

Influence of Tillage Practices on the Grain Yield of Maize and Some Soil Properties in Maize – Wheat Cropping System of Iran

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ABSTRACT

An experiment was conducted to evaluate the effect of various tillage practices on grain yield of maize and some soil properties. Two treatments of wheat residue management (burned & retained) along with three tillage methods (conventional tillage, reduced tillage & minimum tillage) were used in the study. The experiment was laid out in randomized complete block design in strip plot arrangement, with four replications. Reduced tillage and conventional tillage treatments had the highest grain yield and plant height, respectively. At harvest, grain protein, organic matter, potassium and phosphorus in soil were higher in minimum tillage treatment than others. Wheat residue treatments had non-significant effect on all traits. However, grain yield, 1000 grain weight, grain protein and organic matter were higher in retained residue treatment. Interaction of reduced tillage and conventional tillage with retained residue produced highest grain yield (15.96 & 14.94 t ha⁻¹, respectively).

Key Words: Maize; Seedbed preparation; Yield; Tillage; Wheat residue

INTRODUCTION

In double cropping system, decreasing tillage is very important due to limited time for seedbed preparation and to keep the production cost low (Wilhelm *et al.*, 1986; Limon-Ortega *et al.*, 2002). Continuous burning of crop residue results in decreasing soil fertility and soil organic matter (Bond & Willis, 1969; Wilhelm *et al.*, 1986; Limon-Ortega *et al.*, 2002). On the other hand decreasing soil tillage and limited time for decomposition of previous crop residue result in soil compaction, troubling the establishment of next crop, varying the seeding depth, limiting the penetration of seeding machine into soil, poor plant emergence, decreasing the depth of root development and oxygen diffusion into soil and hindering root respiration (Karlen & Sojka, 1985; Izaurralde *et al.*, 1986; Sharralt, 1996; Uri, 2000).

Effect of tillage practices and wheat residue management on maize yield and soil properties have been reported (Unger, 1991; Raimbault & Vyn, 1991; Lal *et al.*, 1994). Deep tillage breaks up high-density of soil layers and improves water infiltration and movement in the soil, enhances root growth and development and increases crop production (Bennie & Botha, 1986). Raimbault and Vyn (1991) obtained minimum grain yield and maximum nitrogen, potassium and phosphorus in topsoil layer in minimum tillage. Bond and Willis (1969) reported that burning residue increased bulk density and decrease soil infiltration, due to decreased soil organic matter.

One of the management practices for increasing water use efficiency (WUE) and decreasing soil evaporation is residue retention in soil surface. It moderates soil temperature, conserves soil moisture and decreases soil evaporation and soil erosion due to crop residue coverage

(Wilhelm *et al.*, 1986; Gajri *et al.*, 1994; Fawcett & Towery, 2002). Utilization of planting practices that permit tillage reductions and retention of crop residues on the soil surface for gravity irrigated corn production systems is very rare in Iran. Farmers in Orzoiyeh region of Kerman province continue to use extensive tillage and considerable crop residue burning as do most other farmers following similar production systems in other regions of Iran. In this region, Wheat-maize rotation is practiced. Because of limited time available for seedbed preparation, wheat straw is usually burned (Najafinejad, 2002; Najafinejad & Amiri, 2004). There are nearly 30 days between the harvest of wheat and recommended last days of maize planting date. More delay in planting of maize will result in exposing the milky and dough stages to low temperature (Najafinejad, 2002). Because of the lack of knowledge about minimum or no tillage, the local farmers burn the straws to do extensive tillage by their conventional equipments easier. Although the soil organic matter less than 0.6% (Najafinejad & Amiri, 2004) the farmers do not consider the long term benefits of crop residues in soil and sustainability of crop production. Therefore, due to the lack of scientific information and the limited time for seedbed preparation in the region, this study was conducted to determine the effect of tillage methods and wheat residue management on grain yield of maize and some soil properties.

