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RESEARCH ARTICLE :

Effect of different weed control methods on growth and yield of maize

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SUMMARY : A field experiment was carried out at the Agronomy Crop Research Farm SHUATS Allahabad, during *Kharif* season of 2015 to study the "Effect of different weed management practices (Chemical and Non-chemical) on growth and yield of maize". The experiment comprised eleven treatments, *viz.*,weed free, 2 hand weeding, Paddy straw mulching, black polythene mulching, Atrazine @ 0.75 kg ha^{-1}, Atrazine @ 1.0 kg ha^{-1}, Atrazine @ 1.50 kg ha^{-1}, Atrazine @ 0.75 kg ha^{-1} + hand weeding, Atrazine @ 1.0 kg ha^{-1} + hand weeding, Atrazine @ 1.50 kg ha^{-1} + hand weeding and un weeded plot. Significantly lower density and dry weight of weeds per m^2 was recorded with Paddy straw mulching and Black polythene mulching (61.00g) compared to other weed management treatments. However, they were at par with Application of Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45DAS (75.00 g) and significantly lower weed dry weight per m^2 was recorded in Paddy straw mulching (20.70g) compared torest of the treatments. Pre-emergence application of Atrazine @ 1.0 kg ha^{-1}+ one hand weeding at 45 DAS was recorded significantly higher 1000 seed weight (203.48g) and grain yield (8.79 t ha^{-1}) over rest of the weed control treatments. Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS recorded higher net returns (Rs.91700ha^{-1}) and B:C ratio (3.40) over other treatments and it was on par with the Paddy straw mulching and black polythene mulching treatment.These weed control methods significantly controlled weeds and enhanced yield and yield components of maize during the study years. The economic analysis of these weed control methods also showed better performance of application of Atrazine@ 1.0 kg ha^{-1} + hand weeding at 45 DAS as compared to rest of the treatments.

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KEY WORDS :
Economic, Integrated weed control, Weed density, Weed index, 1000 seed weight.

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BACKGROUND AND OBJECTIVES

Maize (*Zea mays* L.) is the second most important cereal crop in the world after Wheat, in terms of total food production. It is grown for fodder as well as for grain. The grains of maize are used in a variety of ways by the human beings. Recently, with the release of improved cultivars and hybrids, the grain yield has been increased but still the maize crop faces many problems. Weeds are one of the most important factors in maize production. They cause major yield losses worldwide with an average of 12.8% despite weed control applications and 29.2% in the case of no weed control (Oerke and Steiner, 1996). Therefore,

weed control is an important management practice for maize production that should be carried out to ensure optimum grain yield.

Weeds Compete with crop for light, moisture, space and plant nutrients and other environmental requirements and consequently interfere with the normal growth of crops, which reduce not only the yield, grain quality and hinder harvest operations but also increase the cost of production (Rutta *et al.*, 1991).

Losses of grain yield could range from 18-25, 20-65, 20-45, 13-43, and 25-55 percents in wheat, rice, maize, cotton, sugarcane and pulses, respectively from weeds interference, while the annual monetary losses caused by weed in agricultural production are estimated at more than $ 18.2 billion (Alarm, 2003). Therefore, the need to increase the supply of maize corn to meet with the increasing demand has called for better crop management practices including weed control strategies to enhance crop productivity.

To minimize the weeds losses several methods are available such as mechanical, cultural, biological and chemical control. Exhausted by cultural method, farmers are moving towards other alternative method of weeds control. In the present scenario, chemical weed control is the best option. Chemical weeds control method is suggested by many researcher (Johnson *et al.*, 1997, Khan and Haq, 2004, Juhl, 2004 and Toloraya *et al.*, 2001 etc.). Success of weeds control methods depend upon several factors; however, the weeds emergence pattern, application timing and stage of crop are important in chemical control (Hovestad *et al.*, 2004). Similarly, time of application of herbicides is very important for proper controlling of weeds and the effectiveness of herbicides can be increased (Vandini *et al.*, 2005).

