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Short Communications

Bio-efficacy of herbicides against weed flora in hybrid maize (*Zea mays*)

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Maize (*Zea mays* L.) is considered as a miracle crop due to its high yield potential, adaptability and versatile uses like human consumptions, livestock and poultry feed, for oil extraction etc. In India, maize is grown on an area of 9.43 M ha with an annual production 24.26 mt and productivity of 2583 kg/ha. In Odisha, maize is cultivated an area of 2.81 lakh ha with the average productivity of 2407 kg/ha. Being a crop of rainy season, maize suffers from severe weed competition which causes huge yield reduction in the tune of 28-100% (Patel *et al.* 2006).Weeds emerge fast, grow rapidly and competing with the crop plants severely for growth factors during crop ontogeny. Further in widely spaced maize, presence of weeds reduces the photosynthetic efficiency, dry matter production and distribution of photosynthates to the economical parts of maize which resulted in poor grain yield. Now-a-day' smanual weed management becomes very tedious and time consuming, requires higher energy and economic investment which makes manual weeding an uneconomic option for weed management. Furthermore, labour availability is also a great hurdle in timely execution of weed management strategies. Farmers seldom use pre-emergence herbicides as recommended by weed researchers. Even though early weed control measures are not sufficient because weeds germinate in flushes and also continues after critical period of crop-weed competition.The single application of an herbicide as pre-emergence or post-emergence is unable to bring down weed population below the economic threshold level. To control the weeds for wider window during active growing periods, combined use of pre-emergence and post emergence herbicides is advocated for economic weed control in hybrid maize during the *kharif*.

Therefore, keeping the above facts in view, the present study was conducted to find out the economical and suitable pre and post-emergence herbicide (s) for proper weed management in hybrid maize.

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A field experiment was conducted during *kharif* 2015 at Agronomic Main Research Farm, Orissa University Agriculture & Technology, Bhubaneswar at an altitude 25.9 m above mean sea level. The meteorological data of weather parameters, viz. rainfall, number of rainy days and temperature were recorded during the experimentation. The highest amount of rainfall 223.5 mm and number of rainy days 18 were recorded in month of July, while the maximum temperature 33.0 ^{0}C in August. The soil of the experimental plot was sandy loam in texture, acidic in reaction (pH 4.7), medium in organic carbon (0.59%) and low in available nitrogen (224.0 kg/ha), medium in phosphorus (21.9 kg/ha) and low in potassium (156.7 kg/ha). Ten treatments combinations, viz. T_1 (Atrazine 1.0 kg/ha as PE at 1 DAS) , T_2 (Oxyfluorfen 0.03 kg/ha as PE at 1 DAS), T_3 (Pendimethalin 1.0 kg/ha as PE at 1 DAS), T_4 (Atrazine 0.5 kg/ha + Oxyfluorfen 0.03 kg/ha as PE at 1 DAS), T_5 (Pendimethalin 1.0 kg/ha + Oxyfluorfen 0.03 kg/ha as PE at 1 DAS), T_6 (Halosulfuron 0.06 kg/ha as POE at 25 DAS), T_7 (Pendimethalin 1.0 kg/ha as PE at 1 DAS followed by Halosulfuron 0.06 kg/ha as POE at 25 DAS), T_8 (Oxyfluorfen 0.03 kg/ha followed by Halosulfuron 0.06 kg/ha as POE at 25 DAS), T_9 (farmers practice as two hand hoeing/weeding) and T_{10} (un-weeded control) were tested in three time replicated randomized block design (RBD). Maize hybrid (P504) was sown using seed rate 15 kg/ha during second week of July with a spacing of 60 cm × 30 cm. Herbicides were applied as per treatments with the help of knapsack sprayer. The crop was fertilized with 120:60:60 kg N, P_2O_5, K_2O/ha respectively. Recommended agronomic management practices were followed to raise the crop.The maize crop was harvested in second week of October 2015. The standard methodology was followed for recording data on weeds and crops. Data regarding narrow leaf weeds (NLW) and broad leaf weeds (BLW) were recorded at 40, 60 and 80 days after sowing (DAS). The data on yield attributes were recorded at time of harvesting. Subjected data were analyzed statistically as per randomized block design analysis as suggested by Panse and Sukhatme (1985).

