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Weed growth, Yield components, Productivity, Economics and Nutrient uptake of Maize *(Zea mays* L.) as influenced by Various Herbicide applications under Rainfed condition

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Abstract: A field trial was conducted in Instructional farm, Krishi Vigyan Kendra, Angul of Odisha during kharif seasons of 2013 and 2014 to study weed growth, yield components, economics and nutrient uptake in maize as influenced by various herbicide applications under rainfed condition. The experiment comprised of seven treatments viz. T_1-Pendimethalin 1.0 kg ha^{-1} *fb*1 HW at 30 DAS, T_2-pendimethalin 1.5 kg ha^{-1} *fb* 1 HW at 30 DAS, T_3-atrazine 0.75 kg ha^{-1} *fb* 1 HW at 30 DAS, T_4-atrazine 1.0 kg ha^{-1} *fb* 1 HW at 30 DAS, T_5- atrazine 1.5 kg ha^{-1} *fb* 1 HW at 30 DAS , T_6-farmers practice of 2 hand weeding at 20 & 40 DAS and T7-weedy check in randomized block design with three replications. The minimum weed index (9.12 %) was obtained in application of atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS with curtailed removal of N, P and K by weeds to the tune of 87.5, 91.2 and 87.1 %, respectively over that of weedy check where as maximum uptake by maize was observed in farmers practice 164.01 kg N, 39.45 kg P and 165.17 kg K ha^{-1} respectively . Farmers practices recorded maximum cob length (15.27 cm), cob weight(130.24 g), number of grains cob^{-1} (433.90) and weed control efficiency (80.87 %) with significantly reduced in both weed density (20.16 m^{-2}) and weed dry weight(27.05 g m^{-2}) at 60 DAS. The same treatment also recorded maximum gross return (Rs.59126 ha^{-1}) and B:C ratio(1.91) with additional net return of Rs.21690 ha^{-1} as compared to weedy check Maximum weed density m^{-2} at 60 DAS(173.34) and weed dry biomass(141.41 gm^{-2}) was found in weedy check . Hence, farmers practice was found to be effective in case easy availability of labours where as in case of non availability of laborers, application of atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS was found economically viable for weed control with better nutrient uptake , higher grain yield and net profit.

Keywords: Herbicides, Nutrient uptake, Hand weeding, Maize, WCE, WI

INTRODUCTION

Maize *(Zea mays* L.) is one of the most popular and important cereal crop grown throughout the world for agricultural economy. In Odisha, it is grown in an area of 0.26 million hectare with a production of 0.6 million tonnes [1]. There are many socio-economic, physical and biological factors limiting the productivity of maize crop. One of the major problems in maize productivity is posed by the weeds that have shown to reduce the yields from 25 - 50%. In rain-fed areas inter-culture of maize field is done for controlling weeds. It is costly, time and labour consuming. Integrated weed management is the need of the day, because of its sustainability and higher productivity [2].

Reduction in grain yield of maize due to weed infestation is reported to be ranged from 40-60% that depends on the intensity and types of weed flora. Pre-emergence application of atrazine @ 0.5 to 1.0 kg ha^{-1} in combination with hand weeding at 30 DAS has been recorded to be the highest weed control efficiency, lowest weed density and weed dry weight [3].

The crop requires large amounts of N, P and K in addition to other micro elements. Weed control can increase fertilizer use efficiency of the crop with checking wasteful removal of nutrients by weeds [4]. Hand weeding, is time consuming, high expensive and is not feasible during critical period of weed competition due to scarcity of labour.

Keeping this in view present investigation was under taken to study weed growth, yield components, economics and nutrient uptake in maize as influenced by various herbicide applications under rainfed condition .

MATERIALS AND METHODS

A field trial was carried out in Instructional farm, Krishi Vigyan Kendra, Angul during *kharif* seasons of 2013 and 2014 to study weed growth, yield components, economics and nutrient uptake in maize as influenced by various herbicide applications under rainfed condition. The geographical location of the area

