

Weed Control and Fertilizer Interaction in Rainfed Maize (*Zea mays* L.)

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ABSTRACT

The study was aimed at assessing the effectiveness of hand weeding against chemical weed control in maize under four levels of NPK i.e. 0-0-0, 50-25-0, 100-50-0 and 150-100-0 kg/ha under rainfed conditions during 1983 and 1984. Pre-emergence applied herbicide used in the study was, atrazine + metolachlor (Primextra) at 2.0 kg ai/ha. Hand weeding and herbicide application both were effective in controlling weeds. Atrazine + metolachlor was found significantly better than hand weeding during both the years. However, hand weeding produced grain yields 2604.17 kg in 1983 and 2652.09 kg/ha in 1984 significantly higher than chemical weed control which was 2220.17 kg in 1983 and 2364.59 kg/ha in 1984. Fertilizer application rates, 150-100-0 and 100-50-0 produced grain yields of 2734.45 kg and 2665.56 kg (1983) and 2713.90 kg and 2597.23 kg/ha (1984) respectively, statistically at par with each other but different from all other fertilizer treatments. Hand weeding with 100 kg N and 50 kg P_2O_5 /ha produced yield of 3416.68 (1983) and 3250.01 kg/ha (1984) which were higher than the yields obtained by the chemical weed control even with 150 kg N and 100 kg P_2O_5 /ha. Weeding increased grain yields of maize from 64.29 to 116.25 percent over weedy check under different fertilizer rates during both the years. Chemical weed control was more

economical with a cost benefit ratio of 3.37 (1983) and 3.74 (1984) than hand weeding with a CBR of 2.69 (1983) and 2.73 (1984). Chemical weed control with 100 kg N and 50 kg P_2O_5 seems to be more economical with CBR of 3.49 and 3.46 during 1983 and 1984 respectively as compared to hand weeding with CBR of 3.12 (1983) and 2.88 (1984) under rainfed condition. From this study it is concluded that fertilizer application will only contribute to increase grain yield when weeds are controlled.

INTRODUCTION

Maize (*Zea mays* L.) after wheat and rice is the third important cereal in Pakistan. Besides, its use in supplementing the food and feed supplies, it is put to a number of industrial uses. With the expansion of poultry industry, it is quite likely that Pakistan will need to import maize and other feed grains in the near future (Amir, 1986).

In Pakistan, maize is cultivated under irrigated and rainfed conditions with over 20% of the area covered by this crop. However, yield per hectare in rainfed areas is well below the potential yield, which is attributed to so many factors, out of which improper use of fertilizer and poor weed control are of more importance. The stress that weeds exert on the cultivated crops, results from interference consisting of allelopathy, parasitism, and competitions. Weeds compete with the maize crop too, as they do with other crops for water, nutrients and light thus reduct-

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ing the yield of maize. The extent of damage due to weeds vary with the nature, intensity of weed infestation and duration for which weeds compete with maize plants. Reduction in yield varying from 25 to 80% is quite common (Gupta and Gangwar 1967, Blanco et al. 1978).

Traditionally, weeds are kept under control in maize mechanically or culturally. Khan (1979) reported that the number of weeds/unit area were more in the plots where hand weeding was done in maize as compared to herbicide application. Similarly Zafar et al. (1981) observed higher number of weeds per unit area (60 x 60cm) where the weeds were controlled manually in corn as compared to pre-emergence spray of Gesaprim. Effective weed control in maize by application of simazine 1-2 kg ai./ha was reported by Rathi and Tewari (1979). Higher yields of irrigated maize were obtained when weeds were controlled by hand weeding compared with chemical weed control (Carson, 1976, Zafar et al. 1981, Rathi and Tewari, 1979 and Rana 1980). However, it was found that chemical weed control was economical and more efficient as compared to hand weeding, in rainfed areas due to frequent and excessive rainfall during early growth stages, hand weeding in maize cannot be done in time. Under these conditions, pre-emergent herbicide application is the effective weed control method.

