Diversity of Weed Flora, Weed Density and Crop Weed Competition in Maize

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Maize (zea mays l.) Is one of the most important crops among the cereals in the world agricultural economy both as food and fodder crop and is regarded as “queen of cereals”. Weeds can suppress crop growth and yield by effectively competing with crop for environmental resources like water, light, nutrients and production of allelopathic compounds. The weed flora differs widely with environment and soil conditions. Generally, weeds are found in larger numbers and with more vigour, because of their wider adaptability even under extremities of climatic, edaphic and biotic stresses. High persistence nature of weeds is attributed to their ability of high seed production and seed viability. Determination of the most critical period of crop-weed competition for nutrients, moisture, light and space is of greater importance to make weed management practices more effective and economical and thereby increasing crop yield.

Introduction

In Andhra Pradesh, rabi maize followed by greengram crop sequence is promising for reaping high returns by farmers but many reasons are responsible for the lower yields of maize. Among the several factors, the most dominant factor responsible for the lower yields of maize are weeds, which competes with crop for nutrients, water, sunlight and space.

Wide spacing, intensive use of inputs and initial slow growth of maize are some of the factors responsible for increased weed growth. Weeds can suppress crop growth and yield by effectively competing with crop for environmental resources like water, light, nutrients and production of allelopathic compounds. The extent of reduction in grain yield of maize has been reported to be in the range of 33 to 50 per cent depending on type of weed species in standing crop (Hawaldar
and Agasimani, 2012). At the earlier times, since no synthetic chemicals were known, weed control was achieved by some methods such as hand weeding, crop rotation, polyculture and other management practices that were low input but sustainable.

With the discovery of synthetic herbicides in the early 1930s, there was a shift in control methods towards high input and target-oriented ones. Now labour component in agriculture is becoming scarce, not available at time and cost prohibitive. Use of herbicides to manage weeds forms an excellent alternative to manual weeding. In India, till date only pre-emergence application of atrazine pendimethalin has been widely recommended for the control of weeds in maize.

There is a need of post-emergence herbicide usage for management of weeds which occur at 15-25 days of crop and offer severe competition for growth resources, thereby lowering the productivity of maize. Hence, it is proposed to test the new post emergence herbicides without residual effect in maize has greater field applicability. Effective fertilizer management is also an important component of integrated weed management systems (Blackshaw et al., 2007).

**Weed Flora**

The weed flora differs widely with environment and soil conditions. Generally, weeds are found in larger numbers and with more vigour, because of their wider adaptability even under extremities of climatic, edaphic and biotic stresses. High persistence nature of weeds is attributed to their ability of high seed production and seed viability. Kamble et al. (2005) reported that the major weed flora in maize field comprised of the broad leaf weeds *viz.*, *Digera arvensis*, *Celosia argentea*, *Euphorbia hirta*, *Lagasca mollis*, *Parthenium hysterocephorus* and the narrow leaf grassy weeds *viz.*, *Cynodon dactylon* and *Dinebra arabica*. Silvernail (2005) from Serbia (Europe) stated that in organically produced sweet maize the most dominant weeds were *Digitaria sanguinalis*, *Setaria faberi*, *Amaranthus hybridus*, *Panicum miliaceum* and *Ambrosia trifida*. Chalka and Nepalia (2005) from Udaipur, Rajasthan noticed that maize was infested with a mixed flora of weeds, chiefly consisting of *Echinochloa crusgalli*, *Echinochloa colonum*, *Portulaca oleracea*, *Commelina benghalensis*, *Digera arvensis*, *Triantema portulacastrum* and *Phyllanthus niruri*. Sharma and Gautam (2006) from Pantnagar (Uttarakhand) reported that *Cynodon dactylon*, *Cyperus rotundus*, *Echinochloa colonum*, *Echinochloa crusgalli*, *Agropyron repens*, *Parthenium hysterocephorus*, *Digitaria sanguinalis*, *Eclipta alba*, *Euphorbia hirta* and *Commelina benghalensis* were dominant weeds in maize.

In an experiment conducted at Annamalai University (Tamil Nadu) Selvakumar and Sundari (2006) observed that *Triantehma portulacastrum*, *Cyperus rotundus*, *Cynodon dactylon* and *Phyllanthus niruri* were predominant weeds in maize. Malviya and Singh (2007) from Faizabad, Uttar Pradesh noticed that maize was infested with a mixed flora of weeds chiefly consisting of *Cyperus rotundus*, *Cynodon dactylon*, *Eclipta alba*, *Solanum nigrum*, *Digera arvensis*, *Phyllanthus niruri*, *Echinochloa colonum* and *Commelina benghalensis*.

