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EFFECT OF TILLAGE AND ZINC APPLICATION METHODS ON WEEDS AND YIELD OF MAIZE

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Abstract

Field trials were conducted at the Agricultural Research Farm, NWFP Agricultural University Peshawar during summer 2006 to investigate the effect of tillage and Zinc application methods on maize yield and its associated weeds. The experiment was laid out in randomized complete block design with split-plot arrangement having 3 replications. The main plot consisted of conventional tillage (CT) and reduced tillage (RT) while Zn application methods were assigned to the subplots which included seed priming (dry seed, soaking seed in water, 0.01, 0.02 and 0.03% Zn solutions), foliar spray of 0.01% Zn solution, soil application @ of 5 kg ha^{-1} and combination of soil application (@ 5 kg ha^{-1}) plus foliar spray (0.01% Zn solution). Tillage significantly affected weed density (WD) and yield of maize. CT suppressed WD recorded 21 and 42 days after sowing (DAS). Likewise, CT also suppressed the major weeds viz., *Cyperus rotundus*, *Digitaria sanguinalis* and *Convolvulus arvensis.* Higher grain yield was recorded in CT plots as compared to RT. Zinc application methods significantly affected WD recorded 42 days after sowing and grain yield of maize. The interaction between tillage and Zn application methods for WD recorded 42 DAS was also significant. Greater WD was recorded in RT as compared to CT. Mean of the interaction values indicated that WD was lower in CT as compared to RT irrespective of Zn application methods. Yield was higher in CT as compared to RT. Likewise water soaking and Zn application methods improved maize yield as compared to control. It is concluded that CT resulted in lower WD and higher yield of maize. Furthermore, water soaking and Zn application methods enhanced grain yield of maize as compared to control.

Introduction

Tillage is considered the most effective farm activity for the purpose of developing a desired soil structure. It improves the physical conditions of soil and favors the rooting characteristics of plants, which lead to an enhanced nutrient uptake and better yield of crops. Weeds are probably the most ever-present class of crop pests and on the odd occasion cause massive crop failures over vast areas. They reduce the crop yield and deteriorate the quality of produce and hence reduce the market value of the turn out (Arif *et al*., 2006). They use the soil fertility, available moisture, nutrient and compete for space and light with crop plant, which result in yield reduction (Khan *et al*., 2002, 2004). If left uncontrolled, the weeds in many fields are capable of reducing yields by more than 80% (Karlen *et al*., 2002).

The composition of weed communities is greatly affected by tillage but it is difficult to control weeds in reduced tillage (RT). RT often favors annual grasses and discourages annual dicotyledonous species (Froud-Williams *et al*., 1981; Gill & Arshad, 1995). However, generalizations are limited, because the effect of tillage on annual weeds is species-specific (Buhler, 1992) and the same species may respond differently when soil properties and other site characteristics vary. A study carried out in Saskatchewan, Canada, revealed that the influence of location and year on changes in weed communities was more as compared to tillage systems (Derksen *et al*., 1993). Increased soil disturbance decreased the number of weed species and species diversity in maize cropping (Cardina *et al*., 1991). The relative contributions to the size and diversity of weed flora were greater by common species under conventional tillage (CT) and by rare species in less intensive tillage systems in spring crops (Gill & Arshad, 1995).

The disadvantages of RT are infestations by several annual and perennial species and rapid increase of the seed bank near the soil surface. Hence, occasional or rotational use of RT may be a practical way to adopt RT into CT systems. Changes between tillage practices, from CT to RT and *vice versa*, were effective in suppressing weed growth and preventing seed accumulation (Nakamoto *et al*., 2006).

The response of crop yield to tillage practices is rather contradictory. Zugec (2003) reported that the highest and the most stable maize grain yields were obtained with CT. Whereas Hussain *et al*., (1999) reported that four year average maize yields were equal for no tillage, chisel plow and moldboard plow systems and four year average soybean yield with no tillage was 15% higher than with the moldboard plow systems. Similarly, Tarkalson *et al*., (2006) reported that no-till system increased long term average winter wheat and grain sorghum yields compared to CT.