Chemical analysis of maize and weeds growing in maize has revealed that the weeds contained approximately twice as much nitrogen, 1.6 times as much phosphorus, 3.5 times as much potassium, 7.6 times as much calcium and 3.5 times as much magnesium as the maize (Kalingman, 1961).

Visanath (1980) found that weeds utilized 62 kg N - 23 kg P + 124 kg K/ha. In a study Balnco et al. (1980) observed that applied N reduced the effect of weed competition. Similarly Visvanath (1980) observed that weed dry matter and number were not significantly affected by fertilizer application.

Meelu et al. (1976) observed a significant increase in yield due to addition of 25 kg P₂O₅ and 50 kg N than N alone and there was no further increase in yield due to K application. Kasana and Ropal (1979) found that NPK application to maize in rainfed areas of Punjab at 54, 41 and 20.5 kg/acre gave a maximum net income of Rs.636/- and highest value cost ratio of 3.57. Shukla et al. (1978) reported that maize grain yields were higher with 60 kg N/ha in 1974, however, they were the highest with 90 kg N/ha in 1975 under midhill conditions of Himachal Pradesh. Visvanath (1980) reported that with 112.5 kg N + 56.3 kg P₂O₅ + 28.1 kg K₂O/ha, weed growth significantly affected crop yield when present 30 to 50 days after sowing. The present study was conducted to evaluate the effect of hand weeding and chemical weed control with different nitrogen and phosphorus rates on grain yield of maize under rainfed conditions.

MATERIALS AND METHODS

These studies were conducted at Arid Zone Research Sub-station, Rawalpindi for two years, during Kharif, 1983 and 1984 to find out suitable fertilizer dose for getting optimum yield of maize (variety Sunehry) and suitable method of weed control under rainfed conditions. The location of experiment receives an average annual rainfall of 750 mm, two third of which occurs during the growing season of

maize crop. The crop was sown on July 7, 1983 and July 11, 1984. In the experiment, hand weeding (W_2) was compared with chemical weed control (W_1) and weedy check (W_3) at four levels of NPK, 0-0-0 kg(F1), 50-25-0 (F2), 100-50-0 (F3) and 150-100-0 (F4)/ha. The system of layout of the experiment was split plot with three replications. The fertilizer treatments were randomized in main plots and the weed control treatments in the sub plots. The whole size of the experiment was 5m x 3m. All nitrogen and phosphorus as per plan of the trial, was applied at the time of sowing in the form of urea and single super phosphate respectively. The weeds were removed twice from plots under hand weeding treatment. The pre-emergence herbicide used was primextra, (atrazine - metolachlor) at the rate of 2.0 kg ai./ha to control the weeds of the respective plots. The data regarding weed population were collected from an area of 60 x 60cm randomly selected at three different places in each plot before the harvest of the crop. The crop was harvested from net plot size of 5M x 1.5M on October 10, 1983 and October 20, 1984. Grain yield per hectare was calculated and reported on 13% moisture basis. All the data so recorded were statistically analysed by Fisher's Method of Analysis of variance (Fisher, 1958). Duncan's New Multiple Range Test was used to see the significance of the treatments (Leclerge et al., 1962). In calculating the cost benefit ratio of weed control methods, cost associated with the inputs and operations required to raise a successful crop were kept constant. The economics of weed control was worked out on the basis of variable cost associated with treatments on the basis of prevailing market rates.

RESULTS AND DISCUSSION

The most common weeds in the fields were, *Cynodon dactylon*, *Echinochloa colonum*, *Digera arvensis*, *Cyperus rotundus*, *Sorghum halepense*, *Convolvulus arvensis*, *Tribulus terrestris* and *Amaranthus bilitum*. Weed population (Table-1) was significantly affected by weed control treatments. Weed density was significantly higher in hand weeded plots than in atrazine - metolachlor (2.0 kg ai./ha as pre-emergence applied) treated plots, but was significantly lower than control. Similar findings were reported by Khan (1979), Zafar et al. (1980) and Rathi and Tewari (1979). Weed density, however, was not significantly affected by fertilizer treatments and fertilizer x weed control treatments. Similar results were reported by Blanco et al. (1980) and visvanath (1980).

