Rs. 3.3 lakh), high (Rs.3.3- Rs. 4.2 lakh) and very high (>Rs. 4.2 lakh). The findings revealed that all the retail farmers were almost equally distributed in all the four groups. In case of non-retail farmers 32 per cent of them had high level of income, 26 per cent of them had medium level of income, followed by low (24 %) and very high (18 %).

The study found that 37 per cent of the retail respondents had farming experience in the range of 10-20 years. In case of non- retail farmers, 39 percent had farming experience in the range of 21-30 years. Hence, the profile that emerged for retail farmers was that the majority of them were middle aged, educated up to high school level, full time farmers, who belonged to joint families and were small farmers. The profile of the non-retail farmers was that the majority of them were middle aged, educated up to primary level, full time small farmers who belonged to joint families. Except for level of education, farming experience and net income both categories had more or less similar profile.

Based on the total obtainable scores on the knowledge test three categories of knowledge level were identified and the respondents were grouped according to their per cent score obtained on the knowledge test (Table 2).

It could be inferred that the retail farmers had mean knowledge score of about 25 out of 58 maximum obtainable score, with the range 34 and standard deviation 13.38, while that of non-retail farmers had 33 and 12.47, respectively. The data showed that farmers from both the groups apparently had on an average equal knowledge, however, there was greater variability in the knowledge of the individual farmer from both the groups. It was found that most of the farmers were aware of the production practices mainly the varieties grown, land preparation methods, seed rate and spacing. However, it was observed that the farmers simply take up pesticide application without even the pest reaching the level of threshold and spray high quantity of pesticides than as prescribed in the package of practices. Hence, there was a chance of pesticide residues being present in the vegetables and also increased cost of cultivation. Mukherjee (2003) studied about pesticides residues in vegetables in and around Delhi and reported that all the vegetable samples were contaminated with pesticides and 31 per cent of the samples contained pesticides above the prescribed tolerance limit. Hence, an awareness programme should be conducted among vegetable farmers regarding judicious and timely use of pesticides. With respect to the market information, the collection centres located in the villages displayed the market information of procurement of different vegetables in rupees per kg on daily basis. It was recorded that the price mentioned in the collection centres is more than the price procured in the local market.

Table 2. Knowledge level of retail and non-retail farmers regarding vegetable cultivation (n=200)

	Retail farmers		Non-retail farmers	
Mean	25.66		23.33	
S.D	13.38		12.47	
Range	34 (17-51)		33 (16-49)	
Knowledge Level	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Low (<12)	7	7	6	6
Medium (12-39)	74	74	76	76
High (>39)	19	19	18	18

According to the total score obtained by an individual farmer and the mean scores and standard deviation of the groups, farmers were classified into three categories *viz.,* low, medium and high. It was recorded that 74 per cent of the retail farmers had medium level of knowledge about vegetable cultivation (Table 2). It was followed by high level (19 %) and low level (7 %) of knowledge. It was also clear that 76 per cent of the non-retail farmers had medium level of knowledge about vegetable cultivation, followed by high level (18 %) and low level (6 %) of knowledge. Similar kind of results were reported by Dhadwad and Prasad (2012) in their study of Vidarbha Region in Maharashtra on knowledge level of cotton farmers and reported that 70 per cent of the respondents had medium level of knowledge in cotton cultivation practices. Singh *et al.* (2011) in their study on adoption behaviour of vegetable growers towards improved technologies found that majority of the tomato cultivated farmers were having medium (41.7 %) to high level (33.3 %) of knowledge about improved technologies. On the contrary, the study also reported that the majority of the cauliflower cultivating farmers (69%) had low knowledge level about improved cultivation practices.

In order to find out which of the independent variables were influencing farmers knowledge about vegetable cultivation, Spearman's rank correlation was computed (Table 3). The results showed that the age, farming experience, income, socio-political participation, mass media exposure and extension contact had a positive and significant relationship among the respondents of both the retail and non-retail farmers. Singh *et al.* (2010) also observed similar results in his analysis of farmers' socio-personal characteristics and their association with farmers' knowledge about cabbage farmers. It was observed that extension contact for retail farmers was highly significant compared to non-retail farmers.