The growth of maize plants in the first 3-4 weeks is rather slow and it is during this period that weeds establish rapidly and become competitive. The major broad leaves weeds infestating maize include (*Anagalisarvensis, Euphorbia hiria, Commelinabengalensis, Chenopodium album, Phyllanthusniruri, Partheniumhysterophorus, Convulvulusarvensis* etc. Grassy weeds includes: *Dactylecteriumaesgypticum, Cynadondactylon, Sorghum helepense*) etc reported by (Sigh and Ragput, 1995) and among allowed to grow up to 30 DAS. The yield reduction due to weeds after ward is very marginal.

Atrazine a prominent triazine herbicide is currently one of the most widely used herbicides in agriculture world. It is selective post-emergence herbicides for the control of broadleaves weeds and grasses. Alachlor is used as pre-emergence and post-emergence herbicides. It is applied at the rate of 2-4.0 kg ha^{-1}. It has been found effective in case of nut grasses also.

RESOURCES AND METHODS

The field experiment was conducted under rain-fed conditions in the years (2015) at Agricultural Research Field SHUATS Allahabad UP. The experiment was laid out in Randomized Block Design with three replications. *Cyperusrotundus, Sorghumhalepense, Digeraarvensis, Echinochloa colona, Chenopodium album* L., *Partheniumhysterophorus* L. and *Cynodondactylon* were the main weed species found inmaize field. Eleven weed control methods were included in the study. These were; weed free, 2 hand weeding, Paddy straw mulching, black polythene mulching, Atrazine @ 0.75 kg ha^{-1}, Atrazine @ 1.00 kg ha^{-1}, Atrazine @ 1.50 kg ha^{-1}, Atrazine @ 0.75 kg ha^{-1} + hand weeding, Atrazine @ 1.00 kg ha^{-1} + hand weeding, Atrazine @ 1.50 kg ha^{-1} + hand weeding and un weeded plot. Ahybrid recommended maize variety (MRM 3777) was planted in the month of July in rows 60 cm apart 30 cm plant to plant distance. Recommended plant population was maintained for all crops. All other agronomic operations except those under study were kept normal and uniform for all the treatments. Standard procedures were adopted for recording the data on various growth and yield parameters. Data collected were statistically analyzed by using the Fisher's Analysis of Variance technique and cumulative difference test at 0.05 P was applied to compare the differences among treatments (Steel & Torrie, 1984).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

Weed density, weed dry weight, weed control efficiency and weed index :

Weed density (No. m^2) :

The data regarding the effect of different weed control methods, all weed control treatments reduced the

weed population significantly compared with un weeded plot. There many weed species that were observed in the field experiment, but the major weed species were:- *Cyperusrotundus,Sorghum halepense, Spergualaarvensis, Partheniumhysterophorus* L., *Echinochloa colona* and *Cynodondactylon*. Similar weeds prevailing in *Rabi* maize has been reported by Singh and Rajput, (1995). The statistically maximum (156.0 m^2) total weed density recorded in control plot (T11) where no weed control practices were done. The maximum reduction in density of the weeds was observed with the treatment T3 and T4 (61.0 m^2) followed by T9.Comparatively less reduction in weed density was observed with T11 (156.0m^2).These results are in line with those reported by Roy *et al.*(2002), Skoko and Zivanovic (2002). They reported that there has been significant difference in weed density of various weed density of various weed control practices and negatively affected the weed growth.

Weed dry weight (g m^2) :

The data regarding to weed dry weight was found to be significant differences and the weed continued to decrease up to 100 DAS (Table I). Similar trend was found in case of weed dry biomass as observed in weed density. The dry weight of *Cyperusrotundus, Sorghum halepense, Spergualaarvensis, Partheniumhysterophorus Echinochloa colona* and *Cynodon dactylon* at maturity was maximum reduced with the treatment T11 (83.17g), Comparatively less reduction in weed density was observed with T3 (20.70 g) and T3 (20.70 g). Similar finding was reported by Pandey and Prakash (1999).

Weed control efficiency (%) :

The data regarding to WCE (%),Shows that, the maximum weed control efficiency has a significantly affected by all weed control treatments (Table 1). The maximum weed control efficiency was recorded in the T9 and T3 in which Atrazine at 1.0 kg ha^{-1} + one hand weeding at 45 DAS should be applied and paddy straw mulching. A similar finding has been reported by Dadi *et al.* (1988) and Varshney (1990). The probable reason for increase in weed control efficiency was observed with successive decrease in weed population and the effect of herbicides or agronomic practices had effect on weed control efficiency.

