Middle East Journal of Agriculture Research
ISSN 2077-4605

Volume : 07 | Issue : 01 | Jan.-Mar. | 2018
Pages:175-181

Effect of Tillage Practices and Weed Control Methods on Yield and Yield Components of Maize

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Received: 06 Jan. 2018 / Accepted: 25 Feb. 2018 / Publication date: 07 Mar. 2018

ABSTRACT

The research was carried out at Agronomy Research Farm of the University of Agriculture Peshawar, during summer 2016. The study was conducted in randomized complete block design (RCBD) with split plot arrangement with four replications. Tillage practices (chisel plough + rotavator, mouldboard plough + rotavator, cultivator + rotavator and rotavator) were assigned to main plots. Weed control methods (control, hoeing 15 days after sowing (DAS), hoeing 15 and 30 DAS, hoeing 15, 30 and 45 DAS, and herbicide i.e. Nicosulfuron) were assigned to sub-plots. Results indicated that the treatment of chisel plough + rotavator had significantly reduced fresh and dry weight of weeds at 60 days after sowing (DAS), and produced highest grains ear^{-1}, thousand grains weight, grain yield and stover yield as compared to other tillage practices. Among weed control methods, the treatment of hoeing 15, 30 and 45 DAS produced maximum grains ear^{-1}, thousand grains weight, grain yield, stover yield, and lowest weeds fresh and dry weight at 60 DAS. It is concluded that chisel plough + rotavator and hoeing 15, 30 and 45 days after sowing (DAS) has significantly decreased weeds fresh weight and weeds dry weight at 60 DAS and improved yield and yield components in maize crop.

Key words: Chisel plough, mouldboard plough, rotavator, hoeing, grain yield

Introduction

Maize (*Zea mays* L.) belongs to family poaceae, an essential cultivated cereal crop all over the world and has a great economic importance in poultry and livestock production (Harris *et al*., 2007). Being tropical region crop, it is grown on a large area in Pakistan every year in summer. In the year 2014-2015, in Pakistan it was grown on an area of 1142.5 thousand hectares which produced 4936.8 thousand tons grains and mean yield was 4321 kg ha^{-1}. In KP, it was cultivated on 463 thousand hectares with a whole production of 909.7 thousand tones and mean yield was 1965 kg ha^{-1} (MNFSR, 2015).

Tillage is one of the most important components of crop production system that influence crop yield. About 20% yield contribution is due to tillage implements amongst the crop production elements (Khurshid *et al*., 2006). Plowing operations and disturbance of soil usually can improve soil aeration, mineralization of organic nitrogen and its availability for plant consumption (Halvorson *et al*., 2001; Dinnes *et al*., 2002). A hard seedbed may possibly reduce growth of seedlings and severely disturb crop production. The success or failure of crop production system amongst different variables depends upon seedbed environment. Weeds control is one of the utmost important factors for sustainable agriculture (Arif *et al*., 2013). Weeds are unwanted plants species growing in yieldable crops. The idea of weeds as undesirable plants was considered when man began to develop plants for food and other different purposes (Dangwal *et al*., 2010). Weeds infestation is also responsible for low yield of the crops. Extreme weeds growth in corn field leads to 66 - 80 % reduction in crop yield (Adigun, 2001; Ford and Pleasant, 1994). Weeds compete for space, water, light and nutrients with main crop and thereby decreasing crop yield and increasing production cost (Shah *et al*., 2003). About half of the maize yield may be reduced when weeds are not sufficiently controlled (Chikoye *et al*.,

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2001). Weeds can be controlled through several measures such as cultural, mechanical, biological and chemical methods.

Lacking suitable tillage practices with conventional weeds control measures are the key problems in declining yield of maize in Pakistan. Keeping in view the importance of tillage practices and weed control methods, the present research was conducted to find out suitable tillage practice(s) along with proper weed control method(s) for attaining higher maize yield.

Materials and Methods

Experimental Site

The experimental site (34°00'43.2"N 71°28'00.4"E) was Agronomy Research Farm of the University of Agriculture Peshawar, Pakistan. Peshawar is located at 34ºN latitude, 71ºE longitude with an altitude of 350m above sea level and has a sub-tropical climate.