The grain yield (Table-2) was significantly affected by weed control treatments, fertilizer treatments and weed control x fertilizer treatments during the year, 1983 and 1984. The maximum yield of 2604.17 kg/ha (1983) and 2652.09 kg/ha (1984) obtained by hand weeding was significantly higher than the grain yield of 2229.17 kg/ha (1983) and 2364.59 kg/ha (1984) produced by chemical weed control. The results are quite in agreement with the reports of Carson (1976), Zafar et al. (1981), Rathi and Tewari (1979) and Rana (1980). Higher grain yields from hand weeding may be due to moisture conservation and aeration by hoeing.

Application of 150 kg N and 100 kg P_2O_5 /ha resulted in maximum grain yield of 2734.45 kg (1983) and 2713.90 kg/ha (1984) and application of 100 kg

Table 1. Weed density (60cm x 60cm) under different fertilizer rates and weeding methods

Treatments	F1 0-0-0	F2 50-25-0-	F3 100-50-0	F4 150-100-0	Means
1983					
W ₁ Weedy check	38	36	39	36	37.25 a*
W ₂ Hand weeding	10	11	13	11	11.25 b
W ₃ Chemical weeding Atrazine + Metolachlor 2.00 kg ai./ha.	6	8	9	9	8.00 c
Mean	18.0 ^{n.s.}	18.33	20.33	18.16	
1984					
W ₁ Weedy check	39	41	42	41	40.75 a*
W ₂ Hand weeding	10	13	13	14	12.50 b
W ₃ Chemical weeding Atrazine + Metolachlor 2.00 kg ai./ha.	9	9	10	10	9.50 c
Mean	19.33 ^{n.s.}	21.00	21.66	21.66	

* - Any two figures not sharing a letter differ significantly at 5% level of significance according to D.M.R. Test.

n.s. - Non significant.

Table 2. Grain yield of maize under different fertilizer application rates and weeding methods

Treatments	F1 0-0-0	F2 50-25-0	F3 100-50-0	F4 150-100-0	Means
1983					
W ₁ Weedy check	666.67 h*	1166.67 g	1580.00 f	1620.00 ef	1258.33 c*
W ₂ Hand weeding	1166.67 g	2333.34 c	3416.68 a	3500.02 a	2604.17 a
W ₃ Chemical weeding Atrazine + Metolachlor 2.00 gk ai./ha.	916.67 gh	1916.67 de	3000.02 b	3083.35 b	2229.17 b
Mean	916.67 c*	1805.56 b	2665.36 a	2734.45 a	
1984					
W ₁ Weedy check	708.34 g*	1308.34 ef	1516.67 e	1265.0 e	1289.59 e*
W ₂ Hand weeding	1291.67 ef	2683.34 c	3250.01 ab	3383.53 a	2652.09 a
W ₃ Chemical weeding Atrazine + Metolachlor 2.00 kg ai./ha.	1091.67 f	2208.34 d	3025.01 b	3133.35 ab	2364.59 b
Mean -	1030.56 c*	2066.67 b	2597.23 a	2713.90 a	

* - Any two figures not sharing a letter differ significantly at 5% level of significance according to D.M.R. Test.