The weed flora consisting of *Cynodon dactylon*, *Cyperus rotundus*, *Triantehma portulacastrum*, *Phyllanthus niruri*, *Digera arvensis*, *Euphorbia hirta*, *Aristolochia bracteata*, *Commelina benghalensis*, *Sidag acuta* and *Cleome viscosa* were dominant in maize on clay loam soils of Bapatla (Vanaja, 2007). Muhammad et al. (2007) observed that the major weeds in fodder maize field at
Peshawar (Pakistan) were *Cyperus rotundus*, *Cynodon dactylon*, *Chenopodium album*, *Echinochloa crusgalli* and *Cucumis prophetarum*. Kumar (2008) indicated that the common weed species noticed in clay loam soils of Agricultural Research Station, Devihosur, Haveri district (Karnataka) during kharif,2007 were *Cynodon dactylon*, *Digitaria marginata*, *Dinebra retroflexa*, *Echinochloa colonum*, *Eleusine indica*, *Panicum spp* and *Setaria italica* among monocots; *Ageratum conyzoides*, *Amaranthus viridis*, *Acanthospermum hispidum*, *Alternanthera sessilis*, *Argemone mexicana*, *Commelina benghalensis*, *Cyperus iria*, *Brachiaria ramosa*, *Cynodon dactylon* and *Ipomoea purpurea* among grasses, sedges like *Cyperus iria* and *Cyperus rotundus*, broadleaved weeds like *Cleome viscosa*, *Borreria hispida*, *Amaranthus spinosus* and *Trianthema portulacastrum* were dominant in sweet corn in Tirupati (Sunitha et al. 2010).

Chopra and Angiras (2008) from Palampur (Himachal Pradesh) reported that *Digitaria sanguinalis*, *Echinochloa colonum*, *Panicum dichotomilorum*, *Commelina benghalensis*, *Cyperus iria*, *Brachiaria ramosa*, *Cynodon dactylon* and *Ipomoea purpurea* were dominant weeds in maize. Singh et al. (2009) declared that the major predominant weed species infesting rainfed maize in medium to deep black soils at Bijapur (Karnataka) were *Cyperus rotundus*, *Cynodon dactylon*, *Eclipta alba*, *Solanum nigrum*, *Digera arvensis*, *Phyllanthus niruri*, *Echinochloa colonum* and *Commelina benghalensis*.Mahadevaiah et al. (2010) from Tirupati (Andhra Pradesh) observed that *Cynodon dactylon*, *Digitaria sanguinalis* and *Dactyloctenium aegyptium* among grasses, *Cyperus rotundus* among sedges, *Commelina benghalensis* and *Trichodesma indicum* among broad leaved weeds as dominant weeds in baby corn.

In a study conducted by Srividya et al. (2011) reported that weed species namely *Cyperus rotundus*, *Phyllanthus niruri*, *Digera arvensis* and *Cynodon dactylon* were dominant in maize at Agricultural College, Bapatla. The weeds such as *Cynodon dactylon*, *Digitaria sanguinalis* and *Panicum repens* among grasses, sedges like *Cyperus iria* and *Cyperus rotundus*, broadleaved weeds like *Cleome viscosa*, *Borreria hispida*, *Amaranthus spinosus* and *Trianthema portulacastrum* were dominant in sweet corn in Tirupati (Sunitha et al. 2010).

Ahmed and Susheela (2012) indicated that the major weed flora associated with maize crop in the sandy loam soils in college farm, Rajendra Nagar, Hyderabad during kharif, 2010 consisted of three monocots viz., *Cynodon dactylon*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium* and eight dicots viz., *Parthenium hysterophorus*, *Commelina benghalensis*, *Amaranthus viridis*, *Euphorbia geniculata*, *Celosia argentea*, *Digera arvensis*, *Trichodesma indicum* and *Lagasca mollis*.

Ishrat et al. (2012) reported that the weed flora of the experimental site comprised of grasses, sedges and broad leaved weeds in maize. The important grassy weeds observed were *Cynodon dactylon*, *Dinebra retroflexa*, *Alt...
Echinochloa colonum and Eleusine indica. Cyperus rotundus was alone in sedge category. Among the broad leaved weeds, Parthenium hysterophorus, Commelina benghalensis, Portulaca oleracea, Cyanotis cucullata, Phyllanthus niruri and Amaranthus viridis were the dominant weeds. Muhammad et al. (2012) stated that the weed species infesting autumn planted maize field in Faisalabad was Trianthema portulacastrum, Cyperus rotundus, Coronopus didymus, Cynodon dactylon and Convolvulus arvensis. Aleem et al. (2012) conducted a field experiment at College of Agriculture, Rajendranagar, Hyderabad on sandy loam soils and reported that the major weed flora associated with maize crop in the experimental site consisted of four monocots viz., Cyperus rotundus, Cynodon dactylon, Digitaria sanguinalis, Dactyloctenium aegyptium and eight dicots viz., Parthenium hysterophorus, Commelina benghalensis, Amaranthus viridis, Euphorbia geniculata, Celosia argentea, Digera arvensis, Trichodesma indicum and Lagasca mollis.