Soil description

Soil of experimental site was alkaline (pH 8.02) and calcareous in nature, low in organic matter (0.845 g kg^{-1}), non-saline (EC (1:1) 0.87 d S m^{-1}), low in available nitrogen (0.04 g kg^{-1}) and phosphorous (4 mg kg^{-1}) with near sufficient in potassium (80 mg kg^{-1}). The texture of the soil was silty clay loam having 40% clay, 51.3% silt and 8.7% sand. Canal water was available for irrigation (Saleem *et al*., 2015).

Experimental details

A field experiment was conducted at Agronomy Research Farm of the University of Agriculture Peshawar, Khyber Pakhtunkhwa during kharif season 2016. The experiment was carried out in randomized complete block design (RCBD) with split-plot arrangement. Each treatment was replicated 4 times. Experiment was comprised of two factors namely tillage practices and weed control methods. Tillage practices (chisel plough + rotavator, mouldboard plough + rotavator, cultivator + rotavator and rotavator) were allotted to main plots and weed control methods (control, hoeing 15 days after sowing (DAS), hoeing 15 and 30 DAS, hoeing 15, 30 and 45 DAS, and herbicide i.e. Nicosulfuron) to subplots. Azam variety of maize was sown with a seed rate of 30 kg ha^{-1}. Row to row distance was 0.75 m and plant to plant distance was maintained 0.2 m. The sub plot size was kept 3 m x 3.75 m. Recommended nitrogen and phosphorous was applied at the rate of 150 and 90 kg ha^{-1} from urea and diammonium phosphate (DAP), respectively. Herbicide, Nicosulfuron was applied at the rate of 750 ml ha^{-1} to suppress both grassy weeds and broad leaf weeds. The herbicide was sprayed at 4-5 leaf stage of weeds (25 days after sowing of maize crop). All other agronomic practices were applied equally to each experimental unit. Data was recorded on weeds fresh weight (g m^{-2}) at 60 days after sowing (DAS), weeds dry weight (g m^{-2}) at 60 days after sowing (DAS), number of grains ear^{-1}, thousand grains weight, grain yield and stover yield.

Procedure for recording data

A 25 cm x 25 cm iron ring was randomly thrown at three different places into each experimental unit. Within the ring weeds were cut down and were weighed to find out weeds fresh weight. The weeds were then sun dried for ten days to a constant weight and then weighed to find out weeds dry weight. The data was then converted into g m^{-2}. Data regarding number of grains ear^{-1} were recorded by counting the number of grains in ten randomly selected cobs in each sub plot and were then averaged for a single mean value. The cobs taken for grains ear^{-1} were shelled, and then thousand clean grains were randomly selected from seed lot of each experimental unit and were weighed with the help of sensitive balance to find out 1000 grains weight (g). For grain yield, three central rows were harvested, threshed, cleaned and weighed with an electronic balance for computing grain yield data and was then converted into kg ha^{-1}. Stover yield was calculated by subtracting grain yield from biological yield (kg ha^{-1}) in each experimental unit.

Statistical analysis

All the collected data was analyzed statistically according to the appropriate procedure used for randomized complete block design with split plot arrangement. Least significant difference test ($P \leq 0.05$) was applied in case of significant F-test for mean comparisons to classify the significance between treatments means as described by Jan *et al*. (2009).

Results and discussion

Weeds fresh weight (g m^{-2}) at 60 days after sowing (DAS)