There are two reasons to increase the micronutrient content of the grains of major food crops: enhancement of the agronomic productivity of the crop and improvement of the nutritional value of staple foods for humans. It has been estimated that roughly 40 % of people throughout the world suffer from micronutrient malnutrition, most commonly from iron, zinc (Zn), iodine or various vitamin deficiencies (Welch *et al*., 1997).

There are three main methods of applying micronutrients to crops: soil fertilization, foliar sprays and seed treatment. Foliar applications of micronutrient sprays are effective towards both goals (Wilhelm *et al*., 1988; Savithri *et al*., 1999), but this method is too costly to be widely practiced by resource-poor farmers in some regions because of the amount of fertilizer, equipment and labour required for repeated spraying. Likewise, the difficulty in obtaining high quality micronutrient fertilizers and spreading them evenly on the soil can be unaffordable. Treating seeds with micronutrients potentially provides a simple inexpensive method for improving micronutrient plant nutrition. Farmers in south Asia have responded favorably to seed priming, a simple technology of soaking seeds overnight in water prior to sowing (Harris, 1996; Harris *et al*., 1999). Seed priming in water has been shown to decrease time between sowing and emergence and to improve seedling vigour (Harris, 1996; Parera & Cantliffe, 1994). Priming seeds in solutions of macro or micronutrients has been shown to improve yield of rice (Peeran & Natanasabapathy, 1980), wheat (Khalid & Malik, 1982; Marcar & Graham, 1986; Wilhelm *et al*., 1988) and forage legumes (Sherrell, 1984), but the potential to damage the seed and inhibit germination by priming at high nutrient concentrations has also been reported (Roberts, 1948). The present project was initiated with the objectives to study the effect of tillage and Zn application methods on weeds and grain yield of maize.

Materials and Methods

Experimental site: Field experiment was conducted at Agricultural Research Farm, NWFP Agricultural University, Peshawar, Pakistan during summer 2006. The experimental site is located at 34° N, 71.3° E and an altitude of 347 m ASML. The soil of the field was clay loam, low in nitrogen (0.03-0.04%), low in organic matter (0.7-0.9%) and alkaline in reaction (pH 8.0-8.2). The average monthly temperature, relative humidity, rainfall and soil temperature data during the growing season of the crop are shown in Fig. 1.

Experimental procedure: The experiment was laid out in Randomized Complete Block design with split plot arrangement and three replications. The main plot consisted of conventional tillage (CT) and reduced tillage (RT). Zn application methods were assigned to the subplots which included seed priming (dry seed, soaking seed in water, 0.01, 0.02 and 0.03% Zn solutions), foliar spray of 0.01% Zn solution at 5-6 leaf stage, soil application @ of 5 kg ha^{-1} before sowing and combination of soil application @ 5 kg ha^{-1} before sowing plus foliar spray of 0.01% Zn solution at 5-6 leaf stage. Dry seed of maize was used as control treatment. Zinc sulphate ($ZnSO_4.7H_2O$) was used as source of Zn. Nitrogen and phosphorus were applied @ 120 and 100 kg ha^{-1}. Urea and single super phosphate were used as sources of N and P, respectively. Certified category seed of maize variety 'Azam' was procured from Cereals Crops Research Institute (CCRI), Nowshera, NWFP and was sown with the help of a hand hoe in 15 m^2 plot at the rate of 60 kg ha^{-1}. The row to row distance was 70 cm while plant to plant distance of 20 cm was maintained. All other agronomic practices were carried out uniformly in all plots. The data on weed density (WD) were recorded 21 and 42 days after sowing (DAS).

Statistical analysis: The data were statistically analyzed using ANOVA and means were separated using LSD test at 5% level of probability (Steel & Torrie, 1984).