Data subjected to the populations of narrow leaf weed (NLW), broad leaf weed (BLW) and weed control efficiency (WCE) are presented in Table 1. In general, weed density

Table-1 Efficacy of weed management practices on weed populations and weed control efficiency (WCE) in hybrid maize

Treatment	Weed population (m^{-2})						WCE (%)	
	NLW			BLW				
	DAS							
	40	60	80	40	60	80	40	80
Atrazine @1.0 kg/ha at 1 DAS	7.6 (56.7)	7.8 (60.0)	7.2 (51.0)	7.3 (53.0)	7.7 (58.0)	7.5 (55.0)	76.3	66.0
Oxyflurofen @ 0.03 kg/ha as PE at 1 DAS	7.0 (49.0)	7.4 (54.0)	6.8 (45.0)	7.0 (49.0)	7.2 (51.0)	6.8 (45.0)	78.4	68.3
Pendimethalin @1.0 kg/ha as PE at 1 DAS	7.2 (51.0)	7.5 (56.0)	7.0 (49.0)	7.2 (51.0)	7.5 (55.0)	7.3 (52.0)	77.0	67.0
Atrazine @ 0.5 + Oxyfluorfen 0.03 kg/ha as PE at 1 DAS	6.8 (45.3)	7.0 (49.0)	6.6 (43.0)	6.9 (47.0)	7.0 (49.0)	6.4 (41.0)	79.8	71.1
Pendimethalin @ 1.0 + Oxyflurofen 0.03 kg/ha as PE at 1 DAS	6.5 (42.3)	6.9 (47.0)	6.2 (37.3)	6.5 (42.0)	6.8 (46.0)	6.4 (40.0)	82.0	74.2
Halosulfuron @ 0.06 kg/ha as POE at 25 DAS	8.0 (112.0)	8.3 (119.0)	8.9 (128.0)	6.4 (40.0)	6.8 (45.0)	6.4 (41.0)	57.8	49.2
Pendimethalin @ 1.0 as PE at 1 DAS fb by Halosulfuron 0.06 kg/ha as POE at 25 DAS	6.5 (42.0)	6.7 (44.0)	5.5 (30.0)	4.7 (22.0)	5.0 (24.0)	4.0 (16.0)	83.5	80.0
Oxyfluorfen @0.03 fb by Halosulfuron 0.06 kg/ha as POE at 25 DAS	5.8 (33.0)	6.2 (38.0)	4.7 (21.3)	4.3 (18.0)	4.7 (22.0)	3.8 (14.0)	86.2	82.5
Farmers practice (2 hand hoeing)	7.4 (54.0)	6.7 (44.6)	5.7 (31.7)	6.9 (47.0)	5.2 (27.0)	4.5 (20.0)	77.6	80.8
Un-weeded	12.6 (209.0)	12.8 (212.0)	12.6 (205.0)	11.5 (131.0)	11.6 (135.0)	11.3 (126.0)	0.0	0.0
SEM (±)	0.27	0.26	0.25	0.14	0.26	0.21		
CD (P=0.05)	0.80	0.75	0.72	0.40	0.76	0.58		

PE= Pre-emergence, POE= post-emergence, DAS= days after sowing, fb= followed by

of both NLW and BLW from 40 DAS to 60 DAS showed the increasing trend and decreased thereafter (Table 1).

Application of Oxyflurofen @ 0.03 kg/ha followed by Halosulfuron @ 0.06 kg/ha recorded the lowest population of NLW 5.8 (33.0/m^2), 6.2 (38.0/m^2), 4.7 (21.3/m^2) and BLW, 4.3 (18.0/m^2), 4.7 (22.0/m^2), 3.8 (14.0/m^2) at 40, 60 and 80 DAS, respectively. It could be attributed to the cumulative effect of herbicides which resulted in reduced dry matter production by weeds. Similarly weed control efficiency was calculated at 40 and 80 days after sowing. The highest WCE (86.2%) was observed with application of (Oxyfluorfen 0.03 kg/ha followed by halosulfuron 0.06 kg/ha as POE at 25 DAS) at 40 DAS over the 80 DAS among the herbicidal treatments. However the lower values of WCE was found with treatment received Halosulfuron 0.06 kg/ha as POE at 25 DAS at 40 and 80 DAS. WCE of treatments usually decrease with the progress of crop age. The higher value of WCE indicates better weed control with application of herbicides. These results are in agreement with the findings of Kumar *et al.*(2103), Dobariya *et al*. (2014) and Chand and Puniya (2017).

