Indian Journal of Weed Science **48**(4): 390–393, 2016
DOI: 10.5958/0974-8164.2016.00102.7

Management of complex weed flora in maize with post-emergence herbicides

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Received: 3 November 2016; Revised: 11 December 2016

ABSTRACT

Some weed species are not controlled by atrazine where the farmers are using this herbicide year after year and different flushes of weeds in rainy season are among the major problems in maize growing areas of India. A field experiment was conducted during the crop growing seasons of 2012 and 2013 at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana to evaluate the efficacy of glyphosate 41% SL against complex weed flora in maize. The treatments included glyphosate 41% SL 900, 1800 and 3600 g/ha applied as post-emergence at 2-4 leaf stage of weeds, atrazine 750 g/ha as pre-emergence, paraquat 24 SL 500 g/ha as post-emergence at 2-4 leaf stage of weeds, 2,4-D sodium salt 1000 g/ha as post-emergence at 2-4 leaf stage of weeds, weed free and unweeded control. The results revealed that non-selective herbicides paraquat at 500 g/ha and glyphosate at 900 and 1800 g/ha as a directed spray in maize as post-emergence at 2-4 leaf stage of weeds recorded effective control of grass and broad-leaf weeds during both the years and recorded grain yield at par with atrazine.

Key words: Glyphosate, Grain yield, Herbicides, Maize, Post-emergence, Weed flora, Weeds

Maize (*Zea mays* L.) is an important cereal crop of *Kharif* season in Punjab and it ranks third on the basis of area and production amongst cereals after wheat and rice. In Punjab, maize was grown on an area of 130 thousand hectares with average productivity of 3898 kg/ha during 2013-14 (Anonymous 2015). Some hardy weeds like *Bracharia reptans, Acrachne racemosa, Commelina benghalensis etc*. posing serious problems and are not controlled by atrazine. Worldwide maize production is reduced to about 40% due to competition from weeds, which are the most important pest groups (Oerke and Dehn 2004). Use of atrazine as pre-emergence is the biggest tool in the hands of farmers as it provides good control of weeds during initial stages of crop-weed competition. But some weeds start emerging afterwards and attain good growth due to frequent incessant rains. Some post-emergence herbicide is therefore, required to check the complex weed flora and late emerging weeds.

Directed post-emergence herbicide sprays are a possible alternative for mid- to late-season weeds and have been used in various crops (Borland 1973, Richards 1977). This practice usually involves relatively non-selective herbicides sprayed at the base of the crop and is aimed at controlling existing weeds and often provides residual control of further weed flushes. These herbicides should be used with care to avoid drift losses to main crop.

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Glyphosate and paraquat are the most commonly and widely used herbicides on the wastelands, uncropped situations *etc*. Gylphosate is mainly used by the farmers in non–agricultural or wastelands in India. It is mostly used before sowing of the crop or with specialized application equipment (hood) to avoid contact with the crop or other desirable vegetation. Glyphosate provides a viable, flexible and profitable alternative to conventional weed control programmes. The widespread use of glyphosate is due to its very broad weed spectrum and high efficacy. It is a nonselective, systemic (or translocated) post-emergence herbicide. Being nonselective, it is a broad-spectrum herbicide capable of killing grasses, sedges and broad-leaved weeds. Although paraquat is also a non-selective, broad spectrum herbicide, it does not move through plants systemically like glyphosate. So, non-selective herbicides can be used in maize for inter-row weed control to remove weeds growing between the crop rows. Shield/hood sprayers are commonly used for precision, directed-spray applications of non selective herbicides. Keeping in view the above points, the experiment was planned to evaluate the bio-efficacy of glyphosate 41% SL against mixed weed flora in maize, to find out effect of different doses of herbicide on growth and grain yield of maize.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* 2012 and 2013 at Research Farm, Department of