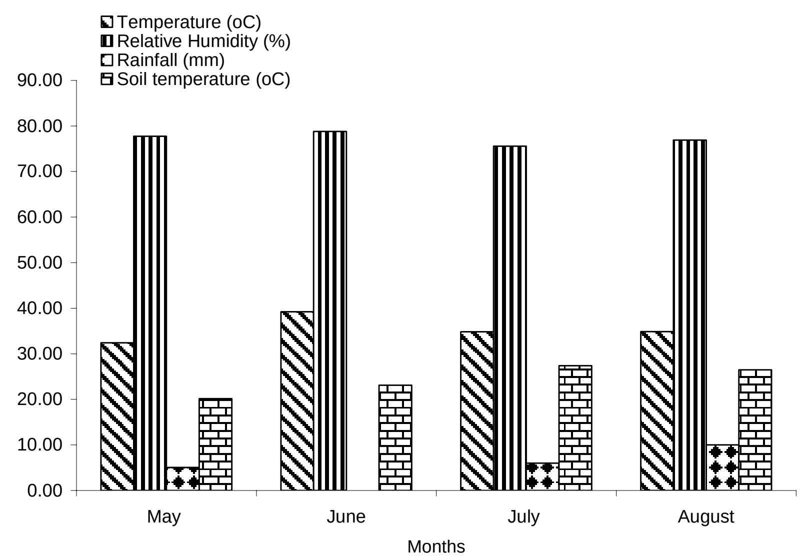

Fig. 1. Average monthly temperature, relative humidity, rainfall and soil temperature for May to August 2005. Source: Weather Station, NWFP Agricultural University, Peshawar, Pakistan

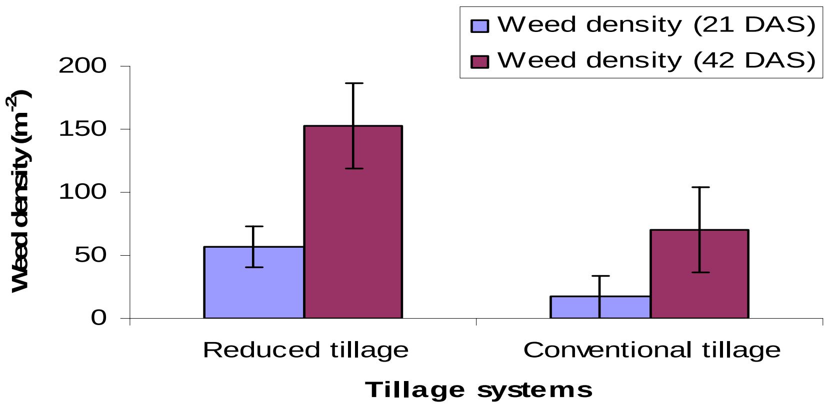

Fig 2. Effect of tillage on weed density recorded 21 and 42 DAS. Vertical bars denote Standard Error.

Results and Discussion

Weed density m^{-2} (21 DAS): The effect of tillage on weed density was significant whereas the effect of Zn application methods was not significant. The interaction between the two factors for WD 21 DAS was also not significant (Table 1). Weed density was higher in RT as compared to CT (Fig. 2). The higher weed density in RT was obviously because of seed bank which was not disturbed to the greater extent. Moreover most of the weed seeds (71%) are concentrated at a depth of 10-15 cm therefore deep and repeated tillage affected the weed seed bank (Nakamoto *et al*., 2006; Swanton *et al*., 2000). The results are in line with Cardina *et al*., (1991) who reported that density of weed populations may increase under RT. These results also confirm the findings of Khattak & Khan (2005) who stated that with increasing the number of tillage, weed density was decreased due to destruction of the germinated annual and perennial weeds.

