IMPACT OF INTEGRATED WEED MANAGEMENT ON WEEDS AND YIELD OF MAIZE

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ABSTRACT

A field study was conducted at Agricultural Research Farm, NWFP Agricultural University Peshawar during summer 2006 to evaluate integrated weed management in maize, variety "Azam". Randomized complete block design, having three replications was used in the experiment. The treatments were; 1) Stomp (pendimethalin) 330 EC + high population (90,000 plants ha^{-1}), 2) Stomp + medium population (60,000 plants ha^{-1}), 3) Stomp + low population (30,000 plants ha^{-1}), 4) Stomp + weeding 4 weeks after sowing (WAS) + high population, 5) Stomp + weeding 6 weeks after sowing (WAS) + medium population, 6) Stomp + weeding 8 weeks after sowing (WAS) + low population, 7) weeding 4 weeks after sowing (WAS) + high population, 8) weeding 6 weeks after sowing (WAS) + medium population, 9) weeding 8 weeks after sowing (WAS) + low population, 10) control + high population, 11) control + medium population and 12) control + low population. The major weeds infesting the experimental field were Cyperus rotundus, Sorghum halepense, Echinochloa crus-galli, Digitaria sanguinalis, Portulaca oleracea and Digera muricata. Analysis of the data showed that higher crop density greatly suppressed weeds and their dry biomass. However Stomp proved to be the best in controlling weeds. In Stomp treated plots, maximum light was intercepted by the crop plants which indicate the vigour of the crop plants. Maximum grain yield (3.613 t ha^{-1}) was recorded in Stomp + medium population + weeding 6 WAS while minimum grain yield (2.430 t ha^{-1}) was recorded in control + low population. Increasing weed control, significantly increased the grain yield and other yield related traits of maize. However combination of high crop population, hand weeding and Stomp proved more effective against weeds and favoured crop. Stomp was not effective against C. rotundus therefore hand weeding in combination with Stomp application is recommended for getting higher maize yield.

Key words: Maize, integrated weed management, weeds, yield

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INTRODUCTION

Maize is the most important cereal crop of the world, after wheat and rice. Botanically, it is known as *Zea mays* L. while its vernacular name is Maki and belongs to family Poaceae. It is an annual cross pollinated crop with thick and strong stem, bears leaf at each node. The leaf consists of a sheath and a broad, large blade. The sheath covers the stem. The male or terminal inflorescence is called tassel while female inflorescence known as ear is in the middle (Khalil and Jan, 2004). The internodes are straight and nearly cylindrical in the upper part of the plant but alternatively grooved on the lower part (Arnon, 1972).

Maize is one of the most important food crops in Pakistan and is increasingly gaining an important position in crop husbandry because of its higher yield potential and short growth duration. It contributes a lot to the economy of the country, as it is a rich source of food, fodder, feed and also provide raw materials for the industry. In recent years corn oil is becoming popular among the people due to its non cholesterol character. In addition, its products like corn starch, corn flakes, gluten germ cake, lactic acid, alcohol and acetone are either directly consumed as a food or used by various industries like paper textile, foundry and fermentation etc. About two-third of the total world production of maize is used for livestock feed or for commercial starch and oil production (Khalil and Jan, 2004). It is estimated that 75% of the total production of maize is used as food by the farming community and the remaining finds its way in starch manufacturing industry, poultry feed and urban food grain sales (Muhammad, 1979).

Maize has a great promise of higher yield and easy cultivation than any other cereal crop and if managed properly can go a long way in increasing food production in our country. But unfortunately, in spite of its great yield potentials, the average yield in Pakistan is still very low as compared to other important maize growing countries of the world. To obtain better grain yields, it is essential to maintain the optimum number of plants ha^{-1}. Because it is an important factor for controlling weeds and increased yield. Weeds compete with maize for nutrients, soil moisture, space and light and considerably reduce the yield and the quality of the crop (Hussain, 1983). Apart from population density introduction of chemical weed control is necessary to replace traditional weed control measures. Chemical weed control certainly has its merits over traditional weed control methods. Weed control in maize through the use of herbicides has received little attention in Pakistan and particularly in NWFP (Shah, 1998).

