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Effect of weed management practices on growth, yield and economics in *kharif* maize *(Zea mays* L.)

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Abstract
A field trial was conducted during *kharif* season of 2015-16 and 2016-17 in farmer's field at *Banuasahi* village of Angul district in Odisha to study the effect of weed management practices on growth, yield and economics in *kharif* maize comprising five treatments *viz.* one hoeing at 20 DAS *fb* one hand weeding at 40 DAS, pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS, pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* post-emergence application of 2,4-DEE @ 1.0 kg ha^{-1} at 20 DAS, pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS and weedy check, laid out in randomized block design with ten replications. Pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS recorded significantly higher plant height(152.10 cm), cob length (15.06 cm), number of grains cob^{-1} (296.15) and 100 grain weight(30.23 g) with maximum gross return (Rs.66545.88 ha^{-1}), B:C ratio (2.27), additional net return of Rs.23431.28 ha^{-1}, weed control efficiency (79.52%) and significantly reduced weed density (32.31 m^{-2}) and weed dry weight (22.43 g m^{-2}) at 60 DAS. Maximum weed density m^{-2} at 60 DAS (173.34) and weed dry biomass (141.41 g m^{-2}) was observed in weedy check.

Keywords: Economics, maize, weed management, weed control efficiency, yield

Introduction
Maize (*Zea mays* L.) is one of the most important cereal crops in the world agricultural economy and is regarded as queen of cereals. In India maize is grown over an area of 8.7 million hectares with an annual production of 22.30 million tonnes and average yield of 2470 kg ha^{-1} (Anonymous, 2013) [1]. In Odisha, it is grown in an area of 0.27 million hectares with a production of 0.77 million tones (Anonymous, 2014) [2]. One of the major problems in maize productivity is posed by the weeds, which might reduce the yields from 25 - 50%. Effective weed management is considered to be an important factor for achieving higher productivity. Hand weeding, is time consuming, expensive and is not feasible during critical period of weed competition due to scarcity of labour. Weeds not only cause severe crop losses but also compete with farmers and their families to spend a considerable amount of their time on weeding. Different weed control methods have been used to manage the weeds. But, mechanical and chemical methods are more frequently used for the control of weeds. Mechanical methods including hand weeding are still in practice in the less developed countries, where the peak labor requirement is often for hand weeding (Tesfay *et al.*, 2014) [9]. Integrated weed management is the need of the day, because of its sustainability and higher productivity (Birendra *et al.*, 2013) [3]. Keeping this in view, present investigation was undertaken to study the effect of weed management practices on growth, yield and economics in *kharif* maize.

Materials and Methods
A field trial was conducted during *kharif* season of 2015-16 and 2016-17 in farmer's field at *Banuasahi* village (20° 50′ 37.2″ N, 84°57′9.3″ E) of Angul district in Odisha to study the effect of different weed management practices on weed growth, yield and economics in *kharif* maize. The average rainfall in both the year during the study period from June to September was 678.4 mm. The mean maximum and mean minimum temperature registered in both the year was 32.0 ^{0}C and 24.0 ^{0}C respectively. The treatments comprised of different weed control methods *viz.* T_1- Farmers practice (One hoeing at 20 DAS *fb* one hand weeding at 40 DAS), T_2- pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS, T_3- pre-emergence

application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* post-emergence application of 2,4-DEE @ 1.0 kg ha^{-1} at 20 DAS, T_4- pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS and T_5-weed check were arranged in randomised block design with ten replications. The soil of the experimental site was slightly acidic in reaction (pH-5.4), sandy loam in texture with medium in organic carbon (0.55%), available nitrogen (281.5 kg ha^{-1}), potash (175.3 kg ha^{-1}) and low in phosphorus (9.7 kg ha^{-1}) content (Jackson, 1973) [5].

The maize *cv.* Hybrid Super 36 was planted in the trial field during 2nd week of June and harvested during 2nd week of September with recommended package of practices. The crop was sown with 60×30 cm spacing with recommended fertilizer dose of 120:60:60 kg N-P_2O_5-K_2O ha^{-1} respectively. Full dose of P, K and half dose of N of RDF were applied as basal and rest N was applied at 30 DAS. All the herbicides were sprayed with manually operated knapsack sprayer using a spray volume of 500 litres water per hectare. Weed density m^{-2} was sampled randomly at ten places with the help of one square meter quadrates at 60 DAS and weed dry weight m^{-2} were recorded. The weed control efficiency (WCE) was calculated by using the formula.

$$\text{WCE} = \frac{(\text{DWC}-\text{DWT})}{\text{DWC}} \text{X}100$$

Where:
DWC = Dry weight of weeds under control plot; DWT = Dry weight of weeds under treated plot

Observation on different yield parameters were taken and economic analysis was done by calculating cost of cultivation, gross return, net return and B:C ratio. The data were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05 (Cochran and Cox, 1977) [4].

Results and Discussion

Growth and yield attributes

Pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS produced significantly higher plant height (152.10 cm), cob length (15.06 cm) and number of grains cob^{-1} (296.15) than rest of treatments due to lesser weed population, weed dry biomass and removal of weeds regularly at early and later stages by mechanical weeding (Table 1). Minimum plant height (137.25 cm), cob length (13.57 cm) and number of grains cob^{-1} (215.25) was found in weedy check. Maximum 100 grain weight(30.23 g) was recorded in pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS followed by pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS *fb* post-emergence application of 2,4-DEE @ 1.0 kg ha^{-1}at 20 DAS (30.17 g). These results are also similar with the findings of Sharma and Gautam (2006) [11].