Weed density m^{-2} (42 DAS): Perusal of the data revealed that the effects of tillage, Zn application methods and interaction between the two factors were significant (Table 1). Greater weed density was recorded in RT as compared to CT (Fig. 2). It is obvious from the data that WD 42 DAS was higher than WD recorded 21 DAS. It can be implied that all weeds did not germinate till 21 DAS and weeds germinated with the passage of time. Major weeds infested the experimental field were *Cyperus rotundus*, *Convolvulus arvensis* and *Digitaria sanguinalis.* These results suggested that perennial as well as annual weeds can be suppressed by tillage. The disadvantages of RT are infestations by several annual and perennial species and rapid increase of the seed bank near the soil surface. These disadvantages became more prevalent with time and may hinder the continuous long term use of RT without herbicides applications. Analogous results were reported by Nakmoto *et al*., (2006) who reported that switching from CT to RT and *vice versa*, were effective in suppressing weed growth and preventing seed accumulation. Maximum WD (140 m^{-2}) was recorded for foliar spray of Zn while minimum WD (95 m^{-2}) was noted for seed priming in 0.02% Zn solution. Mean values of the interaction indicated that WD was lower in CT as compared to RT irrespective of Zn application methods (Table 2).

Table 1. Mean squares for weed densities and grain yield as affected by tillage and Zn application methods.

Source of variance	df	Weed density 21 DAS	Weed density 42 DAS	Grain yield	*Convolvulus arvensis*	*Cyperus rotundus*	*Digitaria sanguinalis*
		Mean squares					
Replication	2	67.69	1667.2	97258	4.88	141.6	77.0
Tillage	1	19240*	83792.3*	1269179*	584.5*	59361.3*	3176.9*
Error a	2	40.77	799.3	40946	0.318	42.3	89.3
Zinc	7	75.64	1253.6*	1747029*	15.94	1472.3	78.8
T x Zn	7	127.21	2967.6*	252920	10.16	1479.3	73.9
Error b	28	147.87	420.2	305516	9.77	627.2	35.4

*Significant at 5% level of probability

Table 2. Weed density (42 DAS) as affected by tillage systems and Zn application methods.

Zn application methods	Tillage x Zn application methods		Mean
	Reduced Tillage	Conventional Tillage	
Dry seed	124 de	84 fg	104 bc
Water soaking	157 bcd	70 fgh	113 bc
0.01% Zn priming	161 bc	85 fg	123 ab
0.02% Zn priming	138 cd	51 gh	95 c
0.03% Zn priming	182 b	43 h	112 bc
Foliar Spray	218 a	62 fgh	140 a
Soil application	123 de	73 fgh	98 c
Foliar Spray + Soil application	124 de	90 ef	107 bc
LSD	34.28	24.24	

Means in a column followed by the same letters are not significantly different at alpha 0.05 using LSD test.

Density of major weeds: Density of major weeds 42 DAS was significantly affected by tillage (Table 1). However, the effect of Zn application methods was not significant. Likewise the interaction between the two factors for density of major weeds was also not significant. Major weeds included *Cyperus rotundus*, *Digitaria sanguinalis* and *Convolvulus arvensis.* CT suppressed densities of all major weeds (Fig. 3). The results are in line with those of De La Fuente *et al*., (1999) who reported that tillage was a major variable influencing weed communities in soybean fields. Similar results were reported by Staniforth & Wiese (1985); Frick & Thomas (1992) who found annual and perennial weed at lower densities in CT than in RT. Many researchers like Froud-Williams *et al*., (1981) are of the opinion that introduction of new tillage practices (reduced, minimum or non-tillage) commonly causes changes in the composition and abundance of weed species present in cropping systems. The results are in agreement with Swanton *et al*., (1999) who reported that disturbance caused by tillage was more important than nitrogen rate and cover crop as a mechanism influencing the composition of the weed flora within mono-cropped maize. However, according to Pollard *et al*., (1982) the response of weeds to tillage is variable. Likewise, the results are not agreed by Derksen *et al*., (1993) who suggested that changes in weed communities were influenced more by environmental factors (location and year) than by the tillage systems.