Weed Index (%) :

Table 1 Shows that, the minimum amount of loss caused by weeds in T6 (Atrazine @ 1.0 kg ha^{-1}) followed by T10 (Atrazine @ 1.50 kg ha^{-1} + one hand weeding at 45 DAS). In weedy check (control plot), yield reduction was to be excess, which show the total loss of crop. The

Table 1 : Total number of weeds, weed dry weight (g), weed control efficiency (%) and weed Index (%) as Influenced by various treatments

Treatments	No. of broad leaves/m^2	No. of Grasses/ m^2	No. of Sedges/ m^2	Total	Weed dry weight (g)	WCE (%)	W I (%)
T_1= Weed free	17	49.67	31.67	88.33b	28.37c	65.77b	153.22d
T_2 = Hand weeding @ 20 and 45 DAS	9.68	41.67	27	88.33b	26.50c	68.00b	175.75b
T_3= Paddy straw mulching	8	25	18	61.00b	20.70d	74.90a*	173.53c
T_4 = Black polythene mulching	11	29.33	22	61.00b	21.33c	73.87a	142.40f
T_5= Atrazine @ 0.75 kg ha^{-1}	24	94.33	45	135.67a	28.33c	65.40b	132.56g
T_6 = Atrazine @ 1.0 kg ha^{-1}	27.33	81.67	49.33	141.33a	29.50b	64.11b	115.43j
T_7 = Atrazine @ 1.50 kg ha^{-1}	21.67	73.3	48.33	142.33a	26.67c	67.60b	149.06e
T_8 = Atrazine @ 0.75 kg ha^{-1} + Hand weeding @ 45 DAS	11	35.3	28.67	92.33b	22.50c	72.13a	130.15h
T_9 = Atrazine @ 1.0 kg ha^{-1} + Hand weeding @ 45 DAS	9.33	24	23.33	75.00b	20.50d	74.90a*	197.92a*
T_{10} = Atrazine @ 1.50 kg ha^{-1} + Hand weeding @ 45DAS	22.67	100.67	59.67	141.00a	36.43b	55.57c	122.46i
T11= Control plot	34.33	132.67	65	156.0a	83.17a	0.00	0.00
F-test				S	S	S	S
S.E. ±				18.094	3.410	2.670	2.670
C.D. (P=0.05)				37.347	7.038	5.510	5.510

probable reason for increasing in weed index was observed with successive in weed population and the effect of herbicide on agronomic practices had been due to minimum weed competition. A similar finding has been reported by Angiras and Singh (1999).

Yield and yield components :

Plant height (cm) :

Statistical analysis of the data regarding to plant height was significantly affected by various weed control methods. The maximum plant height (210.53 cm) was recorded with Application of Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS (T9) which was statistically at par with Black polythenemulching (203.20 cm) in T4, followed by Paddy straw mulching (201.87 cm) in T3.Whereas the significantly minimum plant height (109.47 cm) was recorded in weedy check control plot (T11). The variation in plant height of maize in all weed control methods could be attributed to varying effect of weed competition duration for available resources offered by different weed densities in different weed control practices. These results are in line with Akhtar *et al.* (1998) and Hussain *et al. (*1998), who stated maximum plant height was in control plots.

No. of grain rows/cobs/plant :

Data regarding number of cobs $plant^{-1}$ is shown in Table-2. Statistical analysis of the data indicated that various weed control methods had significantly ($p < 0.05$) affected on the number of cobs $plant^{-1}$.The effect of different weed control methods was a significant differences. Highest number of (13.80) grain row/cobs $plant^{-1}$ was produced by plots treated with the application of Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS. The statistical minimum number of grains rows per cob (7.5) was reported in control plot (T11). The observation of this parameter showed that good weed control methods are affective to get more number of grain rows per cob and consequently higher grain yield. These results are in close agreement with the results obtained by Singh *et al.* (1985) and Suleska*et al.* (2006), who reported that, weed control methods resulted in increased number of grain rows per cob.