Grain yield

All the treatments including farmers practice (Table 1) produced significantly higher grain yield (32.04 to 69.85%) than the weedy check (29.12 q ha^{-1}). This may be due to vigorous weed growth and suppression in crop growth in weedy check. Maximum grain yield was obtained from pre-emergence application of atrazine @1.0 kg/ha at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS(49.46 q ha^{-1}) followed by pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS *fb* post-emergence application of 2,4-DEE @ 1.0 kg ha^{-1}at 20 DAS [1](46.20 q ha^{-1}) due to minimum crop weed competition throughout crop growth period and the herbicides prevented the germination of weed and reduced the growth of weed (Malviya and Singh, 2007) [6]. Farmers practice (one hoeing at 20 DAS *fb* one hand weeding at 40 DAS) recorded grain yield of 40.63 q ha^{-1} which was significantly higher than pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS due minimum crop weed competition through out crop growth period. Samant *et al.* (2015) [10] also reported similar results.

Table 1: Effect of weed management on crop growth and yield parameters of maize (Pooled data of 2 years)

Treatment	Plant height (cm)	Length of the cob	No of grains/cob cob^{-1}	Test weight (100 grain wt) (g)	Grain yield (q ha^{-1})
Farmers practice (One hoeing at 20 DAS *fb* one hand weeding at 40 DAS)	141.40	14.27	274.66	27.54	40.63
Pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS	139.34	13.87	276.97	25.40	38.45
Pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS *fb* post-emergence application of 2,4-DEE @ 1.0 kg ha^{-1}at 20 DAS	147.44	14.25	282.76	30.17	46.20
Pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS	152.10	15.06	296.15	30.83	49.46
Weedy check	137.25	13.57	215.25	23.72	29.12
S. Em. ±	0.05	0.12	1.66	0.02	0.51
CD (P=0.05)	0.13	0.35	4.75	0.07	1.45

Weed infestation

All the weed management practices(Table 2) significantly reduced the weed density than weedy check (151.45m^{-2} at 60 DAS), which was due to uninterrupted growth of these weeds as no weed control measures were adopted in weedy check plots. Pre-emergence application of atrazine @1.0 kg/ha at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS produced the minimum weed density (32.31 m^{-2}) because of effective weed control and was found at par with pre-emergence application of atrazine @1.0 kg/ha at 3 DAS *fb* post-emergence application of 2,4-DEE @ 1.0 kg ha^{-1} at 20 DAS and superior over rest of treatments in decreasing weed density (Malviya and Singh, 2007) [6].

The weed dry biomass at 60 DAS was maximum (109.70 g m^{-2}) in weedy check owing to higher weed density. Among all the weed management treatments, pre-emergence application of atrazine @1. kg ha^{-1}at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS recorded the minimum weed dry biomass(22.43 g m^{-2}). Application of herbicides might have reduced the growth of germinated weeds by inhibiting the process of photosynthesis and minimal dry

weight of weeds due to effective control of all types of weeds during the course of weeding (Pandey *et al*, 2002) [7].

The weed control efficiency(WCE) varied from the maximum of 79.52 per cent with pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS to the minimum of 60.14 per cent with pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS. Farmers practice (one hoeing at 20 DAS *fb* one hand weeding at 40 DAS) recorded WCE of 63.70%) (Table 2). This may be due to effective control of weeds with decrease in weed biomass production during early stages of crop growth by herbicides and in later stages removal of weeds by mechanical weeding. Similar result was given by Singh *et al*. (2009) [8].

Economics

Among the treatments, pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS recorded (Table 2) the maximum gross return (Rs.66545.88 ha^{-1}) and B:C ratio(2.27) with additional net return of Rs.23431.28 ha^{-1} as compared to weedy check owing to higher grain yield. Minimum cost of cultivation (Rs. 25382.10 ha^{-1}) was occurred in weedy check in comparison to other treatments due to saving of labour cost towards weeding. Similar result was reported by Sunitha and Kalyani (2012) [12].

Table 2: Effect of weed management on weed density, weed dry biomass, weed control efficiency and economics of maize (Pooled data of 2 years)

Treatment	Weed density (No m^{-2})	Weed dry biomass at 60 DAS (g m^{-2})	Weed control efficiency at 60 DAS (%)	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net Return (Rs ha^{-1})	B:C ratio
Farmers practice (One hoeing at 20 DAS *fb* one hand weeding at 40 DAS)	52.21	39.78	63.70	29757.10	54694.33	24937.23	1.84
Pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS	56.82	43.74	60.14	28162.11	51764.98	23602.87	1.84
Pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* post-emergence application of 2,4-DEE @ 1.0 kg ha^{-1} at 20 DAS	36.14	26.15	76.12	29857.08	62191.08	32334.00	2.08
Pre-emergence application of atrazine @1.0 kg ha^{-1} at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS	32.31	22.43	79.52	29337.10	66545.88	37208.79	2.27
Weedy check	151.45	109.70		25382.10	39159.61	13777.51	1.54
S. Em. ±	2.22	0.95		113.78	680.30	709.14	0.03
CD (P=0.05)	6.37	2.72		326.27	1950.81	2033.51	0.08

Conclusion

Pre-emergence application of atrazine @1.0 kg ha^{-1}at 3 DAS *fb* one mechanical weeding by wheel finger weeder at 20 DAS considerably reduced the weed infestation registering higher weed control efficiency, higher grain yield in maize. Thus, it appeared to be effective, economically viable method for weed control, crop growth, higher grain yield and net profit.

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