Integrated weed management (IWM), which involves the combination of two or more weed control practices, has been identified as a viable alternative to the current methods of weed control (Akobundu 1992; 1996). IWM can lead to sustainable food production, minimize drudgery, and reduce the cost of removing weeds from crops. Hand weeding is difficult in maize due to very high temperature during the hot months of June, July and August. Similarly the herbicide application cause weed shift, herbicide resistance in weeds and environmental pollution. As atrazine based herbicides are used in maize in NWFP which has longer residual life in soil, therefore cultural and most importantly IWM is a good option for controlling weeds. Integrated weed management uses all available weed control options in the best possible way to manage weeds. Such option include crop rotation, cover crops, intercropping, manipulation of nitrogen fertility, planting pattern, tillage systems, critical period of weed control, alternative weed management strategies in conservation tillage systems and economic thresholds. All these practices are components of an IWM system and none of these control measures on their own can be expected to provide acceptable levels of weed control. Therefore, instead of banking on a particular method of weed control, an IWM system uses a mixture of methods of weed control; for example, reduced rates of herbicides can be combined with mechanical tillage for improved weed control. Weed interference in maize is a serious problem in NWFP and cause considerable yield losses. Various summer annual and perennial weeds infest the maize crop and thus share the available resources like moisture, sunlight, nutrients and space. Therefore numerous researchers have documented the importance of weed control in maize. Ali *et al*. (2003) reported that herbicides significantly increased maize yield and decreased the weed density. Khan *et al.* (2003) reported that weeds decreased the grain yield of maize.

This study was therefore conducted to evaluate the influence of combinations of herbicide, time of weeding and population densities of maize on weeds and crop yield.

The specific objectives of the study were:

i. To evaluate the effect of integrated weed management on yield and yield related traits of maize.
ii. To compare the effectiveness of different weed control methods.

MATERIALS AND METHODS

An experiment was conducted at Agricultural Research Farm, NWFP Agricultural University, Peshawar, Pakistan during summer 2006. Peshawar lies between 71^0-27' and 72^0-47' east longitude and 33^0-40' and 34^0-31' north latitude. The experimental site had mean soil pH of 7.47 with 22.8,55.7 and 21.5% clay, silt and sand, respectively.

The experiment was laid out in Randomized Complete Block (RCB) design with three replications. Field was ploughed thrice to make a fine seedbed followed by planking. Weather (temperature, rainfall, humidity and soil temperature) data were recorded during the crop season (Fig. 1). Experimental field was irrigated when needed. The size of each treatment was 3x5m. There were 12 treatments in the experiment with row to row distance of 75 cm. Number of rows in each treatment were four. There were three maize population viz., high (90,000 ha^{-1}), medium (60,000 plants ha^{-1}) and low (30,000 plants ha^{-1}) in combination with different weed control treatments. The seed rate was used higher than the required and then thinning was done after complete germination to maintain the required plant population. Maize seed was sown by drill method. Maize variety 'Azam' was used in the experiment. Nitrogen was applied at the rate of 120 kg ha^{-1} in the form of urea and P_2O_5 was applied in the form of SSP at the rate of 60 kg ha^{-1}.

The experiment was comprised of the following treatments.

i. Stomp 330 EC + high population (90,000 plants ha^{-1})
ii. Stomp 330 EC + medium population (60,000 plants ha^{-1})
iii. Stomp 330 EC + low population (30,000 plants ha^{-1})
iv. Stomp 330 EC + weeding 4 weeks after sowing (WAS) + high population
v. Stomp 330 EC +weeding 6 weeks after sowing (WAS)+medium population
vi. Stomp 330 EC + weeding 8 weeks after sowing (WAS) + low population
vii. Weeding 4 weeks after sowing (WAS) + high population
viii. Weeding 6 weeks after sowing (WAS) + medium population

ix. Weeding 8 weeks after sowing (WAS) + low population
x. Control + high population
xi. Control + medium population
xii. Control + low population