Table 3. Correlates of farmers' knowledge about vegetable cultivation

(n=200)

S.No.	Independent Variables	Retail farmers	Non- retail farmers
		Spearman Rank Correlation (ñ)	Spearman Rank Correlation (ñ)
1	Age	0.365*	0.275*
2	Education	0.141	0.162
3	Occupation	0.108	0.127
4	Farming Experience	0.482**	0.422**
5	Family Type	0.064	0.072
6	Family Size	0.070	0.079
7	Land holding	0.033	0.039
8	Income	0.347*	0.238*
9	Socio- political Participation	0.253*	0.276*
10	Mass Media Exposure	0.289**	0.303**
11	Extension Contact	0.345**	0.322*

** Significant at the 0.01 level (two-tailed); * Significant at the 0.05 level (two- tailed)

Post-harvest management practices

As soon as the vegetable crop is harvested the farmers sold the produce to the outlets of either *Safal* or *Reliance Fresh*. Hence, there was no demand on the farmers to follow all of the post-harvest management practices. Post-harvest management practices were studied only for the retail farmers as they were selected as control group for assessment of socio-economic impact. The Post-harvest management practices followed by the retail farmers were observed and these were interpreted using percentage scores.

It could be inferred from Table 4 that cent per cent of the farmers washed the vegetables in their field itself before transporting the produce to the collection center. In case of sorting and grading the produce, 62 per cent of the farmers (those who sold their produce to *Safal* outlet) graded the produce by themselves in the presence of *Safal* executives. For farmers (38 %) who sold their produce at *Reliance Fresh* vegetable outlet, grading was done by the employees working with *Reliance Fresh*. All the farmers have transported their produce to the collection centers immediately after harvest, since there was no provision for storage. Roy and Paul

(2015) studied factors affecting vegetable marketing in West Bengal and reported that lack of adequate storage facilities was the most important problem faced by the vegetable growers related to marketing. Hence, availability of collection centers at the village level may reduce the post-harvest losses in marketing of vegetables to certain extent.

Table 4. Post-harvest management practices followed by the retail farmers

(n=100)

S.No	Particulars	Yes		No	
		f	%	*f*	%
1	Washing of vegetables	100	100	0	0
2	Sorting and grading of vegetables	62	62	38	38
3	Storage	0	0	0	0
4	Transportation	100	100	0	0

f = Frequency; %= Percentage

It was also found that majority of the retail farmers were following post-harvest operations such as sorting and grading of vegetables, washing and transport of produce to the collection centre. The study conducted by Karim and Wee (1996) had revealed that well managed post-harvest activities for vegetables led to higher yields and profits to producers. It is therefore, important that the post-harvest practices be given as much attention as production practices. Moreover, establishment of collection centers at village level may reduce the post-harvest losses of vegetables to certain extent. Hence, Government should take appropriate steps to establish collection centers at village level.

CONCLUSION

The results showed that majority of the the retail (74 %) and non-retail (76 %) farmers possessed medium level of knowledge about vegetable cultivation. However, there was wide variation in individual knowledge scores of the respondents. Correlation analysis revealed that age, farming experience, income, socio-political participation, mass media exposure and extension contact had a positive and significant relationship with their knowledge about vegetable cultivation. It was found that cent per cent of the farmers have knowledge about post- harvest management practices.As most of the farmers brought their vegetables immediately after harvesting of the produce, all the farmers performed the post-harvest management practices such as washing, drying, sorting, packaging, and transportation.

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EFFECT OF IRRIGATION LEVELS AND FERTILIZER DOSES ON YIELD AND QUALITY OF CHILLI (*Capsicum annuum* L.)