Table 1 presents weeds fresh weight (g m^{-2}) at 60 days after sowing (DAS) as affected by different tillage practices and weed control methods. Fresh weight of weeds (g m^{-2}) at 60 days after sowing (DAS) was significantly ($P \leq 0.05$) affected by various tillage practices and weed control methods. The interaction of tillage practices and weed control methods was non-significant. Minimum fresh weight of weeds (252.56 g m^{-2}) was recorded from the treatment of chisel plough + rotavator followed by weeds fresh weight (312.82 g m^{-2}) from treatment of mouldboard plough + rotavator and weeds fresh weight (361.54 g m^{-2}) from cultivator + rotavator. Highest weeds fresh weight (370.22 g m^{-2}) was recorded from treatment of rotavator. The minimum weeds fresh weight obtained from chisel + rotavator may be due to the disturbance of seed bank and other reproductive material of weeds in the soil by deep tillage and resulted in lower weeds density than other tillage operations and hence resulted in lowest weeds fresh weight. Gul *et al*., (2011) found significantly lower weeds fresh weight at different tillage operations. Nakamoto *et al*., 2006; Swanton *et al*., 2000 reported that majority of weeds (71%) are concentrated in soil at the depth of 10-15 cm which can be disturbed greatly by deep tillage operations. Significant variations were also observed in weeds fresh weight (g m^{-2}) at 60 days after sowing (DAS) with various weed control methods. Hoeing 15, 30 and 45 DAS produced significantly lowest weeds fresh weight (173.97 g m^{-2}) followed by application of herbicide (Nicosulfuron) with weeds fresh weight of 253.02 g m^{-2} and hoeing 15 and 30 DAS that produced 264.53 g m^{-2} weeds fresh weight. The treatment of hoeing 15 DAS produced weeds fresh weight of 424.91 g m^{-2}. Highest weeds fresh weight (505 g m^{-2}) was recorded from control. The lowest weeds fresh weight obtained from the treatment of hoeing 15, 30 and 45 DAS may be due to the timely and efficiently control of weeds. Ali *et al*., (2015); Ali *et al*., (2014); Khatam *et al*., (2013); Gul *et al*., (2011) and Tahir *et al*., (2009) revealed that various weed control methods at different stages have significantly reduced weeds fresh weight.

Weeds dry weight (g m^{-2}) at 60 days after sowing (DAS)

Influence of different tillage practices and weed control methods on weeds dry weight (g m^{-2}) in maize crop is exhibited in Table 1. Statistical analysis of data revealed that tillage practices and weeds control methods had a significant ($P \leq 0.05$) impact on weeds dry weight (g m^{-2}) at 60 days after sowing (DAS). The interaction of tillage practices and weed control methods for weeds dry weight (g m^{-2}) at 60 days after sowing (DAS) was non-significant. The tillage treatment, chisel plough + rotavator produced weeds with minimum dry weight (80.61 g m^{-2}) at 60 DAS followed by mouldboard plough + rotavator with weeds dry weight of 99.37 g m^{-2}. The treatment of cultivator + rotavator and rotavator ranked 3rd and 4th with weeds dry weight of 114.72 and 117.54 g m^{-2} at 60 DAS, respectively. This might be due to lowest weeds density and weeds fresh weight that resulted in minimum weeds dry weight. Marwat *et al*., (2007) indicated that deep tillage resulted in suppressed weeds growth and less weeds dry weight. Among weed control methods, minimum dry weight of weeds (56.12 g m^{-2}) at 60 DAS was recorded from the treatment of hoeing 15, 30 and 45 DAS followed by weeds dry weight (81.62 g m^{-2}) from the application of Nicosulfuron. Weeds dry weight of 85.33 g m^{-2} was recorded from the treatment of hoeing 15 and 30 DAS. Maximum dry weight (162.90 g m^{-2}) of weeds at 60 DAS was recorded from the control. Ali *et al*., (2014); Tesfay *et al*., (2014); Khatam *et al*., (2013) and Tahir *et al*., (2009) found significant variation in weeds dry weight. They stated that weeds dry weight was significantly reduced by weeds management with hoeing.

Number of grains ear^{-1}

Data on number of grains ear^{-1} of maize was significantly ($P \leq 0.05$) influenced by different tillage operations and weed control measures (Table 1). Interaction of treatments i.e. tillage practices and weed control measures was non-significant. More number of grains ear^{-1} (454 grains) was calculated by treatment of chisel plough + rotavator followed by grains ear^{-1} (410 grains) from mouldboard plough + rotavator and cultivator + rotavator that produced 396 grains ear^{-1}. Less number of grains ear^{-1} (352 grains) was computed by treatment of rotavator. Maximum number of grains ear^{-1} may be due to well pulverized and smooth soil condition created by chisel plough and rotavator that caused better root expansion, availability of nutrients and soil moisture which improved plant growth and development and ultimately increased grains ear^{-1}. Shahid *et al*., (2016); Ehsanullah *et al*., (2015); Javeed *et al*., (2014) and Memon *et al*., (2012) stated that tillage practices significantly affected number of grains ear^{-1} and they reported maximum number of grains ear^{-1} by deep tillage particularly with chisel plough. Among weed control methods, hoeing 15, 30 and 45 days after sowing (DAS) produced highest number of grains ear^{-1} (443 grains) followed by grains ear^{-1} (411 grains) from application of herbicide (Nicosulfuron). Lowest number of grains ear^{-1} (363 grains) was recorded from control. It might be due to the frequent hoeing practices which improved water infiltration and higher fertilizer use efficiency and drastic decline in weeds invasion. Din *et al*., (2016); Ali *et al*., (2015); Tesfay *et al*., (2014) and Tahir *et al*., (2009) reported that various weed control strategies specifically hoeing increased number of grains ear^{-1} in maize crop.

