Cercetări Agronomice în Moldova
Vol. XLVI , No. 2 (154) / 2013

# EFFECT OF TILLAGE AND ORGANIC MULCHES ON GROWTH, YIELD AND QUALITY OF AUTUMN PLANTED MAIZE (*ZEA MAYS* L.) AND SOIL PHYSICAL PROPERTIES

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Received December 11, 2012

**ABSTRACT.** The research work was conducted to see the effect of organic mulches and tillage practices on growth, yield and quality of autumn planted maize and soil physical properties. Four types of tillage practices i.e. conventional tillage, zero tillage, bar harrow tillage, subsoiler tillage and two types of mulching material i.e. wheat straw mulch and saw dust mulch was used. The mulching material was partially incorporated in the field after germination of crop. The experiment was carried out in randomized complete block design (RCBD) with three replications. Control treatment was kept for comparison. All other practices were kept uniform throughout the crop period. Data about growth and yield components were collected and analyzed statistically by fisher analysis of variance and treatment significance was measured by significant difference test at 5v% level. The results showed that zero tillage + wheat straw mulch gave maximum 1000-grain weight (341.67 g) and grain yield (6.33 t $ha^{-1}$) and it was followed by conventional tillage + saw dust mulch (4.92 t $ha^{-1}$). Higher protein content was recorded in Subsoiler tillage (10.26 %). Conducive soil physical conditions were observed in the zero tillage practices over the other tillage practices. On the basis of these results it could be proposed that the tillage and mulching is a very important practice to increase the yield of crop. Among different practices, zero tillage with wheat straw mulching gave maximum yield and net benefits.

**Key words:** Tillage; Mulch; Yield; Soil physical properties; Maize.

## INTRODUCTION

Like wheat and rice, maize (*Zea mays* L.) is also used as fasten food in many countries and ranks third most essential cereal crop in Pakistan. It

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belongs to *Gramineae* family of plant kingdom. As maize is the highest yielding cereal crop in the world, it is of considerable substance for countries like Pakistan, where rapidly increasing population has already short of existing food supplies. Maize accounts for 4.8 % of the total cropped area and 3.5 % of the value of agricultural output. Khyber Pakhtunkhwa (KPK) and Punjab are the major producers of maize consisting of 57 % of the total area and 68 % of total production (GOP, 2010). Its importance is apparent in daily life food stuff as it uses as edible oil and high valued food for human beings, feed for livestock and poultry and a raw material for various agro-based industries (Chaudhry, 1983). Corn starch, corn oil, alcohol and tanning materials for leather industry are commercially produced from the maize. About two third of the total world production of maize is used for livestock feed or for commercially starch and oil. As many factors i.e. insect pest, diseases, weeds influx, seasonal changes, irrigation and post harvest losses all are accountable in lowering maize yield but among them the most important is tillage practices (Rosner *et al.,*2008). Soil tillage is the establishment of any crop fabrication system and is the biggest factor in maize production. It maintains the accessible structure or improves the poorly structured soils. In recent times, with the acceptance of enhanced crop cultivars that act in response to moisture and nutrients, chemical fertilizers are needed. The application of higher quantities of chemical fertilizers maintains the soil fertility. To attain this probability, soil erosion will have to be condensed. Tillage is the most important factor in reducing soil erosion. Mulches are loose coverings or sheet of organic material that is placed on the soil surface. It helps to preserve moisture, repression of weeds, improving soil consistency, insect pest assault and guard roots from severe temperature. Organic mulches improve soil, pleasant soil temperature, hinder weed growth, lessen soil moisture evaporation and improve the visual qualities of landscapes. A good layer of mulch will help to preserve moisture and suppress weed germination. Mulch enhanced root and increased maize grain yield by increasing plant N-uptake efficiency, falling N discharge losses and improving nutrient preservation over unmulched plots (Aulakh *et al*., 2000). Straw mulch is practiced successfully in many advanced countries like America and Australia where it improved many soil aspect as support soil moisture retention ability, prevent wind erosion, control of weeds, nutrient return and soil structure improvement. Keeping this in view, the present trial was carried out to assess the qualitative and quantitative response of autumn planted maize under different tillage practices and organic mulches and to check the efficiency of tillage practices and organic mulches in improving the soil physical properties.

