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IMPACT OF TILLAGE, PLANT POPULATION AND MULCHES ON WEED MANAGEMENT AND GRAIN YIELD OF MAIZE

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Abstract

Field experiments were conducted during 2006 and 2007 in Peshawar, using open pollinated maize variety "Azam" in RCB design with split-split plot arrangements having three factors viz., tillage, maize populations and mulches. The tillage levels (zero and conventional) were assigned to main plots, populations (90000, 60000 and 30000 plants ha^{-1}) to sub-plots and the mulches (weeds mulch, black plastic mulch, white plastic mulch and mungbean as living mulch), a hand weeding and a weedy check were allotted to sub-sub plots. Data were recorded on fresh weed biomass (kg ha^{-1}), grains cob^{-1}, 1000-grain weight (g) and grain yield (kg ha^{-1}). Grain yield was 2271 kg ha^{-1} in zero-tillage compared to 2429 kg ha^{-1} in conventional tillage. Increasing crop population increased the yield i.e. 2055, 2412 and 2483 kg ha^{-1} in 30000, 60000, and 90000 plants ha^{-1}, respectively. However, grains cob^{-1} and 1000-grain weight of individual plants were affected negatively with increase in crop population. Higher grain yield (2863 kg) was recorded in hand weeding and statistically at par with black plastic mulch (2813 kg), followed by weeds mulch (2460 kg), white plastic (2398 kg) and living mulch (2145 kg ha^{-1}), respectively as compared to weedy check (1422 kg ha^{-1}). Zero tillage resulted in higher fresh weed biomass (183 kg ha^{-1}) than in conventional tillage (165 kg ha^{-1}). Lower weed biomass (158 kg) was recorded in 90000 crop plants ha^{-1} as compared to 60000 (168 kg) and 30000 (196 kg ha^{-1}), respectively. Less fresh weed biomass was observed in hand weeding (112 kg) which was at par with black plastic mulch (120 kg), followed by weeds mulch (164 kg), white plastic mulch (191 kg) and living mulch (195 kg) as compared to check (260 kg ha^{-1}). In light of two years study, conventional tillage with 90000 plants ha^{-1} along with hand weeding or black plastic mulch proved to be the best in terms of weed management and grain yield.

Introduction

The increasing use of maize gives it a prominent place in agricultural economy. In Pakistan, it was planted on an area of 1.0521 m ha with an annual production of 3.593 m tons with an average of 3415 kg ha^{-1} during 2009, while in Khyber Pakhtunkhwa, it was planted on 0.5095 m ha, with annual production of 0.9579 m tons with average of 1880 kg ha^{-1}, (Anon., 2009). Several factors are involved in the lower average yield of maize in Pakistan among which weeds are the major one causing yield loss of about 38% in maize (Hassan & Marwat, 2001). Somervaille (1995) termed the phenomenon of growing crops with less or no soil disturbance as conservation tillage which has an important role in overcoming the physical limits of agricultural land. No-till soil possesses higher microorganisms and biological activity (Sturny, 1998). Our local farming community does not care about the significance of optimum plant population in crop production. Higher plant densities negatively affect grain yield (Wiyo *et al.,* 1999). In conventional tillage, crop residues and associated weeds are burned, incorporated with soil or used for grazing and as feed (Ortega, 1991). On contrary the conservation tillage manages plant cover that serves as mulch protecting the soil surface, providing organic matter and promoting better utilization of rain/irrigation water (Ortega, 1991). Parish (1990) and Karlen *et al*., (1995) emphasized to device economical and environment friendly methods of weed management due to the environmental awareness of the public, their interest in organic food production and possible hazards of herbicide use. Keeping in view the importance of zero tillage, plant populations and mulches as the tools of organic and sustainable farming, experiments were designed to evaluate the weed control under zero and conventional tillage in combination with varying maize populations and different mulches, to find out the effect of cultural control on grain yield of maize and to recommend the most economical and realistic weed control method for the farming community.