M. M. MAIND, S. S. YADLOD* and G. N. THALKARI
Department of Horticulture,
Vasantrao Naik Marathwada *Krishi Vidyapeeth*, Parbhani- 431402

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India is the largest producer, consumer and exporter of chilli, contributing about 40 per cent of total world's production. In India, chilli occupies an area of 760.98 thousands ha with annual production of 1605.01 thousands MT. In case of chilli, water and nutrient management are the two major components which needs careful handling and proper management in order to achieve maximum yield and quality. Drip irrigation method helps to protect, conserve these valuable resources and it is a potential system which could bring additional area under cultivation of vegetable crops with the same quantity of available water. Nutrient use efficiency can be increased through fertigation. Water soluble fertilizers and nutrients move with the wetting front. Hence, a precise scheduling of irrigation and fertilizer application is essential for sustainable crop production. At the same time, adequate fertilization (both in time and through method of application) to maintain optimum nutrient supply for optimum growth and development of the crops are also equally important towards the higher productivity. The primary advantage of micro irrigation is fertilizers can be injected through irrigation water (Nizamudeen and Dharmasena, 2002).

Micro irrigation and fertigation opened new possibilities for controlling water and nutrient supplies to crops and maintaining the desired concentration and distribution in the soil and it is possible to increase the yield potential by three times with the same quantity of water, also saving about 45 to 50 per cent of irrigation water and increasing the productivity about 40 per cent.Vijayakumar *et al.* (2010) found that drip irrigation at 75 per cent pan evaporation recorded maximum yield (11.56 t ha^{-1} in I crop and 10.25 t ha^{-1} in II crop) compared to drip irrigation at 100 per cent (7.78 t ha^{-1} in I crop and 6.79 t ha^{-1} in II crop) and drip irrigation at 50 per cent of pan evaporation (9.49 t ha^{-1} in I crop and 8.86 t ha^{-1} in II crop) in chilli. There is potential to increase the yield and quality in chilli through drip irrigation, hence, the experiment was conducted to find out the optimum level of irrigation and fertilizer doses for yield and quality.

The field experiment was conducted at All India Coordinated Research Project on Water Management, Parbhani during *Rabi* season of 2016-2017. Seedlings were prepared on raised nursery beds and uniform healthy seedlings of six week age were transplanted on flat beds at 60 cm x 45 cm on 10^{th} October, 2016. Light irrigation was given till the seedlings were established, subsequently, gap filling was done to maintain optimum population. The treatments such as A) Factor A -Irrigation levels (I) *i.e.* I_1- Irrigation of 0.6 PE by drip, I_2- Irrigation of 0.8 PE by drip, I_3- Irrigation of 1.0 PE by drip B) Factor B- Fertilizer doses (F) *i.e.* F_1- 60% RDF, F_2- 80% RDF, F_3- 100% RDF and Control. The daily pan evaporation data was measured with U.S.W.B. class-A pan evaporimeter. The data was analysed by statistical methods as suggested by Panse and Sukhatme (1985).

*Corresponding author E-mail: shivayadlod@gmail.com

Yield Parameters

Number of fruits plant $^{-1}$

Effect of irrigation levels on number of fruits plant^{-1} was found to be significant. Highest number of fruits plant^{-1} (172.12) was recorded in treatment I_3 (1.0 PE) and lowest number of fruits (130.17) plant^{-1} was recorded in treatment I_1 (0.6PE). The results indicated that significantly maximum number of fruits plant^{-1} (160.99) was observed in treatment F_3 100% RDF and minimum number of fruits plant $^{-1}$ (138.95) was found in treatment F_1 *i.e.* 60% RDF. The treatment combination I_3F_3 *i.e.* 1.0 PE + 100% RDF recorded significantly maximum number of fruits plant^{-1}(183.57) which was statistically at par with treatment combination of I_3F_2 *i.e.* 1.0 PE + 80% RDF (173.27), whereas, minimum number of fruits plant^{-1} (112.33) were found in control. The results were in conformity with the findings of Krishnamoorthy *et al.* (2014) who reported that increased yields under higher doses of water soluble fertilizers might be due to enhanced chlorophyll content of leaves resulting increased synthesis of carbohydrates and building of new cells. Increasing in yield with higher level of nitrogenous fertilizer might be due to higher amount of nitrogen availability in the vicinity of root zone due to fertigation.