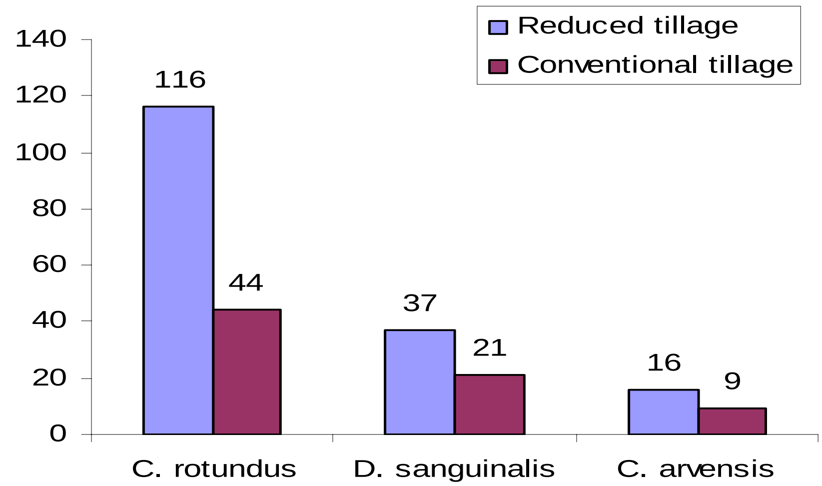

Fig. 3. Effect of tillage on density of *Cyperus rotundus, Digitaria sanguinalis* and *Convolvulus arvensis.*

Grain yield (kg ha^{-1}): Tillage and Zn application methods had significant effect on grain yield of maize, whereas their interaction was not significant (Table 1). Yield was higher in CT compared to RT (Table 3). This phenomenon may be attributed to difference in WD between the tillage treatments. Greater WD occurred in the RT plots and that may have influenced maize yield. Similar results were reported by Khattak *et al*., (2005) who found that deep tillage significantly decreased weed density and increased the crop yield. These results do agree with the findings of Zugec (2003) who obtained the highest and the most stable grain yields with conventional tillage. However the results are not in line with Hussain *et al*., (1999) who concluded that crop yields for eight years (four years maize and four year soybean) appeared to show improved long term productivity of no-till compared with that of moldboard plow and chisel plow systems. Tarkalson *et al*., (2006) are also not supportive of these findings that no-till increased long term average winter wheat and grain sorghum yields compared with conventional tillage.

Water priming produced higher grain yield (37%) as compared to control. The yield increment due water priming has been reported by many researchers who concluded that 'on-farm' seed priming with water alone is effective in substantially increasing yields of chickpea and maize (Harris *et al*., 1999; Musa *et al*., 2001). Seed priming in 0.01, 0.02 and 0.03% Zn solutions produced 33, 34 and 36% more grain yield than control. Foliar spray of 0.01% Zn solution and soil application @ 5 kg ha^{-1} produced 30 and 41% greater grain yield than control. Soil application (@ 5 kg ha^{-1}) along with foliar spray (@ 0.01% Zn solution) resulted in the maximum grain yield which was 44% higher than the control.

Soil applied Zn resulted in higher grain yield of maize as compared to seed priming and foliar spray. Similar results were reported by Yilmaz *et al*., (1997) who concluded that soil applied Zn was a superior fertilization method compared with Zn treated wheat seed or foliar Zn applications. Similar results were reported by Shah *et al*., (1985) and Rehman & Barnard (1988) who obtained maximum yields in maize and lentil with the application of 10 and 5.5 kg Zn ha^{-1} as compared to control, respectively. Likewise application of foliar-sprayed Zn (50 ppm) significantly increased cotton yield as compared to untreated plants (QingFang., 1996). The results obtained are also confirmed by Sawan *et al*., (1988).

Table 3. Effect of tillage and Zn application methods on yield (kg ha^{-1}) of maize.

Zn application methods	Tillage x Zn application methods		Mean	% Increase over control
	Reduced tillage	Conventional tillage		
Dry seed	2619	3113	2866 b	
Water	3214	4246	3730 ab	37
0.01% Zn priming	3433	3204	3318 ab	33
0.02% Zn priming	3108	3632	3370 ab	34
0.03% Zn priming	3460	3819	3639 ab	36
Foliar Spray	3019	2912	2965 ab	30
Soil application	4095	4127	4111 ab	41
Foliar Spray + Soil application	4188	4687	4437 a	44
Mean	3392	3717		
LSD			1563	

Means in a column followed by the same letters are not significantly different at alpha 0.05 using LSD test.

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