The weed flora consisting of Cynodon dactylon, Echinochloa crusgalli, Cyperus rotundus, Trianthema portulacastrum, Phyllanthus niruri, Digera arvensis, Physalis minima, Euphorbia hirta, Aristolochia bracteata, Meremia everta, Commelina benghalensis, Sida acuta and Cleome viscosa were dominant in maize on clay loam soils of Bapatla (Praveena, 2013).

In a study conducted by Rama Devi (2013) weed species such as Cyperus rotundus among sedges, Trianthema portulacastrum, Cleome viscosa, Euphorbia hirta, Phyllanthus niruri and Digera arvensis among the dicots and Cynodon dactylon among grasses were reported in baby corn on sandy clay loam soils of Bapatla. Sakthivel et al. (2014) noticed Trianthema portulacastrum, Digera arvensis, Cleome gynandra, Parthenium hysterophorus, Datura metal, Dactyloctenium aegyptium, Setaria verticillata and Cyperus rotundus were the major weed species in maize on sandy loam soils of Tamil Nadu Agricultural University, Coimbatore.

Madhavi et al. (2014) observed that the experimental field comprised of Cyperus rotundus among sedges, Digitaria spp, Dactyloctenium aegyptium, Dinebra arabica, Cynodon dactylon and Eleusine indica among grasses, Parthenium hysterophorus, Melilotus alba, Trianthema portulacastrum, Euphorbia geniculata, Commelina spp, Tridax procumbens and Amaranthus viridis among broad leaved weeds in maize crop.

Anil kumar et al. (2015) indicated that the most important weeds that can be associated with maize/maize-based cropping systems in the country are Echinochloa colonum, Brachiaria ramosa, Digitaria sanguinalis, Dactyloctenium aegyptium, Eleusine indica, Setaria glauca, Sorghum halepense, Panicum spp, Cynodon dactylon, Digitaria setigera, Digitaria ciliaris, and Leptochloa chinensis among grasses; Ageratum conyzoides, Galinsoga parviflora, Commelina benghalensis, Undernia ciliata, Polygonum hydropiper, Euphorbia geniculata, Oxalis latifolia, Celosia argentea, Cleome viscosa, Sida acuta, Aschynomene indica, Acanthospermum hispidum, Portulaca oleracea, Phyllanthus niruri, Amaranthus viridis, Acalypha indica, Tridax procumbens, Ipomoea pestigridis, Parthenium hysterophorus and Euphorbia hirta among non-grassy weeds and Cyperus rotundus and Cyperus iria among sedges.

Mukherjee and Rai (2015) reported that major weed flora were Polygonum persicaria, P. pensylvanicum, P. orientale, Oldenlandia diffusa, Oldenlandia aquatica, Oxalis corniculata, Stellaria media, Stellaria aquatic, Physalis minima, Solanum nigrum, Hydrocotyl
ranunculoides, Ageratum conyzoides (appeared at latter part of crop growth), the sedge like Cyperus rotundus and the grasses like Cynodon dactylon, Digitaria ciliaris, Setaria glauca, Echinochloa spp. in maize.

Singh et al. (2015) recorded dominant weeds in the maize field were Medicago denticulata, Avena ludoviciana, Phalaris minor and Chenopodium album. Barad et al. (2016) revealed that the weed flora in the experimental site at Junagadh constituted by monocot weeds viz., Brachiaria spp. (17.67%), Asphodelus tenuifolius L. Cav. (1.79%), Indigofera glandulosa L. (1.40%), Echinochloa colona L. (1.23%)and Dactyloctenium aegyptium Beauv (4.79%), dicotweeds viz., Digera arvensis Forsk (19.21%), Amaranthus viridis L. (2.28%), Physalis minima L(2.77%), Launaea nudicaulis L. (1.79%), Euphorbiahirta L. (7.77%), Chenopodium album L. (19.70%), Portulaca oleracea L. (3.52%) and Phyllanthus niruri (2.02%) and sedge weed Cyperus rotundus L. (21.29%).