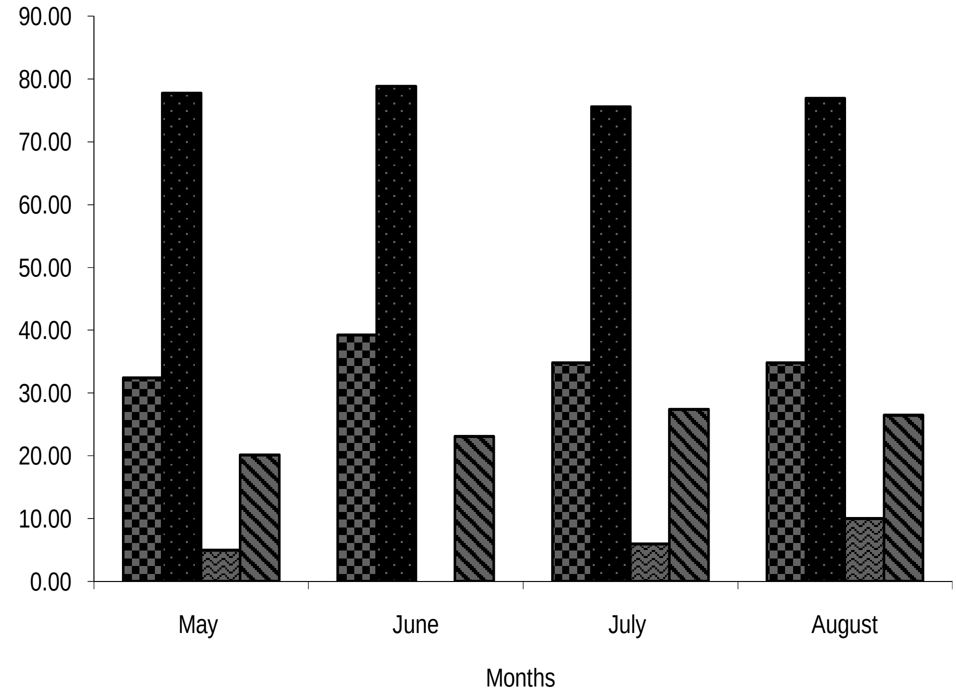

Fig.-1. Meteorological data during the crop season.

The following parameters studied during the course of the experiment;

Weed density (m^{-2}) 25 days after sowing (DAS)

Weeds density data were recorded 25 days after sowing. Each time quadrate having size 0.5 x 0.5 m^2 was placed randomly three times in each treatment. The weeds inside the quadrate were counted and identified to determine the weed density. Average was calculated and then subsequently converted into m^2.

Dry biomass of weeds (m^{-2}) 25 days after sowing (DAS)

Quadrate was randomly thrown at three places in each treatment and the weeds inside each quadrate were harvested, and then oven dried for 48 hours at 70 ^{0}C. Average dry weight was calculated and then were converted into m^2.

Percent light interception (PLI)

Radiation interception (RI) was calculated as (1-It/Io) x 100 where It is incident PAR just below the canopy and Io is incident PAR at the top of the canopy. The value It and Io was obtained with the help of Digital Lux Meter. Data were recorded after complete tasseling. Readings were recorded at 1100-1300 hr on sunny days.

Grain yield (t ha^{-1})

Central two rows were harvested in each treatment. Grain yield was recorded after threshing cobs of each treatment and then were converted into kg ha^{-1} by using the following formula and subsequently converted to t ha^{-1}:

$$\text{Grain yield (kg ha}^{-1}\text{)} = \frac{\text{Grain weight (kg) x 10,000}}{\text{Area harvested (m}^2\text{)}}$$

Statistical Analysis

The data recorded were statistically analyzed using MSTATC Software. The purpose of analysis of variance was to determine the significant effect of treatments on weeds and maize. LSD test at 5% probability level was applied when analysis of variance showed significant effect for treatments (Steel and Torrie, 1980)

