

Integrated weed management in maize

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Maize (Zea mays) is the second most important cereal crop in the world in terms of production. Because of having the highest genetic yield potential, this crop is known as queen of cereals. In India, it is the third most important food crop after rice and wheat. It is grown in ~ 9.26 million ha with production of ~23.67 MT and average productivity of ~2.57 t/ha compared to the world productivity of 4.94 t/ha. Maize is cultivated for grain, fodder, green cobs, sweet corn, baby corn and pop corn in peri-urban areas.

Key words: Biological, Chemical, Cultural, Herbicides, IWM, Maize, Weed management

THE predominant maize growing states that contribute more than 80% of total maize production are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1 %), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%), and Himachal Pradesh (4.4%). Being a rainy season crop, maize is heavily infested with weeds from time it is sown till harvesting. This is because the frequent rains encourage several flushes of weed, hot and humid

climate congenial for weed growth especially grasses, wider row spacing and increased use of fertilizers. Maize crop is sensitive to weed competition during early growth period due to slow growth during first 3-4 weeks. Critical period of weed competition is up to 40-45 DAS. Hence, managing weeds during this phase most critical for achieving the higher productivity. Maize yield was reduced by 25-60% due to weed infestation. Crop losses due to weed competition throughout the world as a whole, are

greater than those resulting from combined detrimental effect of insect-pests and diseases.

As maize has wide adaptability and compatibility under the diverse soil and climatic condition, hence it is considered as one of the potential drivers of crop diversification under different situations and is cultivated in sequence with different crops under various agro-ecologies of the country. Among different maize-based cropping systems in India, maize-wheat is the third most



Maize experimental plot treated with atrazine



Maize field without atrazine application (infested by *Trianthema portulacastrum*)

important cropping system after rice-wheat and rice-rice. Maize is being grown in an area of 8.55 million ha with an average productivity of ~2.5 t/ha, contributes to more than half of coarse cereal production of the country. In Bihar, total area under this crop is 6.98 lakh ha, producing ~21.11 million tonnes and with average productivity of ~3025 kg/ha. The area under *rabi* maize is gradually increasing in Bihar due to several factors such as growing market demand by feed and starch industry and increase in minimum support price (MSP) from ₹ 540/q in 2006-07 to ₹ 1,425/q in 2016-17 which led made it a more competitive crop and encouraged farmers to grow the maize to a larger extent. The contribution of this cropping system to total foodgrain production of the country is considerably large. The low productivity of maize in India compared to world productivity can be attributed to several limiting factors and all but the most important amongst these has been poor weed management, which poses a major threat to crop productivity. Weeds, being hardier in nature compete with maize plants for nutrients, water, sunlight and space during entire vegetative and early reproductive stages of maize, they transpire a lot of valuable conserved moisture and absorb large quantities of nutrients from the soil and their relative density plays a significant role in reducing maize yields. Also, wider

spacing and slow initial growth of maize favours weed growth even before crop emergence. The presence of weeds reduces photosynthetic efficiency, dry matter-production and distribution to economical parts and thereby reduces sink capacity of crop, resulting in poor grain yield. In agro-ecosystem, ideal environmental conditions provided for optimal crop productivity are being exploited by the associated weed. Thus, the proper weed management strategies would continue to play a key role to meet the demand of increasing population.

Dominant weed floral diversity in maize based cropping system

The predominant weed flora, *Cyperus rotundus*, *Digera arvensis*, *Commelina benghalensis*, *Euphorbia hirta*, *Parthenium hysterophorus* and *Cleome viscosa* were recorded in maize at Pusa, Bihar. *Commelina benghalensis*, *Ageratum conyzoides*, *Echinochloa colona*, *Panicum dichotomiflorum*, *Cyperus iria*, *Digitaria sanguinalis*, *Polygonum alatum* and *Aeschynomene indica* were dominant weeds noted at Palampur, Himachal Pradesh. Similarly, *Celosia argentea*, *Commelina benghalensis*, *Dactyloctenium aegyptium*, *Digera arvensis*, *Elusine indica*, *Echinochloa colona*, *Corchorus trilocularis*, *Leptochloa chinensis* and *Rumex acetosella* were dominant weed flora in maize in maize-wheat system at IARI, New Delhi

Integrated weed management in maize

Integrated weed management (IWM) has been defined as a multidisciplinary approach to manage the weeds, utilizing numerous alternative control measures. IWM involves a combination of cultural, mechanical, biological, and chemical methods for an effective and economical weed control that reduces weed interference with crop while maintaining acceptable crop yields. None of the individual control measures can provide satisfactory weed management. However, if different components of IWM are implemented in a systematic manner, significant advances in weed control technology can be achieved.