N and 50 kg P₂O₅/ha ranked second giving grain yields of 2665.56 kg (1983) and 2597.23 kg/ha (1984). However, both these treatments were statistically at par with each other, but different from other fertilizer treatments and control. With the increased fertilizer doses, yield of maize increased. However, at very high fertilizer rates, the yield does not increase in accordance with fertilizer rates (Kasana and Ropal, 1979, Meela et al. 1976, Shukla et al., 1978 and Visvanath, 1980). The less increase in yield with the corresponding increase in fertilizer application rate may be due to low potential of the maize cultivar for assimilating fertilizer. As regards the interaction of the factors under study, during 1983, hand weeded plots with F₂ (150-100-0) and F₃ (100-50-0) treatments produced grain yield of 3500.02 kg and 3416.68 kg/ha respectively. They were statistically at par with each other but differed from all other combinations. Similarly chemically weed controlled plots with F₄ and F₅ treatments gave grain yield of 3083.35 kg and 3000.02 kg/ha, respectively. They were also significantly different from all other treatments but were not different from each other. During 1984, hand weeded plots with application of 150kg N + 100kg P₂O₅/ha gave the highest yield of 3383.33 kg/ha significantly different from all other combinations except the combinations, hand weeding + F₃ and chemical weed control + F₁, which gave grain yields of 3250.01 kg and 3133.35 kg/ha respectively. Hand weeding resulted into higher yields with lower doses of fertilizer (100-50-0) as compared to chemical weed control even with higher dose of fertilizer (150-100-0). Percent increase in grain yield of maize (Table 3) due to hand weeding ranged from 75 to 116.25 and 82.35 to 144.29 in 1983 and 1984, respectively

over weed check under different fertilizer rates. Whereas chemical weeding resulted 37.50 to 90.33% and 82.35 to 92.82% increase in grain yield of maize over no weeding during 1983 and 1984 respectively. There was 82.35% and 89.87% increase in grain yield of maize under fertilizer application + F₁ and hand weeding and chemical weeding respectively over no weeding in 1983. Similarly yield of maize under F₁ increased by 116.05 and 90.33% with chemical weeding and hand weeding respectively over weedy check. Similar increases in grain yield of maize over hand weeding were also found during 1984 under all fertilizer application. From the results it becomes clear that weeding enhanced the impact of fertilizer application on grain yield.

Cost benefit ratio of weed control treatments, fertilizer treatments and fertilizer x weed control treatments were calculated for the years 1983 and 1984 (Table-4). The economic analysis revealed that chemical weed control proved better than hand weeding both the years. In this case by investing one rupee on weeding with chemical weeding one can get Rs.3.47 (1983) and Rs.2.73 (1984). Cost benefit ratio of chemical weed control high over hand weeding has been reported by other research workers (Zafar et al., 1988, Pathak et al., 1988, and Qayum et al., 1988). However, these researchers and Visvanath (1980) reported that hand weeding gave higher net benefit than that of chemical weeding. This method. Cost benefit ratios for different combinations of both the factors under study were also worked out. Amongst these combinations, F₂W₂ gave the highest cost benefit ratio of 3.49 (1983) and 3.46 (1984) followed by treatment F₂W₂ in 1984 with CE. The cost benefit ratio calculation

N and 50 kg P₂O₅/ha ranked second giving grain yields of 2665.56 kg (1983) and 2597.23 kg/ha (1984). However, both these treatments were statistically at par with each other, but different from other fertilizer treatments and control. With the increased fertilizer doses, yield of maize increased. However, at very high fertilizer rates, the yield does not increase in accordance with fertilizer rates (Kasana and Ropal, 1979, Meelu et al. 1976, Shukla et al., 1978 and Visvanath, 1980). The less increase in yield with the corresponding increase in fertilizer application rate may be due to low potential of the maize cultivar for assimilating fertilizer. As regards the interaction of the factors under study, during 1983, hand weeded plots with F₁ (150-100-0) and F₂ (100-50-0) treatments produced grain yield of 3500.02 kg and 3416.68 kg/ha respectively. They were statistically at par with each other but differed from all other combinations. Similarly chemically weed controlled pots with F₃ and F₄ treatments gave grain yield of 3083.35 kg and 3000.02 kg/ha, respectively. They were also significantly different from all other treatments but were not different from each other. During 1984, hand weeded plots with application of 150kg N + 100kg P₂O₅/ha gave the highest yield of 3353.33 kg/ha significantly different from all other combinations except the combinations, hand weeding + F₃ and chemical weed control + F₁, which gave grain yields of 3250.01 kg and 3133.35 kg/ha respectively. Hand weeding resulted into higher yields with lower doses of fertilizer (100-50-0) as compared to chemical weed control even with higher dose of fertilizer (150-100-0). Percent increase in grain yield of maize (Table 3) due to hand weeding ranged from 75 to 116.25 and 82.35 to 144.29 in 1983 and 1984, respectively