MATERIALS AND METHODS

The experiment was conducted at the Orzoiyeh Research Station of Kerman Agricultural Research Center, Kerman - Iran (lat.28°21' N, long 57°-30' E & 1195 m above sea level) during 2002 and 2003 summer. The soil

texture was clay loam with Ph = 7.8, EC = 2.8 dS m⁻¹, FC = 24%, PWP = 12.5% and bulk density = 1.38 g cm⁻³. Experiment was laid out in randomized complete block design with strip plot arrangement having four replications. Tillage treatments were kept as main plots and wheat residue treatments as sub plots. Tillage treatments were conventional tillage (irrigation, moldboard plough with depth of 25 - 30 cm, disk harrow, fertilizer broadcasting, disk harrow, furrow, hand drilling), reduced tillage (irrigation, fertilizer broadcasting, two times of disk harrow with the depth of 15 cm, furrow, hand drilling) and minimum tillage (irrigation, fertilizer broadcasting, one shallow disk with the depth of 5 cm, seeding on furrows of previous crop (wheat), which were 75 cm apart). Wheat residues were burnt and retained. Based on soil analysis 80, 72 and 160 kg ha⁻¹ of potassium (K₂O), phosphorus (P₂O₅) and nitrogen (N) in the form of Potassium sulfate, Triple super phosphate and Urea were applied, respectively. The whole of potassium and phosphorus and 1/3 of N fertilizers were applied at the time of tillage. The rest of N fertilizer was applied at 8- leave (V8) stage. Calculated wheat residue was 8 t ha⁻¹, therefore additional N fertilizer was applied to compensate the N fixing with the rate (1%) of the residue (Lal *et al.*, 1994). Maize (single cross 704) was hand drilled with plant to plant spacing of 18 cm (3 seeds in each hole); in 75 cm a part rows on 20 July and 22 July during 2002 and 2003, respectively. The plots were thinned at six-leave (V6) stage. All other agronomic practices were kept normal and uniform for all treatments. Irrigated water was applied with furrows. In total, 12 irrigations were applied (just after sowing, six DAS, until dough stage with 9-days interval & the others until physiological maturity with 13-days interval). During of maize growth period the depth of applied water was 78 cm (30.71").

Soil and plant sampling was done at final crop harvest. Data regarding plant height, number of grains per row, number of rows per ear, 1000 grain weight and grain yield were recorded at harvest. Plant samples were analyzed chemically for grain protein (Anonymous, 1980) and soil organic matter, soil potassium and soil phosphorus content was also determined at crop harvest (Klute, 1986).

Data were analyzed using statistical software MSTAT-C. Duncan Test (DMRT) was used for comparing the means ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Yield and yield components. Tillage treatments had a significant effect on grain yield (Table I). Among the three tillage practices, reduced and conventional tillage performed better and similarly with grain yield of 15.29 and 14.87 t ha⁻¹ (an increase of 22.81 & 19.43% compared to minimum tillage, respectively). Number of grain per row and 1000 grain weight were not influenced significantly by different tillage practices. Higher grain yield in these treatments might be the result of decrease in soil compaction, better

root proliferation, more uniform distribution of nutrients in soil profile and decrease of allopathic effect of wheat residue (Raimbault & Vyn, 1991). These results are in agreement with findings of Griffith *et al.* (1988), Doren *et al.* (1976) and Uri (2000), who reported that grain yield of maize decreased with minimum tillage.

Residue treatments did not influence any of traits under study to the level of significance. Although retained wheat residues produced higher yield and yield components (Table I). Interaction of tillage and wheat residue treatments (Table II) showed that retention of residue in all tillage levels produced higher grain yield than burning residue. Air temperature and soil evaporation were high during growth period (data not shown), therefore it seems that more yield in retained residue treatment was due to more water conserved in soil and enough available nitrogen, especially in late growth period. More grain yield with supply of equal water shows an increase in water use efficiency. These results are in agreement with findings of Limon-Ortega *et al.* (2002), who concluded that retention wheat residue increased grain yield of maize in summer planting.

Grain protein. Data showed that tillage had a significant effect on grain protein (Table I & II). Regarding tillage treatments maximum protein contents were noted in minimum tillage (10.73%). But wheat residue did not affect the grain protein significantly (Table I). Minimum tillage incorporation with retained wheat residue produced highest grain protein than others (Table II). Soil organic matter in minimum tillage with retained residue treatment was more than others (Table II). Crop residues as stubble are a potential source of N that compensates the need of growing plants. Minimum tillage mixed wheat residues with top soil, but other tillage treatments mixed them with deeper soil layer. It is shown that decomposition of crop residues in top soil is more than deeper soil (Steiner *et al.*, 1999). Organic N derived from plant and microbial residues is not as rapidly available to plants as inorganic N fertilizers and gradual release of organic N is often better synchronized with subsequence plant needs (Dinnes *et al.*, 2002). So considering the role of crop residue as a potential source of N, especially in late of growth period and the effective role of nitrogen in increasing the grain protein, it seems that decomposing of the residue in late of maize growth period (when the soil N content is low) is the reason of more grain protein in minimum tillage and retained residue treatment.