Agronomy, Punjab Agricultural University, Ludhiana, India. The experimental site was situated at 30° 542 N latitude and 75° 482 E longitude with an altitude of 247 metre above mean sea level in the central plain region of Punjab state under Trans-Gangetic agro-climatic zone of India. The climate of this region is sub-tropical and semi-arid with very hot and dry summer from April to June, hot and humid conditions from July to September, cold winters from November to January and mild climate during February and March. The soil of the experimental area was sandy loam with available N, P and K of 191.2, 14.6 and 159.1 kg/ha, respectively. The seedbed was prepared by one ploughing with disc harrow followed by two ploughings with cultivator and each ploughing was followed by planking. The experiment was laid out with a plot size 7.0 x 4.0 m and row to row distance of 60 cm and plant to plant distance of 20 cm. Maize was sown on 13.7.2012 and 2.7.2013. Variety '*PMH 1*' was sown during both years using 20 kg seed/ha in a randomized complete block design replicated four times. The seed was treated with a fungicide agrozim 50 WP carbendazim at 3 g/kg seed. The crop was fertilized with 125 kg N, 60 kg P_2O_5 and 30 kg K_2O/ha. The nitrogen was applied in the form of urea (46% N), P_2O_5 in form of single super phosphate (16% P_2O_5) and K_2O in form of muriate of potash (60% K_2O). One-third of nitrogen and the entire quantity of phosphorus and potassium was drilled at the time of sowing. Remaining one-third of nitrogen was top-dressed at the knee-high stage and the remaining one-third at the pre-tasseling stage. The treatments included glyphosate 41% SL at 900, 1800 and 3600 g/ha applied as post-emergence at 2-4 leaf stage of weeds, atrazine at 750 g/ha as pre-emergence, paraquat 24 SL at 500 g/ha as post-emergence at 2-4 leaf stage of weeds, 2,4-D sodium salt at 1000 g/ha as post-emergence at 2-4 leaf stage of weeds, weed free and unweeded control. Glyphosate and paraquat were applied as directed spray by hood.

The crop was harvested on 23.10.2012 and 19.10.2013. The data on maize grain yield was recorded at the time of crop harvest from the centre rows of each plot. The cobs were shelled, dried and weighed. At each harvest, weeds were clipped at the soil surface, sorted by species, counted, and dried at 70°C to constant moisture content to obtain a measure of aboveground dry matter accumulation. The weed density and dry matter was taken with a quadrate measuring 0.5 x 0.5 m randomly from two spots per plot at 30 days after treatment. The data on weed count and weed dry matter were subjected to square root transformation $(\sqrt{x+1})$ before statistical analysis. All data were analyzed statistically using CPCS1 software.

RESULTS AND DISCUSSION

The experimental field had enough population of *Acrachne racemosa, Dactyloctenium aegyptiacum, Commelina benghalensis, Eragrostis tenella, Digitaria sanguinalis, Echinochloa colona, Trianthema portulacastrum, Phyllanthus niruri, Euphorbia hirta, Euphorbia microphylla, Digera arvensis, Amaranthus viridis, Cyperus rotundus, Cyperus compressus etc*.

Phytotoxicity on the crop was recorded on 0-10 scale which indicated that glyphosate was safe to maize crop when applied at 3600 g/ha during both the years (data not shown).

During 2012, weed density was at par with atrazine when glyphosate was applied at 900 g/ha. *D. aegyptiacum* was effectively controlled by glyphosate at 900 and 1800 g/ha at par with atrazine and paraquat. Glyphosate at 1800 g/ha were at par with paraquat for the control of *C. benghalensis*. 2,4-D sodium salt, being broad-leaf weed killer did not show its phytotoxic effect on any of the grass weed species. Dry matter of grass weeds was significantly less in glyphosate 900 g/ha as compared to atrazine. The dry matter of weeds was significantly decreased as the dose of glyphosate increased (Table 1). With the increase in dose of glyphosate, density of *T. portulacastrum* also decreased considerably. 2, 4-D sodium salt also effectively controlled this weed. Similar trend in weed dry matter was recorded during both the years.

During *Kharif* 2013, all doses of glyphosate recorded similar control of *D. aegyptiacum* and at par with atrazine and paraquat. Similar was the trend for *A. racemosa* except paraquat where the population was significantly more. *C. benghalensis* was effectively controlled by atrazine, glyphosate and paraquat. Significantly less dry matter of grasses was recorded at higher doses of glyphosate than at 900 g/ ha, atrazine and paraquat. Similarly in case of broad-leaf weeds, higher dose of glyphosate recorded significantly less dry matter than its lower dose. 2,4-D sodium salt recorded significantly more dry matter of grass weeds than all herbicides (Table 2).

The maize grain yield was at par where glyphosate was applied at 900 and 1800 g/ha. Paraquat also recorded significantly more grain yield than 2,4-D. As 2,4-D only killed the broad-leaf weeds and the grass weeds pose full competition to the crop

which ultimately resulted into reduction in grain yield. During 2013, all the herbicide treatments yielded at par with each other and attained significantly more grain yield than 2,4-D due to kill of only broad-leaf weeds. Weeds significantly reduced grain yield in unsprayed control. The weed free treatment recorded significantly higher maize grain yield than all the herbicidal treatments during both the years. Glyphosate at all the doses recorded significantly lower grain yield than atrazine during 2012 while during 2013, the grain yield with glyphosate at all the levels was at par to atrazine.