The irrigation level I_3 (1.0 PE) had significantly recorded highest number of fruits plant $^{-1}$ as compared to I_1 and I_2 which revealed that the number of fruits increases with increasing levels of irrigation. The increase in yield with higher levels of irrigation levels might be due to the availability of moisture condition. These results were in agreement with the findings of Bhanu *et al.* (2005) who reported that okra crop when irrigated through drip at 1.0 Epan and fertigated with 120 N ha $^{-1}$ produced higher yields.

Weight of fruit (10 fruits)

The effect of various irrigation levels on weight of fruit (10 fruit) was significant. Highest weight of fruit (34.51g) was recorded in treatment I_3 (1.0 PE) and lowest weight of fruit (27.30g) was recorded in I_1 (0.6 PE).With respect to fertilizer doses significantly maximum fruit weight (32.55g) was observed in treatment F_3 *i.e.* 100% RDF and minimum weight of fruit (28.51g) was found in F_1 *i.e.* 60% RDF. The interaction of irrigation levels and fertilizer doses showed significant effect on weight of ten fruits. Highest fruit weight (35.66g) was found in treatment combination of I_3F_3 which was at par with treatment combination of I_3F_2 (33.66g), I_3F_1 (32.20g), I_2F_3 (31.08g) and I_2F_2 (30.66g). However, lowest weight of fruit (26.33g) was found in control. Similar observations were also reported by Bandi (1994) in chilli under drip and furrow methods.

Fruit yield plant^{-1} (g)

The effect of irrigation levels on yield per plant was found to be significant. The irrigation level I_3 (1.0 PE) produced significantly higher yield (593.99 g plant $^{-1}$) and lower was found in I_1 (355.36 g plant^{-1}). Highest yield (524.02 g plant $^{-1}$) was observed in treatment F_3 and lowest yield (396.15 g plant^{-1}) was found in fertilizer doses of F_1. *i.e.* 60% RDF. Significantly highest yield (654.61 g plant $^{-1}$) was observed in treatment combination of I_3F_3 *i.e.* 1.0 PE + 100% RDF and lowest yield (295.76 g plant $^{-1}$) was observed in control.

Fruit yield (t ha $^{-1}$)

Maximum fruit yield (19.80 t ha^{-1}) was recorded in I_3 (1.0 PE) and minimum fruit yield (11.84 t ha^{-1}) was recorded in I_1 (0.6 PE).The results indicated that significantly highest fruit yield (17.47 t ha^{-1}) was observed in treatment F_3 which was at par with treatment F_2 (15.65 t ha^{-1}) and lowest fruit yield (13.20 t ha^{-1}) was found in F_1. Treatment combination of I_3F_3 had recorded significantly maximum fruit yield (21.82 t ha^{-1}) which was statistically at par with treatment combination of I_3F_2(19.41 t ha^{-1}) and minimum fruit yield (9.86 t ha^{-1}) was observed in control. The above results indicated that significantly higher yield was observed in treatment I_3 which was at par with treatment I_2 and lower yield per plant was found in

Table 1. Effect of irrigation levels, fertilizer doses and their interactions on yield attributes of chilli

Treatments	No of fruitsplant^{-1}	Weight of 10 fruit (g)	Yield plant^{-1}(g)	Fruit yield t ha^{-1}
Factor A – Irrigation levels (I)				
I_1 (0.6 PE)	130.17	27.3	355.36	11.84
I_2 (0.8 PE)	150.23	30.03	451.14	15.04
I_3 (1.0 PE)	172.12	34.51	593.99	19.80
CD at ($P \leq 0.05$)	**11.99**	**3.02**	**5.06**	**2.72**
Factor B – Fertilizer levels (F)				
F_1 (60 % RDF)	138.95	28.51	396.15	13.20
F_2 (80 % RDF)	152.59	30.77	469.52	15.65
F_3 (100 % RDF)	160.99	32.55	524.02	17.47
CD at ($P \leq 0.05$)	**11.99**	**3.02**	**5.06**	**5.72**
Interactions (I X F)				
I_1F_1	118.13	27	318.95	10.63
I_1F_2	132.23	28	370.24	12.34
I_1F_3	140.13	28.91	405.12	13.50
I_2F_1	139.17	28.35	394.55	13.15
I_2F_2	152.27	30.66	466.86	15.56
I_2F_3	159.27	31.08	495.01	16.50
I_3F_1	159.54	32.2	513.72	17.12
I_3F_2	173.27	33.66	583.23	19.44
I_3F_3	183.57	35.66	654.61	21.82
Control	112.33	26.33	295.76	9.86
CD at ($P \leq 0.05$)	**19.25**	**5.15**	**8.76**	**6.2**