has 84^0 16´ to 85^0 23´ E longitude and 20^0 31´ to 21^0 41´ N latitude and average elevation of 300 m above mean sea level. Climate of the region is fairly hot and humid monsoon. The average rainfall in both the year during the study period from July to October was 914.2 mm. The mean maximum and mean minimum temperature registered in both the year was 34.2^0 C and 20.8^0 C respectively. The soil of the experimental site was slightly acidic in reaction(pH-5.6), sandy loam in texture with medium in organic carbon (0.43 %), available nitrogen(292.0 kg ha^{-1}), phosphorus(12.2 kg ha^{-1}) and potash(205.2 kg ha^{-1}) contents . The treatments comprised of different weed control methods *viz.* T_1-Pre-emergence application of pendimethalin 30% EC @1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS,T_2- Pre-emergence application of pendimethalin 30% EC @1.5 kg ha^{-1} *fb* one hand weeding at 30 DAS,T_3-Pre-emergence application of atrazine 50% WP@0.75 kg ha^{-1} *fb* one hand weeding at 30 DAS, T_4- Pre-emergence application of atrazine 50% WP@1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS, T_5- Pre-emergence Atrazine 1.5 kg ha^{-1} *fb* one hand weeding at 30 DAS , T_6-Farmers practice of two hand weedings at 20 & 40 DAS and T_7-Weedy check. The experimental trial was laid out in randomized block design with three replications.

The maize *cv.* Hybrid Super 36 was planted during 1st week of July and harvested during 2nd week of October and fertilizer were applied @ 120:60:60 kg NPK ha^{-1}. 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 at 3 DAS 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 20, 40, 60 DAS and weed dry weight m^{-2} were recorded. The weed control efficiency (WCE) and Weed index (WI) were calculated by using the formula [5, 6].

$$WCE = [(DWC – DWT) / DWC] \times 100$$

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

$$WI== [(X-Y) / X] X100$$

Where,
X=yield from weed free plot
Y=yield from 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. Available soil nutrients as well as nutrient content and their uptake by soil and weeds were determined following the standard procedures [7]. The DASas 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 [8].

RESULTS AND DISCUSSION

Weed density and weed dry biomass

The floristic composition of the experimental site was dominated by *Cynodon dactylon, Echinochloa colona, Commelina communis, Alternenthara sessilis, Digera arvansis, Parthenium hysterophoru, Argimone Mexicana, Cyperus rotundus* during both the years. All the weed management practices (Table 1) significantly reduced the weed density than weedy check (173.34 m^{-2}) at 60 DAS which is followed by pre-emergence application of pendimethalin 30% EC @1.5 kg ha^{-1}(90.45 m^{-2}) & pendimethalin 30% EC @1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS(76.77 m^{-2}) . Farmers practice produced the minimum weed density (20.16 m^{-2}) because of efficiently weed control by two hand weedings at 20 & 40 DAS. Pre-emergence application of atrazine 50% WP@1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS produced weed (47.52 m^{-2}) which found superior over rest of herbicidal treatments in controlling weed density. The weed dry biomass at 60 DAS was maximum (141.41 g m^{-2}) in weedy check owing to higher weed density where as the minimum (27.05 g m^{-2}) was obtained in farmers practice of two hand weedings . Among the herbicide treatments, pre-emergence application of atrazine 50% WP@1.0 kg ha^{-1} recorded the minimum weed dry biomass (40.57 g m^{-2}) than other treatments. Application of herbicides might have prevented the germination of susceptible weed species which reduced the growth of germinated weeds by inhibiting the process of photosynthesis [9].

Weed index and weed control efficiency

The minimum weed index (9.12 %) was obtained with application of atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS followed by atrazine 1.5 kg ha^{-1} *fb* one hand weeding at 30 DAS (11.61 %). Maximum weed index (43.08 %) was found in weedy check because of its lower grain yield (Table 2). The rest of herbicide treatments recorded the moderate range of weed index (13.47 to 19.59 %).The weed control efficiency(WCE) varied from the maximum of 80.87 per cent with farmers practice to the minimum of 54.12 per cent with application of Pendimethalin 1.5 kg ha^{-1} *fb* one hand weeding at 30 DAS . Application with atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS recorded higher WCE (71.31%) than rest of herbicide treatments(Table 1). This may be due to effective control of weeds during early stages of crop growth by herbicides and in later stages removal of both intra and inter row weeds by hand weeding [10].

Cob length, cob weight, , no of grains $cob^{-1}$and 100 grain weight

Farmers practice of two hand weedings produced (Fig. 1) the maximum cob length (15.27 cm), cob weight(130.24 g) and number of grains cob^{-1}

(433.90) as compared to rest of treatments due to lesser weed population, weed dry biomass and removal of weeds regularly at early and later stages by hand weedings [11]. Application of atrazine 1.0 kg ha-1 *fb* one hand weeding at 30 DAS recorded cob length , cob weight, number of grains cob^{-1} 23.7, 61.5 and 34.3 % higher than weedy check. Maximum 100 grain weight(33.52 g) was recorded in Pendimethalin 1.0 kg ha $^{-1}$ followed by atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS (32.74 g).