No. of grains/row :

Analysis of the data also revealed that various weed control methods had significantly affected the number of grains row (Table 2). The maximum number of (35.60) grains/row was produced from the treatment applied with atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS. Minimum number of 8.20 grains/row was recorded in control treatment. The highest number of grains/row in application of atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS, because of very less number of weeds and consequently more photosynthesis are available for the growth and development. These results are in confirmatory to Tanveer *et al.* (1999). They concluded that all weeds control methods significantly increase the number of grain/row and the number of grains per cob.

Table 2 : Yield and yield components of maize as influenced by different weed control treatments

Treatments	Plant height (cm)	No. grains row/cob	No. of grains/rows/ cob	Cob length (cm)	1000-grain weight (g)
T_1= Weed free	186.40b	13.00b	30.60b	15.00a	172.95
T_2 = Hand weeding @ 20 and 45 DAS	193.27b	12.80b	30.40c	14.63a	188.34
T_3= Paddy straw mulching	201.87a	13.40a	31.00b*	15.17a	186.82
T_4 = Black polythene mulching	203.20a	12.00c	27.80e	13.93a	165.56
T_5= Atrazine @ 0.75 kg ha^{-1}	202.47a	12.20c	30.00c	13.73a	158.84
T_6 = Atrazine @ 1.0 kg ha^{-1}	190.47b	13.00b	29.40d	13.63a	147.14
T_7 = Atrazine @ 1.50 kg ha^{-1}	169.73c	12.40c	27.80e	13.20b	170.11
T_8 = Atrazine @ 0.75 kg ha^{-1} + Hand weeding @ 45 DAS	195.33b	13.00b	29.40d	14.37a	157.19
T_9 = Atrazine @ 1.0 kg ha^{-1} + Hand weeding @ 45 DAS	210.53a*	13.80a*	35.60a*	18.40a*	203.48a*
T_{10} = Atrazine @ 1.50 kg ha^{-1} + Hand weeding @ 45DAS	179.67c	12.20c	29.60d	13.83a	151.94
T_{11}= Comtrol plot	109.47d	4.40d	8.20f	7.50c	68.30g
F-test	S	S	S	S	S
S.E. ±	5.895	0.256	0.246	2.333	3.568
C.D. (P=0.05)	12.168	0.528	0.508	4.816	7.363

Cob length (cm) :

Cob length is also very important yield determining factor of maize crop. The longer cob length, more would be number of grains per cob and consequently higher yield in the form of grains. The data regarding to this parameter is given in Table-2 revealed that all weeds control methods significantly affected the cob length then weedy check i.e control plot. The data indicate that data indicate that, maximum cob length (18.40 cm) was obtained in application of Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS (T9) than all other treatments which was followed by Paddy straw mulching (15.17 cm in T3). The significantly minimum cob length (7.50 cm) was recorded in control plot (T11). The cob length was highly significantly in application of Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS was mainly due to effective of weed control methods and thus, less weed competition period in these treatment which allowed the plant to growth and produce more photosynthetic material by using available nutrients. These result is confirmatory with those of Singh and Singh (2003) and Stefanovic *et al.* (2004). They founded that greater cob length in weed control treatments and smallest cob in weedy check plots.

1000 grain weight (g) :

A part from combining effect of all the other individual yield determinant factors, the final grains yield of maize depends upon the 1000-grain weight and seed development nourished under applied inputs and various weed control treatments. Any variation in 1000-grain yield will affect the grains yield. The maximum 1000-grains weight (203.48 g) was attained with in application of Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS which was statistically at par with 2 hand weeding at 20 and 45DAS (188.33 g). The significantly minimum 1000-grains weight (68.30 g) was found in control plot. The significant variation for 1000-grains weight in weed control treatment plot then in weedy check plot due to vigorous growth and development of maize plants which was resulted in more yield photosynthetic assimilation in grains thus more 10000-grains weight. These result are inline with those of Tanveer *et al.* (1999), Hussain *et al.* (1998) and Baye and Bouchache (2007), who concluded that 1000-grains weight was greater in various control treatments than in weedy check plot.