Approaches of weed management

- Preventive measures
- Curative measures

Preventive measures: In this method, weeds are prevented from its multiplication, and introduction. It consists of:

- Use of clean seed for avoiding the weed infestation to the maize crops
- Use of well decomposed FYM/compost to avoid the development of weed seed bank in the soil
- Keep irrigation and drainage channels clean or free from seeds
- Avoid use of sand or soil from weed infested area
- Avoid allowing cattle to move from weed infested areas to clean or cultivated areas
- Clean all farm implements properly after their use in infested areas and before use in clean areas
- Keep farm fences, roads and bunds clean or free from weeds.

Curative measures: These measures are followed to remove or to smother the weed growth and further multiplication. It includes the following approaches

Mechanical methods: These include following types

- Hand weeding
- Burning
- Flooding
- Tillage
- Earthing up and hoeing
- Smothering with non-living material/mulching.

Hand weeding or inter-row cultivation are the most widely

Major weed flora associated with maize

Scientific name	Common english name	Common hindi
Grassy weeds		
<i>Echinochloa colona</i>	Jungle Rice	Mordhan
<i>Eleusine indica</i>	Indian goosegrass	Jangali marua
<i>Cynodon dactylon</i>	Bermuda grass	Dub, hariyali
<i>Digitaria sanguinalis</i>	Crabgrass	Takri
Broad leaf weeds (BLWs)		
<i>Trianthema portulacastrum</i>	Horse purslane, carpet weed	Santhi, patharchatta
<i>Ageratum conyzoides</i>	Goat weed,	Jangli pudina
<i>Galinsoga parviflora</i>	Quick weed	<i>Galinsoga</i>
<i>Phyllanthus niruri</i>	Black catnip	Bhui
<i>Commelina benghalensis</i>	Tropical spiderwort	Kankaua
<i>Polygonum dichotomiflorum</i>	Fall panicgrass	Bijband, hunraj
<i>Aeschynomene indica</i>	Joint vetch	Didhen, chhuimui
Sedges		
<i>Cyperus rotundus</i>	Nut grass, Java grass	Motha
<i>Cyperus esculentus</i>	purple nutsedge	Motha
<i>Cyperus iria</i>	Umbrella sedge	Morphula, motha

followed methods of weed control in maize. But during rainy season, there are not many clear days and as a result, intercultural operations are delayed, due to which, weeds suppress maize and cause severe reduction in yield. Also with rising labour wages and non-availability of adequate labour at required times, it is becoming a serious problem to control weeds manually on larger area at proper time. Growing of legumes such as mungbean, groundnut, cowpea and soybean as intercrops in maize exert suppressing smother effect on weeds. Similarly narrow row spacing, use of higher seeding rate, early application of nitrogen and its placement near to plants help in increasing vigour of crop and exert smothering effect on weeds. Tillage operations in maize resulted in significant reduction in weed density and dry weight at all the stages of crop growth over no-tillage, which resulted in a significantly higher grain yield and net returns compared to no-tillage. This might have happened probably due to the fact that favourable soil conditions resulted in better crop growth and development and lesser crop-weed competition. Intercultural operations like mechanical weeding or two hand weeding at 20-30 and 35-45 days after sowing (DAS) effectively minimized weed population and increased maize yield. Hoeing at 15 DAS effectively controlled weed population, which was less than half (23-32 weeds/m²) compared with no intercultural operation (67-70 weeds/m²). Earthing up at 30 DAS effectively controlled diverse weed flora throughout cropping period. Sowing of maize with manual seed drill in maize-wheat system recorded significantly lower count of *Ageratum conyzoides* as compared to ZT and traditional method. Intercropping with cover/smother crop revealed that soybean intercropping+one mechanical weeding (20 DAS) had lowered weed dry weight and higher yield attributes of maize.