Thousand grains weight (g)

Thousand grains weight (g) of maize as affected by different tillage practices and weed control methods is reported in Table 1. Interaction of tillage practices and weed control methods was non-significant for 1000 grains weight (g). Significantly maximum thousand grains weight (264.91 g) was obtained from the treatment of chisel plough + rotavator followed by thousand grains weight (247.25 g) from mouldboard plough + rotavator and thousand grains weight (229.51 g) from cultivator + rotavator. Minimum thousand grains weight (212.11 g) was obtained from treatment of rotavator. It may be attributed to the to the well pulverized soil and good seed bed prepared by the tillage operation, chisel plough followed by rotavator that resulted in better crop growth, development and dry matter accumulation. Shahid *et al*., (2016); Memon *et al*., (2012) and Wasaya *et al*., (2011) described that deep tillage operations resulted in maximum thousand grains weight in maize crop. Among weed control methods, hoeing 15, 30 and 45 days after sowing (DAS) produced highest thousand grains weight (250.30 g) followed by thousand grains weight of 239.83 g from treatment of hoeing 15 and 30 DAS. The application of Nicosulfuron showed thousand grains weight of 239.49 g. Lowest thousand grains weight (224.82 g) was recorded from control. This may be attributed to maximum water and nutrients uptake in a less competitive environment in the absence of weeds, which caused maximum translocation of nutrients to the sink that produced heavy grains. Din *et al*., (2016); Ali *et al*., (2015); Tesfay *et al*., (2014); Khatam *et al*., (2013) and Tahir *et al*., (2009) stated that various weeds control methods specifically with hoeing improved thousand grains weight (g).

Grain yield (kg ha^{-1})

Grain yield (kg ha^{-1}) of maize as influenced by different tillage practices and weed control methods is given in Table 1. Statistical analysis of the data showed that grain yield was significantly ($P \leq 0.05$) affected by tillage practices and weed control methods. The interaction of tillage practices and weed control methods was non-significant. The treatment of chisel plough + rotavator produced highest grain yield (3411 kg ha^{-1}) of maize. The treatment of mouldboard plough + rotavator ranked 2nd order with grain yield of 3157 kg ha^{-1}. The treatment of cultivator + rotavator and rotavator ranked 3rd and 4th order with grain yield of 2972 kg ha^{-1} and 2694 kg ha^{-1}, respectively. The treatment of chisel plough + rotavator has improved soil physical properties and plants were facilitated in terms of efficient utilization of nutrients and soil moisture. The operation of rotavator has root out weeds from the soil. The weeds were crushed, grinded and buried in the soil which later served as organic matter for crop. Shahid *et al*., (2016); Memon *et al*., (2013); Wang *et al*., (2012); Wasaya *et al*., (2011) and

Gul *et al*., (2011) reported the positive impact of tillage treatment (chisel plough + rotavator) on soil physical properties and weeds control which led to more grains ear^{-1}, heavier grains and ultimately maximum grain yield of maize crop. Weed control methods also had a significant ($P \leq 0.05$) impact on grain yield of maize crop. Among weeds control methods, the treatment of hoeing 15, 30 and 45 days after sowing (DAS) produced highest grain yield (3494 kg ha^{-1}), followed by grain yield of 3185 kg ha^{-1} from the treatment of hoeing 15 and 30 DAS. The application of herbicide (Nicosulfuron) produced grain yield of 3057 kg ha^{-1}. Lowest grain yield (2627 kg ha^{-1}) was harvested from control. The harvest of highest grain yield resulted with 3 hoeings might be due to efficient weeds control, minimum weeds population, and minimum weeds-crop competition in terms of moisture, solar radiation, space and nutrients. Din *et al*., (2016); Ali *et al*., (2015); Sampaio *et al*., (2015); Tesfay *et al*., (2014) and Gul et al., (2011) reported that various weed control methods specifically hoeing has significantly enhanced grain yield of maize crop.