$I_{1.}$ These results are in accordance with the observations of Singandhupe *et al*. (2003) who found in pointed gourd that irrigation at 100 per cent PE resulted in 18 per cent higher fruit yield than 60 per cent PE; irrigation at 80 per cent PE increased the fruit yield marginally (2.6 per cent) over 60 per cent PE.

The effect of fertilizer levels indicated that significantly higher yield was observed in treatment F_3 and found at par with treatment F_2 and lower yield per plant was found in $F_{1.}$ These results are in agreement with the findings of Krishnamoorthy *et al. (*2014) and Shinde *et al. (*2002) who reported that

Table 2. Effect of irrigation levels, fertilizer doses and their interactions on fruit characters

Treatments	Fruit length (cm)	Fruit girth (cm)	Vitamin c (mg100g^{-1})	Capsaicin (%)
Factor A – Irrigation levels (I)				
I_1 (0.6 PE)	6.91	2.37	129.69	0.235
I_2(0.8 PE)	7.04	2.45	130.16	0.237
I_3(1.0 PE)	7.13	2.72	130.88	0.24
CD at ($P \leq 0.05$)	**NS**	**NS**	**NS**	**NS**
Factor B – Fertilizer levels (F)				
F_1(60 % RDF)	6.49	2.35	120.24	0.239
F_2(80 % RDF)	7.19	2.4	130.68	0.246
F_3(100 % RDF)	7.39	2.75	139.81	0.24
CD at ($P \leq 0.05$)	**0.68**	**NS**	**2.61**	**0.009**
Interactions (I X F)				
I_1F_1	6.23	1.68	119.73	0.233
I_1F_2	7.17	2.37	129.71	0.246
I_1F_3	7.34	2.08	139.62	0.233
I_2F_1	6.63	2.35	120.46	0.246
I_2F_2	7.12	2.05	130.47	0.233
I_2F_3	7.36	2.76	139.55	0.233
I_3F_1	6.62	2.01	120.53	0.243
I_3F_2	7.3	2.71	131.87	0.25
I_3F_3	7.47	2.43	140.26	0.233
Control	6.11	1.58	117.46	0.226
CD at ($P \leq 0.05$)	**NS**	**NS**	**NS**	**NS**

maximum yield (26.4 t ha^{-1}) with 100% RDF through water soluble fertilizers in chilli.

Quality Parameters

Fruit length (cm) and fruit girth (cm)

The effect of various irrigation levels on fruit length of chilli was found non-significant. (Table 2).The effect of fertilizer levels on fruit length was found to be significant. The results indicated that significantly maximum fruit length (7.39 cm) was observed in treatment F_3 and minimum fruit length (6.49 cm) was found in F_1.The interaction effect of irrigation levels and fertilizer doses on fruit length was found to be non-significant. Similar results were also reported by Krishnamoorthy *et al.* (2014) who observed more fruit length (11.5 cm) under 100% RDF through water soluble fertilizers. The effect of irrigation levels, fertilizer levels and their interactions on fruit girth was found to be non-significant.

Ascorbic acid content (mg100g^{-1})