Data subjected to yield attributing characters, yields and economics of maize are presented in Table 2. In general, yield attributes, grain and stover yields and economics of the crop differed significantly among the various weed control measures. All the herbicidal treatments recorded significantly higher values of yield attributing characters and kernel yield of maize over the un-weeded control. Among the weed control treatments, application of application of (Oxyfluorfen @ 0.03 kg/ha followed by Halosulfuron 0.06 kg/ha as POE at 25 DAS) resulted the maximum values of number of cobs/plant (1.2), number of rows/cob (16.0), cob girth (13.6 cm), grains/row (35.0) and kernel test weight (287.8 g).Yield is the net photosynthetic material and contributes significantly towards economic yield. Analysis of the data showed that (pre-emergence application of Oxyfluorfen 0.03 kg/ha followed by Halosulfuron 0.06 kg/ha) resulted in significantly higher kernel yield (6.2 t/ha) and stover yield (8.0 t/ha) over other herbicidal treatments including un-weeded control. However, it remains statistically at par with two hand hoeing's. This might be due to poor crop-weed competition during the active growing period of the crop, higher dry matter accumulation. Analogous results were also reported by Sharma *et al.* (2000); Sikkema *et al.* (2008), Nurse *et al.* (2010) and Kour *et al.*(2014).

Economics of different herbicidal treatments and farmers' practice (two hand hoeings') in terms of net returns varied among the treatments. The higher net returns (₹ 56.7×$10^{3/}$ha) were recorded with (Oxyflurofen 0.03 kg/ha followed by Halosulfuron 0.06 kg/ha) followed by

Table 2 Efficacy of weed management practices on yield attributes, yield and net returns of hybrid maize

Treatment	Yield attributes					Yields (t/ha)		Net returns (₹×10³/ha)
	Cobs/ plant	Rows/ cob	Cob girth (cm)	Grains/ row	Test wt. (g)	Grain yield	Stover yield	
Atrazine @ 1.0 kg/ha at 1 DAS	1.0	16.0	13.1	30.8	248.3	4.9	6.8	40.5
Oxyflurofen @ 0.03 kg/ha as PE at 1 DAS	1.0	16.0	13.2	27.8	275.8	5.5	7.4	49.4
Pendimethalin @1.0 kg/ha as PE at 1 DAS	1.1	14.0	13.3	30.6	273.5	5.3	7.4	46.3
Atrazine @ 0.5 + Oxyfluorfen 0.03 kg/ha as PE at 1 DAS	1.0	16.0	13.2	28.9	271.3	5.5	7.4	49.2
Pendimethalin @ 1.0 + Oxyflurofen 0.03 kg/ha as PE at 1 DAS	1.1	14.0	13.3	35.1	283.1	5.6	7.5	49.9
Halosulfuron @ 0.06 kg/ha as POE at 25 DAS	1.0	14.0	12.6	28.7	260.0	4.1	6.4	28.5
Pendimethalin @ 1.0 as PE at 1DAS fb by Halosulfuron 0.06 kg/ha as POE at 25 DAS	1.0	16.0	13.1	26.1	271.5	5.7	7.6	48.2
Oxyfluorfen @ 0.03 fb by Halosulfuron 0.06 kg/ha as POE at 25 DAS	1.2	16.0	13.6	35.0	287.8	6.2	8.0	56.7
Farmers' practice (2 hand hoeings)	1.1	14.0	13.2	27.7	271.8	6.0	8.0	49.1
Un-weeded	1.0	12.0	12.3	22.5	201.4	2.4	5.1	7.7
SEM (±)	0.04	0.58	0.38	2.04	6.55	0.21	0.41	
CD (P=0.05)	0.11	1.71	1.12	6.04	19.14	0.61	1.19	

PE= Pre-emergence, POE= post-emergence, DAS= days after sowing, fb=followed by

(Pendimethalin 1.0 kg/ha + Oxyfluorfen 0.03 kg/ha as PE at 1 DAS). This was due to higher grain yield of the hybrid maize which resulted in higher net returns per unit area. Similar types of results were also reported by Pandey *et al.*(2002) and Nurse *et al.* (2007).

SUMMARY

Results of study indicated that weed dynamics, yield attributing characters, yields and economics of hybrid maize (*Zea mays* L.) were greatly affected by different weed management practices. Findings advocated that the single herbicide application as pre-emergence or post-emergence is not able to control weeds during the active growing period of the hybrid maize. Throughout the growth stages the lowest NLW and BLW population, higher values of yield attributes, yields and net returns were recorded with sequential application of Oxyflurofen 0.03 kg/ha followed by Halosulfuron 0.06 kg/ha over the others. The results from the above study suggested that application of Oxyflurofen 0.03 kg/ha followed by Halosulfuron 0.06 kg/ha is better for effective and economic weed control and obtaining the higher kernel yield of hybrid maize. Based on the one year study, application of Oxyflurofen 0.03 kg/ha followed by Halosulfuron 0.06 kg/ha may be recommended for reducing weed problem and producing maximum yield of hybrid maize in Odisha.

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