Grain yield (t ha^{-1}) :

The Table 3 Show statistical analysis of the data on the grains yield was found to be significant. The pre-emergence Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS gave highest grains yield (8.79 t ha^{-1}) and was statistically similar to faddy straw mulching (5.98 t ha^{-1}) and it is closely to 2 hand weeding at 20 and 45 DAS. This may be due to lesser crop weed competition and least weed dry weight, which shows the effect of severe crop weed competition. The significantly minimum grain yield (0.05 t ha^{-1}) was recorded in control treatment plots. The probable reason for significant increase in grain yield was observe with successive increase in plant population and minimum weed competition and decrease in crop growth rate with decrease in plant population. Similar finding has been reported by Prodhan *et al.*

Table 3 : Grains yield, biological yield, harvest index and cost benefit ratio of maize as influenced by different treatments

Treatments	Grain yield (t ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)	B:C ratio
T_1= Weed free	5.29c	30.80d	34.20b	2.25
T_2 = Hand weeding @ 20 and 45 DAS	8.64a	39.00b	39.60b	2.44
T_3= Paddy straw mulching	5.98b	34.90c	35.60c	2.48
T_4 = Black polythene mulching	4.25d	32.17d	32.70d	1.95
T_5= Atrazine @ 0.75 kg ha^{-1}	3.93e	32.01d	32.70d	1.87
T_6 = Atrazine @ 1.0 kg ha^{-1}	3.71e	31.29d	31.70d	1.79
T_7 = Atrazine @ 1.50 kg ha^{-1}	3.23e	37.68b	38.00b	1.83
T_8 = Atrazine @ 0.75 kg ha^{-1} + Hand weeding @ 45 DAS	3.97e	34.36d	34.80c	1.94
T_9 = Atrazine @ 1.0 kg ha^{-1} + Hand weeding @ 45 DAS	8.79a*	39.98a*	41.90a*	3.40a*
T_{10} = Atrazine @ 1.50 kg ha^{-1} + Hand weeding @ 45DAS	3.62f	37.40b	37.70b	1.92
T_{11}= Comtrol plot	0.05g	30.86e	31.80e	0.82
F-test	S	S	S	
S.E. ±	0.103	0.661	0.528	
C.D. (P=0.05)	0.212	1.363	1.090	

(2007).

Biological yield (t ha^{-1}) :

In Table 1 Various weed control treatments had a significant effect on biological yield of the crop. The highest biological yield (42.02 t ha^{-1}) was gained in Application of pre-emergence Atrazine @ 1.0 kg ha^{-1} + one hand weeding and it was statistically at par with pre-emergence @ 1.50 kg ha^{-1} (37.68 t ha^{-1}), and 2 hand weeding @ 20 and 45 DAS (30.86 t ha^{-1}). The significant minimum biological yield (30.86 t ha^{-1}) was gained in control treatment (un weeded plot) which was statistically different from the remaining weed control practices.

Harvest Index (%) :

The data pertaining to the harvest index revealed that, harvest index was significantly differences in % harvest index of maize in all the treatments and shows the significant difference among the treatment. The increase in percentage of harvest index as compared with T9 may attributed to adequate suppression of weed growth due to some residual effect as well as more availability of plant nutrient to maize crops.

Economic analysis :

Table 3 Shows that, Treatment T9 (pre-emergence Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS) is found to be the best and economic methods of controlling weeds population, and it gave the maximum yield highest gross return and maximum benefit cost ratio in *Kharif* maize season. The maximum yield recorded from this treatment was (8.9 t ha^{-1}), highest gross return (Rs. 129920 ha^{-1}), net return (Rs. 91700 ha^{-1}) and benefit cost ratio 3.4.The cost of cultivation was maximum in weed free plot *i.e.* (Rs. 37463 ha^{-1}). Similar finding has been reported by Kolage *et al.* (2004).

Conclusion :

From the results of the experiments, it is concluded that pre-emergence application of Atrazine @ 1.0 kg ha^{-1} + one hand weeding at 45 DAS was found to be the best and economic method for obtaining highest with corn yield and less in weed density and weed dry weight.

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