Cultural methods

It includes the following approaches:

- **Crop rotations:** It checks growth of

Recommended herbicides in maize for weed management

Herbicides	Dose (kg/ha)	Time of application	Weeds controlled	Remarks
Atrazine	0.75-1.0	Pre-emergence/ Early post-emergence	Broad-spectrum weed control. Some grasses are tolerant	For sole crop only. Does not control <i>Acrachne racemosa</i> , <i>Brachiaria reptans</i> and <i>Commelina benghalensis</i> suitable for intercropping
Alachlor	1.5-2.0	Pre-emergence	Effective control of grasses	Suitable for intercropping
Metolachlor	1.0-1.5	Pre-emergence	Effective control of grasses	Suitable for intercropping
2,4-D	0.50-0.75	Post-emergence	Effective against broad-leaved weeds	For sole crop only. Apply between 4-6 weeks after planting. Good as sequential application to pre-emergence herbicides
Paraquat	0.2-0.5	Post-emerg, directed spray	Broad spectrum weed	Effective against all weeds
Atrazine + pendimethalin	0.75+0.75	Pre-emergence	Broad spectrum weed	For sole crop only
Atrazine + alachlor	0.75+0.75	Pre-emergence	Broad spectrum weed	For sole crop only
Atrazine + metolachlor	0.75+0.50	Pre-emergence	Broad spectrum weed	For sole crop only

weed due to change of crop season and helps to eliminate the crop associated weeds.

- **Kind of crop:** Smother crop like soybean if planted as intercrop with maize significantly reduced the weed population by 30-35%.
- **Use of fertilizers:** Application of higher doses of fertilizers (150-60-40 kg NPK/ha) to crop will help to grow faster.
- **Planting time:** Sowing of crops at proper time i.e. second fortnight of June with optimum seed rate of 20 kg/ha will help crop to cover ground and will make weeds deprived of light.
- **Stale seed bed technique:** It involves removal of successive flushes of weeds before sowing maize. Weeds that germinate after land preparation are managed mechanically, manually or chemically. In mechanical/manual method, soil disturbance should be as shallow as possible.

Biological methods

It includes use of living organisms for suppressing or controlling weeds. Plants, animals or micro-organisms may be used for destruction of weeds. These are called as bio-agents, which feed on only weeds and not on

crop. Biological method is a costly method as lot of investment is required for screening of desirable predator. It is a method of control for limited number of weeds and not for mixed weed flora.

Chemical methods

This is very effective in certain cases and has a great scope provided the chemicals are low cost, efficient, easily available and comparatively safer to the environment. Chemicals used for weed control, which suppress/destroy weed growth are herbicide. These help in killing the weeds by inhibiting their growth. Herbicides which can prevent weed establishment during first 6 weeks vary.

Herbicide resistance

During the past few years, novel and successful strategies have been developed for engineering selective herbicide tolerance in plants by isolating, cloning bacterial or plant genes that detoxify specific herbicides and then transferring them to crops of choice by genetic transformation. The first use of herbicide-resistant crop was in 1994 with introduction of imidazolinone resistant maize hybrids and STS (Sulfonylurea

tolerant) soybean varieties. Resistant genes for several other herbicides or herbicide modes of action have been incorporated into the genetics of maize, cotton, canola, soybean and are now commercially available. These include glyphosate (Roundup Ready) resistant soybean and corn, glufosinate (Liberty Link) resistant maize and soybean, Bromoxynil (BXN) resistant cotton, imidazolinone (Clearfield) resistant canola and sethoxydim (post) resistant corn.

Weeds pose severe competition

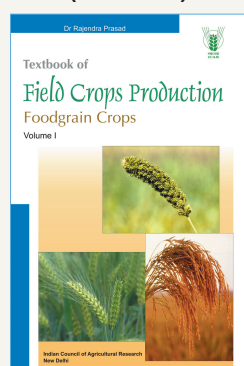
with maize for various growth resources. Besides reduction in grain yield, weeds also reduce quality of produce and act as alternate host for disease causing organisms and insect-pests. Hence, various weed management practices need to be integrated in an appropriate manner during critical period of crop-weed competition. Research on herbicide mixtures, post-emergence herbicides and weed competitive crop cultivars with acceptable yield potential, weed management in changing climate scenario and conservation agriculture,

effect of herbicides on soil microorganisms needs to be strengthened. Considering several advantages of using the herbicide resistant crops, it is worthwhile exploring their possible use under Indian conditions.

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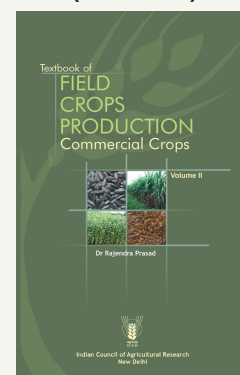
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