## MATERIALS AND METHODS

A field experiment was conducted to see the effect of different tillage practices and mulch materials on the growth, yield and quality of autumn planted maize at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan. Experiment was comprised of four tillage practices viz; conventional tillage, zero tillage, bar harrow tillage and subsoiler tillage and two mulches viz; wheat straw and saw dust. The randomized completed block design was used and was replicated three times. Following treatments were applied in the field: $T_1$= (conventional tillage), $T_2$= conventional tillage + wheat straw mulch (partially incorporated), $T_3$= conventional tillage + saw dust mulch (partially incorporated), $T_4$= zero tillage, $T_5$= zero tillage + wheat straw mulch (partially incorporated), $T_6$= zero tillage + saw dust mulch (partially incorporated), $T_7$= (bar harrow tillage), $T_8$= harrow tillage + wheat straw mulch (partially incorporated), $T_9$= harrow tillage + saw dust mulch (partially incorporated), $T_{10}$= subsoiler tillage (subsoiler), $T_{11}$= sub soiler tillage + wheat straw mulch (partially incorporated), $T_{12}$= subsoiler tillage + saw dust mulch (partially incorporated). Flat sowing was done by hand drill on a well prepared seed bed and thinning is done to maintain the plant to plant and row to row distance. The seed was sown with the help of drill by maintaining 25 cm P×P distance and R×R distance 60 cm. The data regarding to yield and quality parameters were observed at crop harvest to see tillage and mulching effects. Soil sampling was done to analyze soil physical properties.

## RESULTS AND DISCUSSION

Data regarding to plant height at harvest as influenced by tillage practices and mulch application (*Table 1*) indicated that plant height was affected significantly. Data showed that the mean maximum value of plant height 202.89 cm was observed in $T_2$ (conventional tillage + wheat straw mulch) followed by 203.11 cm and 181.89 in case of $T_3$ (conventional tillage + saw dust mulch) and $T_{11}$ (sub soiler tillage+ wheat straw), respectively. The mean minimum plant height value (146.11 cm) was observed in $T_5$ (zero tillage + wheat straw). Significant difference was observed in plant height when wheat straw mulch was applied with different tillage implements as compared with controlled treatments. Taller plants in the conventional tillage and wheat straw mulch might be due to good soil physical conditions and more water conservation under the wheat straw mulch. Such results were also observed by those of Pervez *et al.* (2009) and Vetsch and Randall (2002) who reported that greater plant height, grain yield and biological yield was also seen in case of mulching with tillage.

All the tillage practices and mulch treatments significantly affected the grain yield of maize. The perusal of the data showed that the combined effect of mulching and tillage treatments showed that the mean maximum value 6.33 Mg $ha^{-1}$ was observed in $T_5$ (zero tillage +

wheat straw) followed by 4.92 Mg ha$^{-1}$, 4.53 Mg ha$^{-1}$ in $T_3$ (conventional tillage + saw dust mulch) and $T_2$ (conventional tillage + wheat straw mulch). The mean minimum value 2.70 Mg ha$^{-1}$ was observed in $T_6$ (zero tillage+ saw dust mulch). The higher grain yield in the zero tillage and the wheat straw mulch may be due to better utilization of water and nutrients in the field conditions by the maize plat roots. Moreover, the better contributions of yield building factors i.e. number of grains per cob and 1000 grain weight among the all other tillage and mulch treatments may resulted in good final grain yield. These results are supported by those of Khan *et al*. (2009) who reported that higher grain yield was in zero tillage crop as compared to conventional and deep tillage crop. Similarly, Tolk *et al.* (1999) observed that mulches applied on soil increased grain yield significantly as compare with bare soil.