Table 1: Weeds fresh weight (g m^{-2}) at 60 days after sowing (DAS), weeds dry weight (g m^{-2}) at 60 DAS, number of grains ear^{-1}, thousand grains weight (g), grain yield (kg ha^{-1}) and stover yield (kg ha^{-1}) of maize as affected by different tillage practices and weed control methods.

Tillage Practices	Weeds fresh weight (g m^{-2}) at 60 DAS	Weeds dry weight (g m^{-2}) at 60 DAS	Number of grains ear^{-1}	1000 grains weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Chisel plough + Rotavator	252.56 c	80.61 c	454 a	264.91 a	3411 a	8576 a
Mouldboard plough + Rotavator	312.82 b	99.37 b	410 b	247.25 b	3157 b	8087 ab
Cultivator + Rotavator	361.54 a	114.72 a	396 b	229.51 c	2972 b	7409 bc
Rotavator	370.22 a	117.54 a	352 c	212.11 d	2694 c	6799 c
Weed control methods						
Control	505.00 a	162.90 a	363 c	224.82 c	2627 d	6554 c
Hoeing 15 DAS	424.91 b	129.32 b	392 b	237.78 b	2930 c	7084 c
Hoeing 15 and 30 DAS	264.53 c	85.33 c	407 b	239.83 b	3185 b	8107 ab
Hoeing 15, 30 and 45 DAS	173.97 d	56.12 d	443 a	250.30 a	3494 a	8859 a
Nicosulfuron	253.02 c	81.62 c	411 b	239.49 b	3057 bc	7984 b
$LSD_{(0.05)}$ for TP	37.72	11.89	43.17	16.86	220.29	774.62
$LSD_{(0.05)}$ for WCM	21.92	6.94	27.87	9.30	248.26	794.85
Interaction						
TP x WCM	NS	NS	NS	NS	NS	NS

Stover yield (kg ha^{-1})

Stover yield of maize as affected by tillage practices and weed control methods is presented in Table 1. Mean values revealed that various tillage operations and weed control methods had significantly influenced ($P \leq 0.05$) stover yield of maize crop. Interaction of tillage practices and weed control methods was non-significant. The treatment of chisel plough + rotavator produced highest (8576 kg ha^{-1}) stover yield followed by mouldboard plough + rotavator with stover yield of 8087 kg ha^{-1}. Treatment of cultivator + rotavator ranked 3rd order with stover yield of 7409 kg ha^{-1}. Lowest stover yield (6799 kg ha^{-1}) was recorded from treatment of rotavator. The highest stover yield may be due to the improved efficiency of crop plants to accumulate maximum amount of nutrients in their vegetative parts and to produce maximum biological yield and ultimately highest stover yield. Shahid *et al*., (2016) indicated that deep tillage mainly with chisel plough has produced highest stover yield of maize. Among weed control methods, highest stover yield (8859 kg ha^{-1}) was harvested from the treatment of hoeing 15, 30 and 45 days after sowing (DAS) followed by hoeing 15 and 30 DAS with stover yield of 8107 kg ha^{-1}. The application of Nicosulfuron and treatment of hoeing 15 DAS produced stover yield of 7984 and 7084 kg ha^{-1}, respectively. Lowest stover yield (6554 kg ha^{-1}) was obtained from control. Similar results were declared by Riaz *et al*., (2007) who reported that various weeds control methods has significantly influenced stover yield of maize crop.

Conclusion

From the findings of the study it is concluded that chisel plough + rotavator improved grain yield and reduced weeds fresh weight and weeds dry weight. Similarly, hoeing 15, 30 and 45 days after sowing drastically decreased weeds fresh weight, weeds dry weight and produced maximum grain yield of maize.

Acknowledgements

The authors appreciate the help of The University of Agriculture Peshawar-Pakistan regarding their grant to support research.

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