Paraquat 500 g/ha recorded grain yield similar to atrazine during 2013 but lower than atrazine during 2012 (Table 3). Paraquat and glyphosate both being non-selective in nature, kill weed flora and provided weed free environment for good time and by then the maize crop attained so much growth, that it is not affecting its yield. Atrazine provided good control of weeds during earlier stages and contributed towards attaining good yield. The only advantage of using non-selective herbicides was that the farmers have the option to use some post-emergence herbicide in maize as a directed spray. So farmers have the option to use non-selective herbicide, *viz.* paraquat at 500 g/ ha and glyphosate at 900 and 1800 g/ha as a directed spray in maize in case the need for weed control arises in maize.

These results corroborate with the findings of Larbi *et al.* (2013) where maize showed differential response in terms of yield to the application of the herbicides while better yields were observed on glyphosate and gramoxone treated plots. Maize which was sprayed at later stages lost some lower leaves but this did not affect grain production or did not consistently affect other maize attributes (Thomas 1986)

Regression analysis indicated that there was significant negative linear relationship between grain yield and weed biomass at 60 DAS. In regression analysis, the equations $Y = -0.0036x + 4.4482$ (Fig. 1) and $Y = -0.0027x + 4.7356$ (Fig. 2) were found to be fit for the maize grain yield and dry matter of weeds where Y is grain yield and X is weed dry matter. Correlation between grain yield and weed dry matter at 60 DAS was $R^2 = 0.8302$ (Fig. 1) and $R^2 = 0.8218$ (Fig. 2). It indicated a high degree of negative correlation between weed dry matter and grain yield during both the years. Results indicated that that as the weed dry matter increased, the grain yield of maize was decreased.

Table 1. Effect of different herbicide treatments on weed density and dry matter at 60 days after sowing on maize during *Kharif* 2012

Treatment	Dose (g/ha)	Weed density (no./m^2)				Weed dry matter (g/m^2)			WCE (%)
		A. racemosa	*D. aegyptiacum*	*C. benghalensis*	*T. portulacastrum*	Grasses	BLW	Total	
Atrazine	750	3.0 (8)	2.1 (4)	4.1 (16)	1.3 (0.7)	8.0 (64)	6.3 (39)	10.4 (107)	75.7
Glyphosate	900	2.8 (7)	2.2 (4)	2.9 (7)	1.9 (3)	7.6 (57)	6.2 (37)	10.7 (114)	74.1
Glyphosate	1800	2.4 (5)	2.0 (3)	2.5(5)	1.5 (1)	7.4 (53)	5.9(34)	10.7 (114)	74.1
Paraquat	500	2.4 (5)	2.0 (3)	2.3 (4)	1.8 (2)	7.4(54)	5.9 (34)	10.8 (116)	73.7
2,4-D sodium salt	1000	3.8 (13)	3.2 (9)	4.3 (18)	1.5 (1)	12.5(155)	5.6(30)	13.2 (173)	60.8
Weed free	-	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	100
Unweeded control	-	4.0 (15)	3.4 (11)	4.4 (19)	3.7 (13)	12.3 (150)	11.4 (128)	21.0 (441)	-
LSD (P=0.05)	-	0.3	0.3	0.4	0.3	0.2	0.3	0.3	-

* Figures within brackets are original means, subjected to square root; transformation; BLW - Broad-leaf weeds

Table 2. Effect of different herbicide treatments on weed density and dry matter at 60 days after sowing in maize during *Kharif* 2013