**Table 1 - Effect of organic mulches and tillage on growth and yield of autumn planted maize**

| Treatments | Plant height cm | Grain yield tha$^{-1}$ | 1000 grain weight g | No. of cobs plant$^{-1}$ | No. of grains cob$^{-1}$ | Biological yield tha$^{-1}$ |
|---|---|---|---|---|---|---|
| $T_1$ | 191.55 b | 3.68 e | 303.00 cdef | 1.13 bc | 503.22 abc | 11.50 g |
| $T_2$ | 202.89 a | 4.53 c | 326.67 abc | 1.07 c | 496.89 abcd | 12.24 f |
| $T_3$ | 203.11 a | 4.92 b | 332.00 ab | 1.20 abc | 485.55 bcde | 11.94 f |
| $T_4$ | 145.84 g | 4.26 cd | 308.00 bcde | 1.13 bc | 460.99 de | 13.79 cd |
| $T_5$ | 146.11 g | 6.33 a | 341.67 a | 1.46 a | 532.66 a | 13.49 de |
| $T_6$ | 151.22 f | 2.70 g | 278.67 f | 1.20 abc | 460.44 de | 13.60 de |
| $T_7$ | 181.44 c | 4.10 d | 305.33 bcdef | 1.26 abc | 510.66 abc | 13.39 e |
| $T_8$ | 174.89 d | 4.52 c | 318.33 abcd | 1.40 ab | 453.44 e | 14.41 ab |
| $T_9$ | 170.44 e | 3.24 f | 295.33 def | 1.46 a | 474.22 cde | 13.51 de |
| $T_{10}$ | 182.22 c | 4.45 c | 312.67 bcde | 1.33 abc | 511.33 abc | 14.61 a |
| $T_{11}$ | 181.89 c | 3.13 f | 288.00 ef | 1.40 ab | 483.78 bcde | 14.06 c |
| $T_{12}$ | 178.69 cd | 4.49 c | 316.33 abcd | 1.46 a | 521.66 ab | 14.09 bc |

As regards to number of grains per cob, the mean maximum number of grains per cob was 532.66 in $T_5$ (zero tillage + wheat straw) which was statistically at par with those of 521.66 in $T_{12}$ (subsoiler tillage + saw dust). The mean minimum value 453.44 was observed in $T_8$ (bar harrow tillage + wheat straw) which was statistically at par with those of $T_6$ (zero tillage + saw dust) [460.44] and $T_4$ (zero tillage) [460.99], respectively. More number of grains per cob in no-tillage resulted in a significant increase in soil organic N compared with chisel/disk while in microbial biomass, N was 30 % greater (P > 0.05) under no-till compared with chisel/disk (Sparling *et al.*, 1992). Similarly, these results were observed already by

Albuquerque *et al.* (2001) who concluded that number of green leaves, plant height, number of grains per cob and weight were reduced with zero tillage as compared with conventional tillage. The higher number of grains per cob in the wheat straw mulch treatments might be due to changes in soil physical, chemical and biological characteristics (Nill and Nill, 1993).

All the tillage practices and mulch treatments significantly affected 1000 grain weight of a crop that has a vital role in the ultimate final grain yield. The mean maximum value of 1000 grain weight 341.67 g was observed in $T_5$ (zero tillage + wheat straw), followed by 332 g, 326.67 g in $T_3$ (conventional tillage + saw dust mulch) and $T_2$ (conventional tillage + wheat straw mulch), respectively. The mean minimum value 288 g was observed in $T_{11}$ (sub soiler tillage + wheat straw mulch). Higher thousand grain weight in $T_5$ (zero tillage + wheat straw) might be due to proper moisture availability and frequent availability of nutrients. Furthermore, soil covering by mulch throughout the cropping seasons improves soil physical properties. These findings are supported by those of Shirani *et al*. (2002) and Albuquerque *et al.* (2001) who reported that height of plant, number of green leaves, number of grains per ear and grain weight were higher in zero tillage and mulch application.

The mean maximum value 14.41 Mg $ha^{-1}$ of biological yield was observed in 14.61 Mg $ha^{-1}$ in $T_{10}$ (sub soiler tillage), followed by 14.41 Mg $ha^{-1}$, 14.09 Mg $ha^{-1}$, 14.06 Mg $ha^{-1}$ in $T_8$ (bar harrow tillage + wheat straw), $T_{12}$ (subsoiler tillage + saw dust mulch) and $T_{11}$ (subsoiler tillage + wheat straw mulch). The mean minimum value 11.49 Mg $ha^{-1}$ was observed in $T_3$ (conventional tillage+ saw dust mulch) that was at par with those of $T_2$ (conventional tillage + wheat straw mulch) [12. 24 Mg $ha^{-1}$]. Treatments $T_5$ (zero tillage + wheat straw mulch) was statistically at par with those of $T_6$ (zero tillage + saw dust mulch) and $T_9$ (bar harrow tillage + saw dust mulch). More plant biomass in subsoiler tillage treatment may be attributed to the more plant height and more number of leaves per plant and more crop growth rate. These results are supported by those of Khan *et al.* (2001) and McWilliams (2003). They reported that the subsoil tillage improved the root length and water availability as the root was gone for the extraction of storage of water in the deeper profiles of soil. Sub soiler tillage might have improved the root proliferation of maize crop (Snap and Borden, 2005).