RESULTS AND DISCUSSION

Weed density (m^{-2}) 25 days after sowing

Statistical analysis of the data showed that different treatments significantly affected the weed density 25 days after sowing (Table-1). It was noted that maximum weed density (244 m^{-2}) was recorded in control + low maize population. However the weed density (235.1m^{-2}) in the control + high population was at par with control + low population (Table-2). Minimum weed density (45.47 m^{-2}) was recorded in Stomp+ medium population + weeding 6 WAS (weeks after sowing). These results depicted that Stomp combining with medium maize population and weeding at 6 weeks after sowing effectively controlled the weeds. The weed density in control+medium population, weeding 8 WAS + low population, weeding 4 WAS at high population were close to the control. The respective values were 183m^{-2}, 153.6 m^{-2} and 113.7 m^{-2}, respectively. Similarly the weed density in Stomp + weeding 8 WAS + low population, Stomp + weeding 4 WAS + high population, Stomp + medium population, Stomp + high population and Stomp + low population, were close to minimum values. The respective values were 92.37 m^{-2}, 87.10 m^{-2}, 105.8 m^{-2}, 116.6 m^{-2}, and 113.0 m^{-2}, respectively. These results are in agreement with Hafeezullah (2000) and Khan *et al.* (2003). They reported that weed control methods like application of herbicides and hand weeding significantly decreased weed density. The present findings revealed that Stomp application in combination with hand weeding can show promising results. Apart from other weeds, C*yperus rotundus* was also found in the experimental field, therefore Stomp did not control all the weeds. Similarly hand weeding alone was not effective against the perennial weeds due to regrowth. Overall the results suggest that physical and cultural methods like hand weeding and higher seed rate is not answer to the weeds problem. For controlling summer weeds in maize, chemical weed control is effective and easy. However to make the weed control method more environment friendly, IWM is the best option. Control treatments indicated that higher seed rate can support the weed control methods as at higher crop density, weeds can be suppressed as maize has fast growth rate at early stage. Abdullah (2007) reported that herbicides significantly decreased the weeds density in maize. These results depicts that all the weed control methods like higher crop density, weeding and herbicides are helpful in controlling weed. However, a single method was not effective to control the weeds effectively. Hence the present study suggests that IWM is the only answer for sustainable crop production. Stomp being pre-emergence herbicide kill the germinating weeds therefore weed control at early stage of the crop will give a chance to the crop to shade the late germinating weeds.

Table 1. Mean squares (MS) for the parameters as affected by different treatments in maize.

``	Degree of freedom	Weed density 25 DAS	Weed biomass 25 DAS	Percent Light Interception	Grain yield (t/ha)
Replications	2	7.694	1521.264	1.494	0.051
Treatments	11	10491.235*	19414.904*	5.461	0.397**
Error	22	39.786	298.816	7.650	0.024
CV %	--	4.64	6.91	3.05	5.41

NS = Non Significant
** = Significant at 5% level of probability.

Table 2. Weed density and dry biomass m^{-2} 25 DAS, Percent light interception and grain yield as affected by different treatments in maize.

Treatments	Weed density 25 DAS	Dry biomass 25 DAS	Percent Light Interception	Grain yield (t ha^{-1})
Stump 330 EC + high Population	116.6 e	212.6 ef	91.200b	2.777 def
Stomp 330 EC + Medium Population	105.8 f	194.7 feg	91.817a	3.043 bc
Stomp 330 EC + Low Population	113.0 ef	209.9 ef	91.483b	2.787 cde
Stomp 330 EC + high Population + weeding 4 WAS	87.10 g	173.9 gh	93.513a	3.407 a
Stomp 330 EC + Medium Population + weeding 6 WAS	45.47 h	163.3 h	89.187e	3.613 a
Stomp 330 EC + low Population + weeding 8 WAS	92.37 g	183.3 fgh	91.900a	2.873 bcd
Weeding 4 WAS + high Population	113.7 d	250.1 d	89.227d	2.590 efg
Weeding 6 WAS + medium Population	123.1 de	219.4 e	90.477c	3.103 b
Weeding 8 WAS + low Population	153.6 c	281.3 c	90.780c	2.780 de
Control + high Population	235.1 a	352.1 b	89.863d	2.540 efg
Control + Medium Population	183.0 b	358.7 b	90.707c	2.517 fg
Control + Low Population	244.0 a	402.3 a	88.863d	2.430 g
LSD 0.05	10.68	29.27	2.54	0.2623

WAS = Weeks after sowing, DAS = days after sowing
Value followed by different letters are significant different at 5% level of probability level.

Dry biomass (g m^{-2}) 25 days after sowing

Statistical analysis of the data presented in Table-1, indicated that weed biomass was also significantly affected by different treatments. The maximum (4023 g m^{-2}) dry weed biomass was recorded in control + low population, while minimum weed biomass (163.3 g m^{-2}) was noted in Stomp 330 EC + medium population + weeding 6 WAS (Table-2). These results depicted that Stomp combining with medium maize population and weeding 6 weeks after sowing effectively controlled the weeds. The weed biomass in control + medium population, control + high population, weeding 8 WAS +low population, weeding 6 WAS +medium population and weeding 4 WAS + high population were close to maximum value. The respective values were 358.7, 352.1, 281.3, 219.4 and 250.1 g m^{-2}. The weed biomass in Stomp