Grain yield

All the treatments including farmers practice (Table 2) produced significantly higher grain yield (41.3 to 75.7 %) than the weedy check (28.64 q ha^{-1}) may be due to vigorous weed growth and suppression in crop growth in weedy check. Maximum grain yield was obtained from farmers practices (50.32 q ha^{-1}) followed by application of atrazine 1.0 kg ha^{-1}(45.73 q ha^{-1}) due minimum crop weed competition throughout crop growth period. [12].Application of atrazine 1.5 kg ha^{-1} recorded grain yield of 44.48 q ha^{-1} which was on par with atrazine 0.75 kg ha^{-1} and pendimethalin 1.0 kg ha $^{-1}$ and 9.94 per cent higher yield than pendimethalin 1.5 kg ha^{-1} because of the herbicides prevented the germination of weed and reduced the growth of weed.

Nutrient depletion by weeds and uptake by maize

Minimum nutrient depletion by weed was observed in farmers practice which removed 9.14 kg N, 0.53 kg P and 9.61 kg K ha^{-1} (Table 2). Pre-emergence application of atrazine 1.0 kg ha^{-1} curtailed removal of N, P and K by weeds to the tune of 87.5, 91.2 and 87.1 %, respectively over that of weedy check owing to function of concentration of nutrients and total weed biomass [13]. Similarly, all the treatments significantly increased the uptake of nutrients by maize than weedy check and maximum uptake was observed in farmers practice 164.01 kg N, 39.45 kg P and 165.17 kg K ha^{-1} (Table 2) followed by atrazine 1.0 kg ha^{-1} owing to less crop weed competition and better growth of maize [14].

Economics

Among the treatments, farmers practice recorded (Figure 2) the maximum gross return (Rs.59126 ha^{-1}) and B: C ratio(1.91) with additional net return of Rs.21690 ha^{-1} as compared to weedy check owing to higher grain yield. Highest net return was recorded in farmers practice (Rs.28132 ha^{-1}) followed atrazine 1.0 kg ha^{-1} (Rs.23821 ha^{-1}) with B:C ratio(1.80) owing to more number of grains cob^{-1} resulting higher grain yield. Minimum cost of cultivation (Rs.27210 ha^{-1}) was occurred in weedy check in comparison to other treatments due to saving of labour cost towards weeding [15].

Table 1: Effect of treatments on weed density, weed dry biomass and weed control efficiency (pooled DASa over 2 years)

Treatments	Dose (Kg ha^{-1})	Weed density (No m^{-2})			Weed dry biomass at 60 DAS (g m^{-2})	Weed control efficiency at 60 DAS (%)
		20 DAS	40 DAS	60 DAS		
T_1-Pendimethalin 1.0 kg ha $^{-1}$ *fb* one hand weeding at 30 DAS	1.0	32.78	28.70	76.77	61.25	56.69
T_2-Pendimethalin 1.5 kg ha $^{-1}$ *fb* one hand weeding at 30 DAS	1.5	34.19	30.93	90.45	64.88	54.12
T_3-Atrazine 0.75 kg ha^{-1} *fb* one hand weeding at 30 DAS	0.75	24.99	19.96	56.16	56.55	60.01
T_4-Atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS	1.0	22.23	17.11	47.52	40.57	71.31
T_5-Atrazine 1.5 kg ha^{-1} *fb* one hand weeding at 30 DAS	1.5	26.13	20.98	58.23	60.86	56.96
T_6-Farmer's practice (2 hand weeding at 20 & 40 DAS)		97.33	41.35	20.16	27.05	80.87
T_7-Weedy check		109.92	144.62	173.34	141.41	-
SEM+		2.538	2.773	2.409	2.076	
C.D at 5 %		7.820	8.546	7.423	6.398	

Table 2: Effect of treatments on grain yield, weed index and nutrient uptake by maize & weeds (pooled DASa over 2 years)