Plant height. Tillage treatments had significant effect on plant height, but residue treatments had non significant effect on plant height (Table I). Reduced tillage and conventional tillage produced maximum plant height (198.6 & 192.6 cm, respectively). The mean increase in plant height was 7.35 and 4.1% in reduced and conventional tillage, respectively more than the minimum tillage. This may be attributed to lesser soil compaction and better soil aeration especially in early growth period and more uniform distribution of nutrients in soil profile (Bennie & Botha, 1986). These results are in agreement with those of Nesmith

Table I. Effect of tillage and wheat residue management on growth parameters of maize and some soil properties

Treatment	Grain yield (t ha ⁻¹)	Plant Height (cm)	No. of Rows per ear	No. of Grains Per row	1000 grain weight (g)	Grain Protein (%)	Soil K (mg kg ⁻¹)	Soil P (mg kg ⁻¹)	Soil organic matter (%)
Tillage									
Conventional tillage	14.87 a	192.6 b	15.03	43.54	346.0	10.03 b	210.7 b	11.93 b	0.48 b
Reduced tillage	15.29 a	198.6 a	14.92	43.11	348.0	10.02 b	207.06 b	10.74 b	0.48 b
Minimum tillage	12.45 b	185 c	14.52	37.80	345.7	10.73 a	232.60 a	12.53 a	0.58 a
LSD $p \leq 0.05$			NS	NS	NS				
Wheat residue									
Burned residue	13.78	191.0	14.70	40.80	345.5	10.10	219.00	11.77	0.48
Retained residue	14.60	193.4	14.80	43.37	348.0	10.40	214.54	11.52	0.54
LSD $p \leq 0.05$	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by different letters are significantly different at 5% level of probability

Table II. Effect of interaction of tillage practices* wheat residue management on growth parameters of maize and some soil properties

Tillage /Residue management	Grain yield (t ha ⁻¹)	Grain protein (%)	Plant height (cm)	Soil K (mg kg ⁻¹)	Soil P (mg kg ⁻¹)	Soil organic Matter (%)
Conventional tillage/burned residue	14.69 a	9.77 b	190.20 bc	211.00 bc	12.62 a	0.45 c
Conventional tillage/retained residue	14.94 a	10.29 ab	195.00 ab	210.37 bc	11.25 ab	0.52 bc
Reduced tillage/burned residue	14.62 a	9.94 b	196.96 a	215.25 abc	10.25 b	0.46 bc
Reduced tillage/retained residue	15.96 a	10.01 ab	200.20 a	198.87 c	10.7 ab	0.50 bc
Minimum tillage/burned residue	12.02 b	10.61 ab	186.10 c	230.87 ab	12.44 a	0.54 ab
Minimum tillage/retained residue	12.89 b	10.84 a	185.12 c	234.37 a	12.60 a	0.61 a

Means followed by different letters are significantly different at 5% level of probability

et al. (1987) and Cassel *et al.* (1995), who reported that shoot development depends on root development and increasing tillage depth would improve the vegetative growth of plants.

Soil properties. Tillage methods had significant effect, while wheat residues levels had non significant effect on soil properties (Table I & II). Maximum values of these traits were noted in minimum tillage (0.58% O.M., 232.6 mg kg⁻¹ K & 12.53 mg kg⁻¹ P). This might be due to shallower mixing of wheat residue in soil that resulted in accumulation of organic matter in topsoil layer (Raimbault & Vyn, 1991; Kashif *et al.*, 2006). The data showed that wheat residue levels have non significant effect on organic matter, potassium and phosphorus in topsoil layer (Table I). Interaction between tillage and residue levels showed that minimum tillage with retained residue produced maximum organic matter and increased the amount of potassium and phosphorus in topsoil layer at harvest of maize (Table II).

CONCLUSION

Burning crop residue may reduce the soil organic matter and retaining crop residue is recommended for sustained productivity. Thus, because of the lower cost of seedbed preparation and more grain yield in reduced tillage and also the benefits of retained wheat residue in summer planting, reduced tillage incorporating with retained wheat residue is recommended.

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