The irrigation levels did not affect significantly on ascorbic acid content in chilli, however, fertilizer doses on ascorbic acid content was found to be significant. The maximum ascorbic acid content was found in F_3 (139.81 mg100 g $^{-1}$) and minimum was found in F_1 (120.24 mg100 g $^{-1}$). The interaction effects of irrigation and fertilizers doses on ascorbic acid content was found significant. There was increased ascorbic acid content in fresh chilli fruit due to increasing soil moisture. These results were in accordance with the findings of Bandi (1994). The highest ascorbic acid content was recorded at 100% RDF, which was followed by 80% RDF and lowest was found in 60% RDF. Increase in ascorbic acid content at higher levels of nitrogen may be due to enhancement of enzyme activity for amino acids synthesis leading to higher ascorbic acid content. The interaction effect between irrigation levels and fertilizer levels affect significantly on ascorbic acid content. Treatment combinations, I_3F_3 (irrigation at 1.0 PE with 100% RDF) recorded maximum ascorbic acid content (140.26mg/100g) followed by I_1F_3 (139.62) and I_2F_3(139.55). However, minimum ascorbic acid content (117.46) was found in control. These results are in agreement with findings of Shibhila Mary and Balakrishnan (1990) who reported that high N uptake by plants enhanced the enzyme activities for amino acids synthesis and increased ascorbic acid content in fruits. Similar results are also observed by Gupta *et al.* (2010) and Sathish *et al.* (2014) who recorded that higher ascorbic acid content was observed in treatment, wherein, 100 % RDF was provided through water soluble fertilizers.

Capsaicin content (%)

The irrigation levels did not significantly influence capsaicin content (%). However there was slight increase in capsaicin with increase in irrigation level. The data showed that the effect of fertilizer levels on capsaicin content was found to be significant. The highest capsaicin content (0.246%) was observed in treatment F_2 which was at par with treatment F_1 (0.241%) and lowest capsaicin content (0.239%) was found in F_1. The interaction effects of irrigation and fertilizer doses on capsaicin content was non-significant. The results indicated that irrigation levels along with fertilizer levels showed better response in terms of increase in capsaicin content as compared to conventional surface irrigation method and application of fertilizer. Similar results are observed by Sathish *et al.* (2014) who reported that highest capsaicin content was found in treatment, wherein, 100 % RDF is provided through fertigation.

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STUDY ON PROBLEMS IN ADOPTION OF HOME SCIENCE TECHNOLOGIES IN UNITED ANDHRA PRADESH

B.S. KANTHI SRI, I. SREENIVASA RAO, V. SUDHARANI and A. MARY SWARNALATHA

Department of Agricultural Extension, College of Agriculture,
Professor Jayashankar Telangana State Agricultural University, Hyderabad- 500030

The Government of India through Indian Council for Agricultural Research (ICAR) has established a large network of over 600 Krishi Vigyan Kendras (KVKs) across the country with an aim to conduct technology assessment and refinement through on- farm testing, front line demonstrations and knowledge dissemination to provide critical input support for the farmers with a multidisciplinary approach. KVKs are playing a proactive role in transferring new technologies at field level with beneficial impacts. KVK is an integral part of the National Agricultural Research System (NARS) and have an edge in technology transfer over other service providers by virtue of their having better technical expertise and demonstration units. KVKs implement a number of technologies that are gender sensitive and help in reduction of drudgery, income enhancement and development of self-confidence among women. Another important mandate of KVKs is to conduct need based training programmes for the benefit of farmers, farm women and rural youth. The concept of vocational training in agriculture (through KVKs) grew substantially due to greater demand for improved agricultural and allied technologies by the farmers. The emphasis is given to provide critical knowledge and skills to the participants to enhance the agricultural productivity and also to become economically self-reliant through gainful-employment (Patil and Kokate, 2011). A study conducted on a sample of 200 respondents who participated in vocational training programmes conducted by KVKs in Punjab revealed that knowledge gained through training programmes had resulted in continued adoption of bee keeping (20%) and mushroom cultivation (5%) enterprises respectively (Singh *et al.,* 2010). It also suggested that impact evaluation of the trainings organized by the KVKs should be conducted to identify the constraints and suggestions (ICAR, 2002). Evaluation of the extension activities and vocational training programmes conducted by the KVKs contributes to the reinforcement of transfer of technology. Hence, the study was conducted to know the problems of rural women in adoption of home science technologies and to elicit their suggestions for better adoption of the technologies.