Materials and Methods

Two field experiments were carried out at Agriculture Research Farm, KPK Agricultural University Peshawar during 2006 and 2007 in RCB design with split-split-plot arrangements replicated three times. Zero and conventional tillage were assigned to main plots, three populations of maize viz., 90000, 60000 and 30000 plants ha^{-1} to sub-plots and four types of mulches, a hand weeding and a weedy check to sub-sub plots. Each experimental unit comprised of four rows of maize, four m long and 0.75 m apart. In case of conventional tillage, land was prepared by ploughing the field three times and harrowing afterwards. The rate of N and P fertilizers was 100 and 60 kg ha$^{–1}$ before sowing while 60 kg ha$^{–1}$ N one month after sowing. Maize variety 'Azam' was sown in June 2006 and June 2007 with the help of dibbler to keep uniform plant to plant distance. Additional maize population was maintained for replacing the missing plants in case of no germination to keep the plant population constant. Two rows of mungbean (variety NM-92) were planted as living mulch. The other mulches i.e. black plastic, white plastic and weeds were applied four days after crop emergence. In the weeds mulch, weeds were cut and spread in 4-6 inches layer between maize rows. In hand weeding treatment weeding was done twice (30 and 45 days after crop emergence). All the other agronomic practices were kept uniform during the growing season.

Fresh weed biomass (kg ha^{-1}), grains cob^{-1}, 1000-grain weight (g), and grain yield (kg ha^{-1}) were the parameters on which data were recorded. For fresh weed biomass, all the weeds were pulled out 56 days after sowing, weighed and then values converted to kg ha^{-1}. For grains cob^{-1}, five cobs from each subplot were randomly selected, threshed and their grains were counted separately. Thousand-grain weight was taken at random from the grain lot of each subplot and was weighed by using electronic digital balance. This was repeated thrice and then average weight (g) for 1000 grains was calculated and recorded. Data on grain yield was recorded by cutting two central rows of 4 m length, the cobs were husked, dried and shelled of each subplot and converted to kg ha^{-1}. The data recorded individually for each parameter were subjected to the ANOVA technique. According to Steel & Torrie (1980), the significant means were separated by using LSD Test.

Results and Discussion

Fresh weed biomass (kg ha^{-1}): Statistical analysis of the data showed that the effect of tillage practices, plant populations and mulches was significant on fresh weed biomass. While among the interactions only population x mulches was significant (Table 1). Fresh weed biomass was higher in the zero tillage compared to conventional tillage. While minimum fresh weed biomass was recorded in higher plant populations as compared to lower plant population. Minimum fresh weed biomass was recorded in the hand weeding (112 kg) and black plastic mulch (120 kg), followed by weeds mulch (164 kg), followed by white plastic (191 kg) and living mulch (195 kg) against 260 kg ha^{-1} in check (Table 1). This showed that weed biomass decreased with imposing tillage. Perhaps, tillage destroyed the existing weed flora and prevented the germination of the small seeded weeds by burying them deep. Therefore, the intensity of weeds was less in the tilled plots compared to no-till. These results for the tillage effects are in line with the findings of Tangadulratana (1985) that weeds tended to be minimum when tillage was imposed and conventional tillage was superior to no-tillage regarding weed infestation.

Elliot *et al*., (1993) reported that increasing the number of plowing and harrowing, weed biomass and time required for weeding were reduced whereas grassy weeds were more under zero tillage compared to conventional tillage. Kamau *et al.,* (1999) reported that tillage reduced fresh weed biomass. Lower fresh weed biomass at higher plant population indicated that increasing plant population ensured uniform crop stand and covered the open niches which otherwise might have been utilized by weeds. So, with increasing plant population, the chances of weed establishment were minimized. These results are in agreement with the work of Tollenaar *et al.,* (1994) that increasing plant density reduced weed biomass. Due to the effective weed control hand weeding and black plastic mulch recorded least weed biomass. The weeds in the hand weeding were destroyed through weeding twice, while the weeds under black plastic mulch might have failed to germinate due to lake of light and rise in temperature under black plastic. These results are in line with the findings of Syawal (1998) and Khan *et al.,* (1998) who reported that hand weeding effectively controlled weeds. While Unger & Ackermann (1992) reported that cover crops reduced weed biomass by 41, 62 and 94%, respectively.