Treatment	Grain yield (q ha^{-1})	Weed index (%)	Nutrient uptake (kg ha^{-1})					
			Maize			Weeds		
			N	P	K	N	P	K
T_1-Pendimethalin 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS	42.57	15.40	129.12	31.12	137.37	16.46	1.31	14.96
T_2-Pendimethalin 1.5 kg ha^{-1} *fb* one hand weeding at 30 DAS	40.46	19.59	118.23	28.22	132.16	17.78	1.62	17.14
T_3-Atrazine 0.75 kg ha^{-1} *fb* one hand weeding at 30 DAS	43.54	13.47	139.42	32.32	143.86	12.33	1.06	12.1
T_4-Atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS	45.73	9.12	150.25	36.00	154.40	11.15	0.86	11.51
T_5-Atrazine 1.5 kg ha^{-1} *fb* one hand weeding at 30 DAS	44.48	11.61	142.13	32.43	143.29	14.62	1.27	13.27
T_6-Farmer's practice (2 hand weeding at 20 & 40 DAS)	50.32	0.00	164.01	39.45	165.17	9.14	0.53	9.61
T_7-Weedy check	28.64	43.08	103.32	24.77	112.63	88.86	9.8	89.44
SEM	0.272		0.619	0.2	0.857	0.525	0.101	0.669
C.D at 5 %	0.839		1.907	0.618	2.64	1.617	0.312	2.06

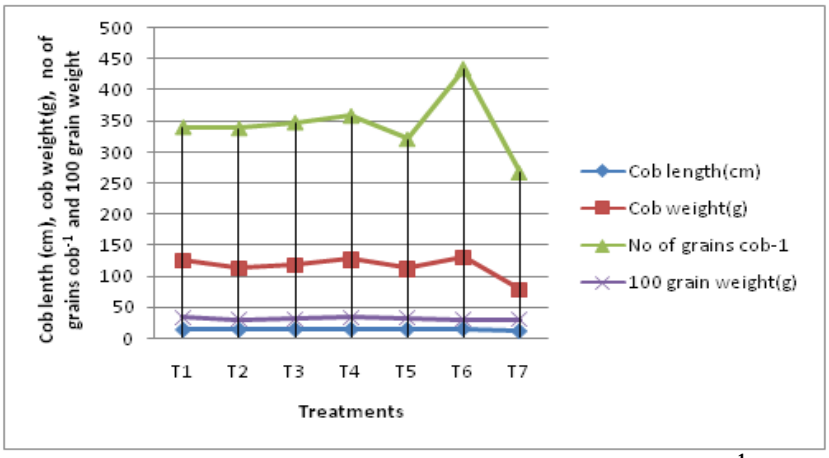

Fig. 1: Effect of different treatments on cob length, cob weight, no of grains cob^{-1} and 100 grain weight

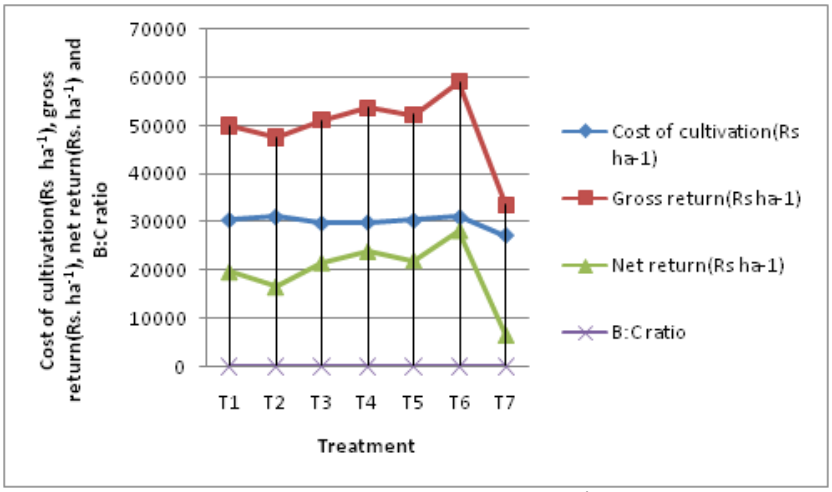

Fig. 2: Effect of different treatments on cost of cultivation (Rs ha^{-1}), gross return (Rs ha^{-1}), net return (Rs ha^{1}) and B: C ratio

CONCLUSION

Hence, it could be concluded from the investigation that farmer's practice of two hand weedings at 20 and 40 DAS was found to be effective where laborers are easily available. In case of non availability of laborers, application of atrazine 1.0 kg ha^{-1} *fb* one hand weeding at 30 DAS was found economically viable for weed control with better nutrient uptake, higher grain yield and net profit.

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