over weed check under different fertilizer rates. Whereas chemical weeding resulted 37.50 to 90.33% and 54.11 to 92.82% increase in grain yield of maize over no weeding during 1983 and 1984 respectively. There was 166.25 and 89.87% increase in grain yield of maize under fertilizer application rate F₁ and hand weeding and chemical weeding respectively over no weeding in 1983. Similarly yield of maize under F₄ increased by 116.05 and 90.33% by weedicide application and hand weeding respectively over weedy check. Similar increases in grain yield by weeding were also found during 1984 under all fertilizer application rates. From the results it becomes evident that weeding enhanced the impact of fertilizer application on grain yield.

Cost benefit ratio of weed control treatments, fertilizer treatments and fertilizer x weed control treatments were calculated for the years 1983 and 1984 (Table-4). The economic analysis revealed that chemical weed control proved better than hand weeding during both the years. In this case by spending one rupee on weeding with primextra one can get Rs.3.47 (1983) and Rs.2.73 (1984). Cost benefit ratio due to chemical weed control higher than hand weeding has been reported by the research workers (Zafar et al., 1985, Pathak et al. 1988, and Qayum et al., 1988). However, these research workers and Visvanath (1980) reported that hand weeding gave higher net benefit than that of chemical weed control method. Cost benefit ratios for different combinations of both the factors under study were also worked out. Amongst these combinations, F₁W₁ gave the highest cost benefit ratio of 3.49 (1983) and 3.46 (1984) followed by treatment F₂W₂ in 1984 with CBR 3.15. The cost benefit ratio calculations also

Table 3. Percentage increase in grain yield of maize due to weeding under different fertilizer application rates

Weeding treatments:	F1	F2	F3	F4
	0-0-0	50-25-0	100-50-0	150-100-0
1983				
W ₂ Hand weeding	75.00	100.00	116.25	116.05
W ₃ Chemical weeding Atrazine + Metolachlor 2.00 kg ai./ha.	37.50	64.29	89.87	90.33
1984				
W ₂ Hand weeding	82.45	105.06	111.29	108.21
W ₃ Chemical weeding Atrazine + Metolachlor 2.00 kg ai./ha.	54.11	68.79	99.45	92.82

Table 4. Cost benefit ratio of different fertilizer application rates under different weeding methods

Weeding treatments	Fertilizer application rates (NPK)				CBR for weeding methods
	0-0-0	50-25-0	100-50-0	150-100-0	
1983					
W ₁ Weedy check	—	2.62	2.39	1.53	—
W ₂ Hand weeding	1.00	2.41	3.12	2.52	2.69
W ₃ Chemical weeding (Atrazine + Metolachlor 2.00 kg ai./ha.)	0.87	2.61	3.49	2.65	3.37
CBR for fertilizer application rates.	—	4.66	4.59	2.91	—
1984					
W ₁ Weedy check	—	2.86	2.12	1.47	—
W ₂ Hand weeding	1.17	3.15	2.88	2.38	2.73
W ₃ Chemical weeding (Atrazine + Metolachlor 2.00 kg ai./ha.)	1.33	3.14	3.46	2.66	3.74
CBR for fertilizer application rates.	—	5.43	4.11	2.70	—

show that all the fertilizer application rates in this study were found more economical combined with weeding operation as compared to when they were applied without weeding during both the years. Therefore, it can be concluded that fertilizer will increase maize yield only with the proper eradication of weeds.

The choice for adopting weed control methods by the farmer would further depends on the availability of funds, equipment, labour, herbicides and know how to apply the chemical properly. Hand weeding is quite effective method of weed control but it is more costly, laborious and time consuming and less efficient. Moreover, in rainfed areas due to frequent rains during early growth period of maize, hand weeding can not be done in time. Therefore, in addition to control of weeds by chemicals and hand weeding, use of clean seed, control on dissemination of weed seeds and cultural control should also be adopted.

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