The study was conducted in the year 2013-2014 in three purposively selected districts from each of the three regions of United Andhra Pradesh *i.e.* Nizamabad District from Telangana Region, YSR Kadapa District from Rayalaseema Region and West Godavari District from Coastal Andhra Region. Three KVKs were selected for the study purposively *i.e.* Rudrur KVK, Utukur KVK and Undi KVKs. Three mandals covering its area of operation were selected under each KVK of which one village was randomly selected, where KVK conducted its activities, thus, a total of nine villages. From each village, 30 rural women trained at KVK were randomly selected. Thus, a total of 90 rural women from Coastal region, 90 from Rayalaseema region and 90 from Telangana region, forming a total of two hundred seventy (270) respondents as the sample size. Personal interview was conducted to study about problems faced by rural women in adoption of seven selected home science technologies.

***Corresponding Author E-mail**: srikranthisri.b@gmail.com

Problems expressed and suggestions given for adoption of the following selected technologies

1. Value addition to millets

Lack of knowledge and skill –Only 16.30 per cent of the respondents expressed this problem. To solve this problem, "Imparting skill among rural women" was suggested by 11.48 per cent of respondents.

No demand in rural market- A total of 25.19 per cent of the respondents expressed this problem. To combat this problem, "Conducting awareness programmes on millet diet for public" was suggested by 16.67 per cent of respondents. These results were in line with the results of Charles (2013) *i.e.* lack of market was the major setback (79.8%) experienced by farmers who complained about low selling price and lack of proper market for value added products of pearl millet.

Raw materials are not easily available- A total of 30.74 per cent of the respondents expressed this problem. To combat this problem, 'Inputs to be made accessible through the KVK**"** was suggested by 23.33 per cent of respondents.

Low marketing skills – A total of 25.56 per cent of the respondents expressed this problem. To overcome the problem, **"**Imparting trainings on marketing skills" was the suggestion given by 12.96 per cent of respondents. Kusuma *et al*. (2013) also supported the results with her findings that about 35 per cent of the respondents had adequate marketing skills and 65 per cent of the respondents had inadequate marketing skills for marketing their value added products.

Processing is difficult - A total of 63.70 per cent of the respondents expressed this problem. As many as *i.e.* 56.67 per cent of the respondents suggested to "provide subsidy on processing machinery".

2. Nutrition Garden

Lack of quality seeds**-** Majority of the respondents *i.e.* 99.62 per cent expressed this problem. To overcome the problem, "KVK can supply at cost once in a season" was the suggestion given by the 83.70 per cent of respondents.

No demand in rural market**-** A total of 37.40 per cent of the respondents expressed this problem. For this the suggestion of "conducting awareness programmes" was suggested by 32.96 per cent of respondents.

Pest & disease management- A total of 48.88 per cent of the respondents expressed this problem. To overcome the problem, 42.96 per cent of respondents suggested **"**trainings should be conducted on organic pest and disease management methods by KVKs.

Lack of interest on nutrition garden in other family members- A total of 19.62 per cent of the respondents expressed this problem. To combat the problem, 18.89 per cent of respondents suggested that "conducting training programmes to family members on importance and advantages of nutrition garden"

3. Fruit and Vegetable Preservation

Lack of awareness among people **–**A total of 56.29 per cent of the respondents expressed this problem. "Awareness generation" was the solution suggested by 50.00 per cent of respondents.

Too short duration of training **-** A total of 20.74 per cent of the respondents expressed this problem. 11.85 per cent of respondents were suggested to "conduct long duration training programmes".

Less number of trainings conducted – A total of 42.59 per cent of the respondents expressed this problem. For this suggestion of "more number of trainings should be conducted" was suggested by 36.30 per cent of respondents.

Unavailability of raw materials **-** A total of 30.00 per cent of the respondents expressed this problem. To combat this problem 28.15 per cent of respondents suggested that inputs accessibility should be made within the village surroundings.

Poor family income **–** Less than one- fourth of respondents *i.e*. 19. 62 per cent expressed this problem.

Difficult to understand preservation points- More than one- third *i.e.* 34.44 of the respondents expressed this problem. To solve the problem “Detailed trainings should be conducted to interested members” was suggested by 25.56 per cent of respondents.

Marketing **–** Only 17.03 of the respondents expressed this problem. To solve the problem, 15.56 per cent of the respondents suggested to “Impart trainings on marketing skills”.