Treatment	Dose (g/ha)	Weed density (no./m^2)					Weed dry matter (g/m^2)			WCE (%)
		A. racemosa	*D. egyptiacum*	*C. benghalensis*	*D. sanguinalis*	*T. Portulacastrum*	Grasses	BLW	Total	
Atrazine	750	1.9 (3)	2.4 (5)	1.7 (2)	1.7 (2)	2.6 (6)	9.7 (93)	9.1 (82)	10.4 (107)	79.3
Glyphosate	900	1.9 (3)	2.6 (6)	2.4 (5)	1.8 (2)	2.6 (6)	10.1(101)	7.5 (55)	10.5 (108)	79.2
Glyphosate	1800	1.9 (3)	2.3 (4)	2.1 (3)	1.6 (2)	2.4 (5)	9.4 (87)	6.7 (44)	10.4 (107)	79.3
Paraquat	500	3.0 (8)	2.8 (7)	2.1 (3)	2.2 (4)	2.2 (4)	10.4 (107)	7.0 (48)	10. 9 (118)	77.2
2,4-D sodium salt	1000	6.1 (36)	3.3 (11)	3.4 (11)	3.5 (11)	2.0 (3)	15.3 (233)	7.3 (53)	15.4 (235)	54.6
Weed free	-	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	100
Unweeded control	-	6.0 (35)	4.0 (15)	3.5 (11)	3.5 (11)	5.1 (25)	16.6 (275)	9.9 (97)	22.8 (518)	-
LSD (P=0.05)	-	0.7	0.3	0.4	0.5	0.4	0.3	0.3	0.3	-

*Figures within brackets are original means, subjected to square root transformation; BLW - Broadleaf weeds

Table 3. Effect of different herbicide treatments on growth and yield of maize during *Kharif* 2012 and 2013

Treatment	Dose (g/ha)	Plant height (cm)		Cob length (cm)		Cob weight (g)		Grain yield (t/ha)	
		2012	2013	2012	2013	2012	2013	2012	2013
Atrazine	750	230.5	242.6	21.3	22.1	19.6	21.3	4.39	4.40
Glyphosate	900	229.5	240.7	20.7	22.3	20.3	20.3	4.01	4.36
Glyphosate	1800	215.7	242.6	20.7	22.1	20.4	20.5	4.04	4.36
Paraquat	500	222.3	238.6	20.4	21.7	18.4	18.3	3.99	4.23
2,4-D sodium salt	1000	235.7	236.9	19.4	19.8	17.2	17.9	3.61	3.92
Weed free	-	238.5	245.1	21.9	22.9	22.4	24.8	4.56	5.14
Unweeded control	-	217.9	222.4	17.6	18.8	11.4	14.9	2.91	3.49
LSD (P=0.05)	-	10.0	5.8	0.4	0.5	0.9	1.0	0.2	0.31

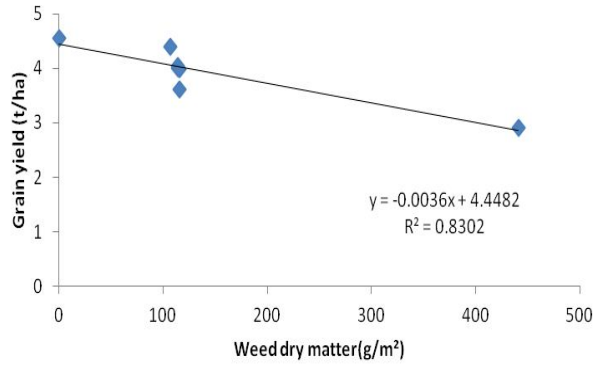

Fig. 1. Correlation and regression analysis of weed dry matter and grain yield of maize (*Kharif* 2012)

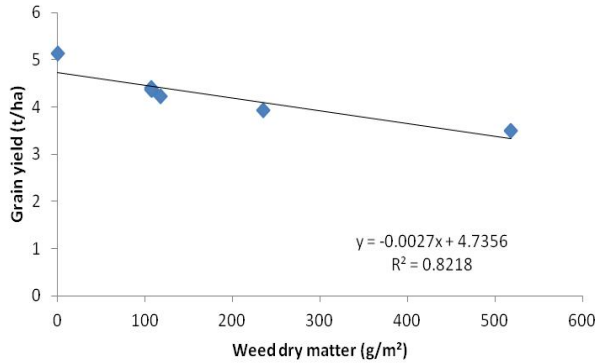

Fig. 2. Correlation and regression analysis of weed dry matter and grain yield of maize (*Kharif* 2013)

Under heavy weed infestation, post-emergence application of paraquat if field is infested with annual weeds can also be done as protected spray using hood. Glyphosate at 900 and 1800 g/ha recorded effective control of grass and broad-leaf weeds during both the years and recorded grain yield at par with atrazine. Thus, the glyphosate at the above doses was safe for use as directed spray maize along with the hood.

Non-selective herbicides paraquat at 500 g/ha and glyphosate at 900 and 1800 g/ha as a directed spray in maize can be used as post-emergence at 2-4 leaf stage of weeds for the control of complex weed flora in maize.

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