Grains cob^{-1}: The effect of tillage practices was not significant, whereas effect of plant population and mulches was significant on grains cob^{-1}; however, none of the interactions were significant (Table 1). Lowest number of grains cob^{-1} (224) was recorded in the highest plant population of 90000 plants ha^{-1} compared to medium plant populations of 60000 plants ha^{-1} (254) and lower plant population of 30000 plants ha^{-1} (280). Maximum number of grains cob^{-1} was recorded in the hand weeding plots (278) and black plastic mulch (269), followed by weeds mulch (251), white plastic mulch (251) and living mulch (246) against weedy check (221) as shown in Table 4.10. Since the early growth and development of the crop was not affected by different tillage practices, which is reflected in several characters of the crop like statistically similar plant height, days to tasseling, silking and physiological maturity, under both the tillage systems. This may explain the situation. These results for the tillage effect are in line with the findings of Al-Ghrerie, (1988) who reported that both the two tillage systems (zero tillage and conventional tillage) did not affect yield and yield components of maize. Similarly, Govaerts *et al*., (2005) also reported that the yield and yield components in the zero-tillage were equivalent to those of conventional tillage system.

The lowest number of grains cob^{-1} at higher plant populations might be due to the rise in competition for light, moisture and nutrients. These results were in line with those of Johnson & Wilman (1997) and Bahadur *et al.,* (1999) that increasing maize density decreased grains cob^{-1}. Dastfal *et al*., (1999) reported that increasing plant density significantly decreased number of grains cob^{-1}. The highest number of grain cob^{-1} in hand weeding and black plastic mulch could be attributed to enhanced soil temperature, better conservation of soil moisture and efficient control of weeds. The lowest grains cob^{-1} in weedy check and living mulch treatments might be due to higher weed infestation and increased interspecific competition. These results are in line with the work of Kwabiah (2003) and Kwabiah (2004) that plastic mulch increased grains cob^{-1}. The lowest number of grains cob^{-1} was recorded in weedy check at lower plant densities due to wider row spacing of maize (Fischer & Larry, 1992).

Thousand-grain weight (g): The effect of tillage practices, plant population and mulches was significant on thousand-grain weight of maize, while none of the interactions were significant (Table 1). Conventional tillage resulted in higher thousand-grain weight (178 g) than zero-tillage (176 g). Maximum thousand-grain weight was recorded in 30000 (181 g) and 60000 (180 g) as compared to 90000 plants ha^{-1} (171 g). Highest 1000-grain weight was recorded in hand weeding (187g) and black plastic mulch (184 g), followed by white plastic mulch (175 g), living mulch (174 g) and weeds mulch (172 g) against 171 g in weedy check (Table 1). Although, zero tillage did not hinder the establishment and early vegetative growth yet later on might have influenced grain development probably due to poor root development under zero tillage conditions. The poor root growth might have affected nutrients uptake during grain maturation and resulted in under weight grain formation. These results for tillage effect are in line with those of Kang *et al*., (1980) that zero tillage maize gave less grain weight than that of conventional tillage maize. Decrease in the thousand-grain weight at higher plant populations might be due to the increased competition for moisture, light and nutrients as a result of increase in plant population. These results for population effect are in line with the work of Bahadur *et al*., (1999) that increasing the maize density decreased thousand-grain weight. Hassan (2000), Oleksy *et al.,* (2001), Ahmad & Khan (2002) and Amanullah *et al*., (2009) reported that increase in plant density significantly decreased thousand-grain weight of maize. The highest thousand-grain weight in black plastic mulch could be attributed to increase in soil temperature and enhanced microbial activity under the plastic mulch, which resulted in enhanced soil physical conditions and faster crop growth. These results for the mulches effect are in line with the findings of Kwabiah (2004) that plastic mulch increased grains weight, while Malik *et al*., (1998) reported that the lowest 1000-grain weight was recorded in the living mulch. Hussein (1997) reported that decrease in grains weight was proportional with the duration of weed competitions.

Table 1. Fresh weed biomass (kg ha^{-1}), number of grain cob^{-1}, thousand grain weight (g) and grain yield (kg ha^{-1}) of maize as affected by tillage, plant population and mulches during 2006 and 2007.