**Critical Period of Crop-Weed Competition**

Determination of the most critical period of crop-weed competition for nutrients, moisture, light and space is of greater importance to make weed management practices more effective and economical and thereby increasing crop yield. Nayital et al. (1989) observed that critical period of crop weed competition in maize was from 20-60 DAS on sandy loamy soils of Bajaura (Kullu). The critical period of competition by weeds coincided with early stages of the crop i.e. 15 to 45 DAS on clay loam soils of Tamil Nadu (Tyagi et al. 1993; Suresh Kumar and Sundari, 2002). The weedy environment beyond 30 days and up to 45days after sowing was detrimental to maize growth and causes yield loss (Porwal, 2000).Ghanizadeh et al. (2009) from Sushtar, Iran stated that critical period for weed control in maize was from 5-9 leaf stage (17-36 DAS). Anil kumar et al. (2015) reported that the emergence of maize and weeds was simultaneous and the first 20-60 days was the most critical period of competition for the crop. However, in winter maize the period beyond 30 days and up to 45 days after sowing was detrimental to maize growth. Experiments conducted at various locations indicated that the most critical period of crop weed competition in maize ranged from 3to 6 weeks after sowing (Varshney, 1990; Sharma and Nayital, 1993; Shad et al. 1993; Ghosheh et al. 1996; Dogan et al. 2004; Nagalakshmi et al. 2006 and Barad et al. 2016).

**Yield Losses**

In situations ideal or otherwise for crop and weed growth, weeds always thrive well. Increase in weed population has a direct effect on reduction in crop yield. The reduction of corn yield by weed competition has been reported by many workers. Season long infestation of composite weed flora in maize field reduced the grain yield by 28-100% (Angiras and Singh, 1989 and Pande et al. 2001) at various maize growing locations Palampur and Almora, respectively. Presence of Amaranthus retroflexus in corn field reduced maize grain yield by 7, 20 and 32 per cent in the presence of 5, 10, and 20 weed plants per m² (Rola and Rola, 1992).

Sharma and Nayital (1993) found that yield loss in maize due to unchecked weed growth was 61.3% as compared to weed free check on sandy loam soils of Bajaura (Kullu). Santos et al. (1993), reported that in silty clay loam texture soils at Sonning (UK), maize grain yield loss ranged from 40 to 80 per cent if weeds were uncontrolled. According to Vargessel et al. (1994) the weed distribution in the corn field was not a critical consideration in determining yield loss. Maize
grown in the presence of weeds viz. *Amaranthus palmeri*, *Eriagrostis diffusa*, *Bidens odorata*, *Brassica campestris* for the whole cycle of the crop showed an 86 to 90 per cent reduction in grain yield (Amador, 1995).

Ferro et al. (1996) opined that depression effect of weeds on grain yield of maize was strongly related with weed dry weight and weed cover, respectively. Virendar (1997) observed that weeds found a serious negative factor in crop production and resulted loss in crop yield by 10 to 15 per cent or more. More over germination and vigour of maize seeds decreased with an increase in weed density (Saayman et al. 1997). Sen et al. (2000) reported that, due to weed competition, yield losses occur up to 15 to 75 per cent in maize crop. The loss in grain yield due to unchecked weed growth was to the extent of 32.4 to 42.3 per cent (Sharma et al. 2000) at PAU, Ludhiana.

Pandey et al. (2002) reported that grassy weeds offered maximum competition to crop reducing grain yield by 77.4 per cent followed by non-grassy weeds of about 44.2 per cent and sedges 38.4 per cent. In an experiment conducted by Walia et al. (2005) at Punjab Agricultural University, Ludhiana the yield loss recorded due to unchecked weed growth was up to 56% in rainfed maize on sandy loam soils.

Maize being a rainy season and widely spaced crop gets infested with variety of weeds and subjected to heavy weed competition, which often inflicts huge losses ranging from 28 to 100 per cent in maize (Patel et al., 2006a).

Malviya and Singh (2007) reported that season long weed competition reduced the grain yield of maize by 70.24% compared with the weed free conditions on salty loams of Uttar Pradesh and also stated that 41% yield loss due to unchecked weed growth in zero tillage maize on clay loam soils. In an experiment conducted at Tirupati, Sunitha et al. (2010) observed that yield loss due to uncontrolled weed growth in sweet corn was to an extent of 40-42% on sandy loam soils. Patil et al. (2014) at TCA farm, Dholi, found that yield loss due to unchecked weed growth was up to 58% in rabi maize.

Anil kumar et al. (2015) revealed that In India, presence of weeds reduced the maize yields by 27-60%, depending upon the growth and persistence of weed population.