+ low population +weeding 8 WAS, and Stomp + high population +weeding 4 WAS were 183.3 m^{-2} and 173.9 m^{-2} which were close to the minimum value. The results were in agreement with Shakoor *et al.* (1986). They reported that dry biomass of weed from the weedy control plots was significantly greater than chemical and manual weeded plots. Hafeezullah (2000) also reported similar results. He concluded that dry weight of weeds was significantly affected by different herbicidal treatment. In crop/weed competition relationship, weed biomass is considered as more important than weed density. The present findings revealed that the weed dry weight at lower crop plant population was greater than at higher plant population. Similarly, the dry weight of weeds was greater in weedy check plots than weed control treatments. In a similar way, weed biomass was lower in Stomp treated plots. The results suggest that weed dry biomass can be decreased if Stomp was applied. However, application of Stomp in combination with other cultural and physical method of weed control would be more effective against weeds. The results were in agreement with Shakoor *et al.* (1986). They reported that dry biomass of weed from the weedy control plots was significantly greater than chemical and manual weeded plots. Gonzalez and Salas (1995) also reported that herbicide application decrease the dry biomass of weeds however this decreasing trend is dependent on several factors e.g. type of weed species, herbicides etc.

Percent light interception (PLI)

Statistical analysis of the data showed that light interception was significantly affected by different treatments assigned to different plots as shown in Table-1. Maximum light interception (93.513) was recorded in Stomp + high population + weeding 4 WAS, while minimum PLA (88.863) was recorded in control + low population. The PLI (91.900) recorded in Stomp + low population + weeding 8 WAS was close to maximum value. However PLI (91.817) recorded for Stomp 330 EC + medium population, PLI (91.483) recorded for Stomp 330 EC + low population and PLI (91.200) recorded for Stomp 330 EC + high population were statistically close to each other. Similarly PLI (89.86) recorded for control + high population were very close to minimum PLI (88.863), which was recorded for control + low population. PLI (90.780) recorded for Weeding 8 WAS + low population were also very close to PLI (90.477) recorded for weeding 6 WAS + medium population. The data presented in Table 2 indicated that overall medium plant population of maize intercepted more light as compared to very high or very low plant population. Hence the present findings suggest that at very high plant population of maize, the vegetative growth of maize is restricted and thus crop plants produce less leaf area which ultimately intercept less. As maize do not produce tillers therefore the plant population do not compensate for vegetative growth. Thus weeds take advantage of the niche and compete with the crop plants for resources. Maddonni *et al.,* (2001) reported that four maize hybrids of contrasting plant type modifications in shoot size and leaf orientation suggest shade avoidance reactions, probably triggered by a reduction in the red:far-red ratio of light within the canopy. An interaction between hybrid and plant rectangularity on leaf azimuthal distribution was determined, with one hybrid displaying a random azimuthal leaf distribution under most conditions.

Grain yield (t ha^{-1})

ANOVA indicated that grain yield was significantly affected by different treatments (Table-1). The data presented in Table-2 indicated that maximum (3.613 t ha^{-1}) grain yield was recorded in Stomp 330 EC + medium population + weeding 6 WAS which was statistically at par with 3.407 t ha^{-1} recorded in Stomp + high population + weeding 4 WAS. While minimum grain yield (2.430 t ha^{-1}) was recorded in control + low population followed by control + medium population (2.517 t ha^{-1}) and control + high population (2.540 t ha-1). Different weed control treatments performed differently and thus different values for weed density, dry biomass and grain yield were obtained. The grain yield in the different treatments ranged from 3.613 – 2.430 t ha-1. The present results revealed that weed control and plant population both can play a vital role in obtaining greater yield of maize. Overall herbicide application proved effective in controlling weeds and increasing the grain yield. Hence it can be concluded from the present findings that plant population and weed control both in combination could be a better weed management technique for obtaining higher grain yield of maize. As the number of kernels cob^{-1}, 500 kernel weight and cob length increased significantly by different treatments the yield was also increased. Gonzalez and Salas (1995) reported that high grain yield was obtained from those plots in which weeds were controlled.

Overall Stomp proved to be the best weed control method if other limitations were not considered. However, combination of Stomp with any other physical and cultural method proved more effective than sole use of Stomp.

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