Factor	Level	Fresh weed biomass (kg ha^{-1})	Number of grains cob^{-1}	Thousand grain weight (g)	Grain yield (kg ha^{-1})
		2006-07	2006-07	2006-07	2006-07
Tillage	Zero	183*	249	176*	2395*
	Conventional	165	256	178	2676
Populations	90000 plants ha^{-1}	158c	224a	171b	2582a
	60000 plants ha^{-1}	168b	254b	180a	2412b
	30000 plants ha^{-1}	196a	280c	181a	2055c
	LSD	**8.5**	**26**	**5.44**	**68.20**
Treatments	Weeds mulch	164c	251b	172b	2460b
	Black plastic	120d	269a	184a	2813a
	White plastic	191b	251b	175b	2398b
	Living mulch	195b	246b	174b	2145c
	Hand weeding	112d	278a	187a	2863a
	Weedy check	260a	221c	171b	1422d
	LSD	**10.4**	**12**	**4.90**	**63.30**
Interactions	Tillage x Population	NS	NS	NS	NS
	Tillage x Mulches	NS	NS	NS	*
	Population x Mulches	*	NS	NS	*
	Tillage x Population x Mulches	NS	NS	NS	NS

* = Significant at p≤ 0.05, ** = Significant at p≤ 0.01, NS = Non-significant

Grain yield (kg ha^{-1}): Statistical analysis of the data showed that there was a significant effect of tillage, plant population and mulches on grain yield of maize, while among the interactions, tillage x mulches and populations x mulches were significant (Table 1). Conventional tillage recorded higher grain yield (2429) than zero-tillage (2271 kg ha^{-1}). Highest grain yield was obtained in plant population of 90000 ha^{-1} (2582 kg) as compared to 60000 (2412 kg) and 30000 plants ha^{-1} (2055 kg ha^{-1}). Highest grain yield was recorded in the hand weeding (2863 kg) and black plastic mulch (2813 kg), followed by weeds mulch (2460 kg) and white plastic mulch (2398 kg), followed by living mulch (2145 kg) against 1422 kg ha^{-1} in weedy check (Table 1). The period of grain formation and grain filling is very sensitive to moisture, nutrients and environmental stresses. The less developed root system under zero tillage conditions might have affected the flow of water and nutrients during grain formation in the hot summer days of July and August. As a result the grains remained small, which is reflected in the smaller thousand-grain weight under zero tillage, which consequently affected grain yield. These results for the tillage effect on root development under zero tillage are in line with the results of Karunatilake (2000) who reported poor root development under zero tillage system compared to the prolific root growth under conventional tillage system. He further stated that soil conditions under zero tillage were unfavorable for growth as compared to conventional tillage. According to Ghuman & Sur (2001), no-tillage maize yielded less than conventional tillage. Zero tillage recorded lower grain yield than tilled maize (Suena, 1997) also conformed our research findings. Increase in grain yield at higher plant populations might be due to 2-3 times increase in number of plants ha^{-1}. As a result the amount of yield components i.e. cobs also increased almost 2-3 times, which ultimately contributed to the final grain yield. But increase in the final yield was not parallel to increase in the number of plants ha^{-1}, because of other factors like, increased plant competition and crowding stress etc., at higher plant populations. Akbar *et al*., (1996) reported highest grain yield obtained from population of 100000 plants ha^{-1}. Grain yield increased with increasing plant population (Mudarres *et al*., 1998; Bahadur *et al.,* 1999; Dastfal *et al.,* 1999). Hussain *et al.,* (2000) and Ahmad & Khan (2002) noted yield enhancement with increasing population and recorded highest grain yield in 80000 plants ha^{-1}, while Hashemi *et al*., (2005) reported higher grain yield from 90000 plants ha^{-1}, which strongly supported our results.

Lower grain yield from living mulch and weedy check treatments might be due to heavy weed infestation and partial weed control as compared to hand weeding and black plastic mulch. These results for the mulches effect are in line with those of Maurya & Lal, (1981) who reported that black plastic and straw mulches yielded more than unmulched treatments and white plastic mulch. Similarly, Saikia & Jitendra (1999) reported that hand weeding due to effective control of weeds recorded significantly higher grain yield. Hand weeding reduced weeds, which resulted in higher yields (Elliot and moody, 1990). Similarly, Khajanji *et al*., (2002) obtained higher grain yield with twice hand weeding. However, according to Chikoye *et al*., (2004) three times hand weeding was necessary to obtain maximum grain yield.

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