**Weed Density and Dry Weight**

Pre-emergence application of atrazine @ 0.5 kg a.i ha$^{-1}$ followed by intercultivation at 35 DAS resulted in the lowest weed dry weight on clay loam soils of Udaipur (Mundra et al., 2002). Anil Kumar and Thakur (2004) from Himachal Pradesh recorded the lowest weed dry weight accumulation with pre-emergence application of alachlor @ 1.5 kg a.i ha$^{-1}$ supplemented with hand weeding at 20 DAS than with application of herbicide alone. Pre-emergence application of atrazine @ 0.5 kg a.i ha$^{-1}$ followed by one hoeing at 20 DAS resulted in the lowest weed dry weight on clay loam soils of Yavatmal in kharif maize (Kamble et al.2005).

Tripathi et al. (2005) reported that atrazine @ 0.5 kg a.i ha$^{-1}$ could provide effective control of weeds when it was supplemented with one hand weeding at 20 DAS in maize on sandy loam soils at Kanpur. Nagalakshmi et al. (2006) obtained the lowest weed density and dry matter with two hand weedings at 21 and 42 DAS in maize on clay loam soils at Agricultural college, Bapatla. Patel et al. (2006a) from Anand (Gujarat) reported the lowest weed density and dry matter with hand weeding at 20 and 40 DAS on sandy loam soils.
Hussein et al. (2008) observed that plant spacing affected dry weight of weeds growing with maize. Biomass of weed species was decreased, in most cases, under narrow plant spacing. Weeds were controlled by all treatments compared with the nontreated check; however, herbicide treatments were not superior to hand hoeing treatments. Application of the three weed control treatments resulted in less weed biomass and greater maize yield in narrow- compared to wide-spacing maize.

According to Demjanova et al. (2009) only 2.6 perennial weed plants per quadrant in conventional tillage as compared to 7.5–9.0 in reduced tillage treatments were noted. Tillage system was more influential than crop rotations on the weed density and diversity and weed biomass. Srividya et al. (2011) stated that application of either atrazine @ 1.25 kg a.i ha$^{-1}$ or pendimethalin @ 1.5 kg a.i ha$^{-1}$ in combination with directed spray of paraquat @ 0.6 kg a.i ha$^{-1}$ in between rows at 3 WAS recorded significantly lower weed density and dry matter comparable with that of two hand weedings and intercultivation with power weeder at 4 WAS on clay loam soils of Bapatla.

Pre-emergence application of atrazine @ 1.0 kg a.i ha$^{-1}$ followed by hand weeding at 40 DAS resulted in the lowest weed dry weight in sweet corn on heavy black soils of Navasari Agricultural University, Navasari (Arvadiya et al., 2012).

Sandhya Rani and Karuna Sagar (2013) reported the lowest weed density and dry weight with two hand weedings at 20 and 40 DAS in maize on sandy loam soils at Tirupati.

At crop research centre, RAU (Pusa) Ranjana Kumari et al. (2014) recorded the lowest weed density and dry weight accumulation with preemergence application of atrazine @ 1.0 kg a.i ha$^{-1}$ followed by working with power weeder at 45 DAS in summer maize.

Amandeep et al. (2014) noticed significantly lower weed dry matter with pre-emergence tank mix application of atrazine 0.75 kg a.i ha$^{-1}$ + pendimethalin 0.75 kg a.i ha$^{-1}$ at University Seed Farm, Nabha (Punjab). Deshmukh et al. (2014) observed that atrazine @ 1.0 kg a.i ha$^{-1}$ followed by mechanical or hand weeding at 30 DAS proved better in controlling weed density and dry matter in kharif maize at Punjabrao Deshmukh Krishi Vidyapeeth, Akola. In another experiment pre-emergence application of atrazine @ 0.75 kg a.i ha$^{-1}$ followed by 2, 4-D @ 0.5 kg a.i ha$^{-1}$ recorded the lowest weed density and it was on par with hand weeding at 20 and 40 DAS in maize on clay soils at Akola, Maharashtra (Sonawane et al. 2014).

Sanjay Kumar Patel et al. (2015) evaluated productivity of kharif maize (Zea mays L.) under legumes intercropping system and its effect on weeds. Intercropping of maize with cowpea, soybean, blackgram or greengram, effectively reduced the population and dry weight of weeds as compared to sole crop of maize.

All legumes intercropping in maize significantly increased maize equivalent yield as compared to sole maize. Metolachlor was found significantly reducing weed population and dry weight which was statistically at par with hand weeding and alachlor and gave the significantly the highest maize equivalent yield.

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