Spoilage of products- A total of 30.37 expressed this problem. To solve the problem, 28.89 of the respondents suggested that “Trainings should be conducted on improved shelf-life and packaging techniques of product”.

4. Tailoring & Embroidery

Difficulty in getting decorative materials **–**Only 19.25 per cent of the respondents have expressed the problem. “Inputs to be accessible within the village” was the solution proposed by 19.37 per cent of respondents.

Too short duration of training **–** A total of 40.27 per cent of respondents were reported the problem. “Adequate training duration should be planned” was the solution expressed by 37.78 per cent of respondents.

Finance availability **–** More than half *i.e.* 61.85 per cent of respondents have expressed this problem. To combat the problem, “Subsidy can be sanctioned through government schemes” was suggested by 56.30 per cent of respondents.

Dual responsibility **–** More than one-third of the respondents **(**35.93%) expressed the problem. “Family members have to share responsibilities” was the solution suggested by 34.07 per cent of respondents.

Too much professional Competition **–**For this the suggestion of “farming in groups” was proposed by 19.63 per cent of respondents.

Stitching quality cannot compete with market**-** Nearly half *i.e.* 42.96 per cent expressed this problem. “Advanced and professional training in stitching & embroidery” was expressed by 37.41 per cent of respondents.

Health problems**-** To combat the problem, 19.63 per cent of respondents suggested that “physical exercises, giving breaks with a time gap, balanced diet” might help in reducing the physical pain.

5. Seed Bag technology

Pocket size is small- A meager *i.e.* 18.59 per cent of respondents expressed this problem. “Increase in pocket size” was suggested by 17.78 per cent of respondents.

No much difference in timing**-** Only 7.40 percentage respondents have expressed this problem.

Less availability**-** The problem was expressed by 22.59 per cent of respondents. To solve the problem, “trainings should be conducted on seed bag stitching” was suggested by 20.00 per cent of respondents.

6. Vermi-compost technology

Lack of finance & subsidy- Majority *i.e.* 68.14 per cent of respondents expressed the problem. To solve the problem, “loan and subsidy from government” was suggested by 63.70 per cent of respondents.

No proper buy-back- Only 7.40 per cent of the respondents have expressed the problem. “Implementation of buy-back policy by the government” was the suggestion by 6.67 per cent of respondents.

Problem of Ants in summer**-**. It was expressed by 25.55 per cent of respondents. “Arranging water traps around the beds” was suggested by 22.59 per cent of respondents.

Less availability of seed worms**-** Nearly half of the respondents *i.e*. 42.22 per cent expressed this problem. “KVK can support for needed information” was suggested by 44.44 per cent of respondents.

Lack of Government encouragement – Only 21.48 per cent of respondents have reported this problem. “Promotion of vermicompost technology by the government” was suggested by 18.89 per cent of respondents.

Lack of credibility among other farmers – Only l8.14 per cent expressed the problem and 6.67 per cent of respondents have suggested “quality assurance of the compost should be given by concerned authority”.

7. Backyard poultry

The major problems faced in adoption of Backyard poultry technologies were- lack of finance to carry it on large scale (27.40%), no proper training for the respondents (65.92%) and diseases (40.00%).

Lack of finance**-** “Loans and subsidy from government” was suggested by 24.44 per cent of respondents.

No proper training**-** “Trainings should be conducted on this technology” was suggested by 58.52 per cent of respondents.

Diseases- “Vaccination should be provided in schedule time” was suggested by 37.41 per cent of respondents to the problem of diseases.

It can be concluded that the problems rural women were facing in adoption of the selected technologies of KVK are difficulty in processing of millets, in-adequate technical knowledge, short duration and insufficient course content in trainings, marketing of the product, etc. Rural women have expressed few solutions to overcome the problems *viz.,* Government should provide loans and subsidies in purchase of millets processing machinery, adequate training with sufficient duration, introduction of buy-back policy through line departments, improved marketing facilities, etc. KVK scientists and policy makers should pay a sincere attention to encourage the adoption of these women friendly livelihood technologies for improving their standard of living.

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