Among major yield boosting components of plant, number of cobs per plant is one of them which can multiply or divide the grain yield. The mean maximum value of number of cobs per plant 1.46 was observed in $T_5$ (zero tillage + wheat straw) which is statistically at par with those of $T_9$ (bar harrow tillage + saw dust mulch) [1.46] and $T_{12}$ (subsoiler tillage + saw dust mulch) [1.46], respectively. The mean minimum value of number of cob 1.07 was observed in $T_2$ (conventional tillage + wheat straw mulch), followed by those of $T_1$ (conventional tillage) [1.13]. Khurshid *et al.* (2006) observed that the interaction effect of mulching and tillage for number of cobs per plant was significant. Such results were given by Khaliq *et al.* (2007) who reported that different organic and inorganic sources showed non significant effect on number of cobs per plant.

Protein is important quality parameter that depends on the management practices. The mean maximum value of protein 10.26% was observed in $T_{10}$ (subsoiler tillage) which is statistically at par with those of $T_{11}$ (subsoiler tillage + wheat straw mulch) [10.23] and $T_{12}$ (subsoiler tillage + saw dust mulch) [10.19], followed by 9.54%, 9.32% and 9.24% in $T_8$ (bar harrow tillage + wheat straw mulch), $T_6$ (zero tillage + saw dust mulch) and $T_5$ (zero tillage + wheat straw), respectively. The mean minimum value 8.12% was observed in $T_1$ (conventional tillage) followed by $T_2$ (conventional tillage + wheat straw mulch) [8.31%] and $T_3$ (conventional tillage + saw dust mulch) [8.37%]. The combined effect of tillage and mulching showed that wheat straw mulch along with mulching showed better results as compare to sole application of tillage and mulches in the treatments. Organic mulches conserved the water and provided the nutrients (nitrogen) in the soil. Rafiq *et al.* (2010) stated that increase in nitrogen significantly increases the grain protein content. These results are in line with Boomsma *et al.* (2009) who stated that chiseled maize grown may up took the nitrogen and water up to 40 cm depth which increased chlorophyll contents and thus causing more protein contents. Vita *et al.* (2007) and Andrija *et al.* (2009) reported that under conventional tillage, highest protein content was obtained than no tilled soils. Temperly and Borges (2005) observed that protein content was significantly lowered in conventional tillage.

Regarding to oil contents in the maize grain seeds after harvesting, the mean maximum value 5.82% of oil content was observed in $T_1$ that was at par with those of $T_2$ (conventional tillage + wheat straw mulch) [5.80%], followed by 5.47%, 5.09% in $T_3$ (conventional tillage + saw dust mulch) and $T_4$ (zero tillage). The mean minimum value 4.74% of oil content was observed in $T_{11}$ (sub soiler tillage + wheat straw mulch) which is statistically at par with $T_{12}$ (subsoiler tillage + saw dust mulch) [4.72%], followed by $T_8$ (bar harrow tillage + wheat straw mulch) [4.78%]. These results are in supported by Diaz-Zorita (2002) who attributed that in compacted soil higher oil content were present as compare to tilled soil. Similarly, Cociu and Alionte (2011) observed that zero tilled sown crop produced higher oil content than moldboard and disc plough.

Data presented in *Table 2* showed that tillage and mulch treatments significantly affected the soil organic matter contents. The mean maximum value of organic matter content (1.07%) in the soil in $T_{10}$ (subsoiler tillage), followed by those of 0.82 and 0.72 in $T_4$ (zero tillage) and $T_1$ (conventional tillage). The mean minimum value 0.34% was observed in $T_7$ (bar harrow tillage) which was statistically at par with those of 0.39 %, 0.39%, 0.39% in $T_8$ (bar harrow tillage + wheat straw), $T_9$ (bar harrow tillage+ saw dust) and $T_3$ (conventional tillage + saw dust), respectively. It was observed that wheat straw mulch showed better results in combination with tillage than saw dust mulch. These conclusions are compatible to those of Turley *et al.* (2003) who reported that the effect of straw mulch on soil mineral nitrogen and organic matter content were smaller and conflicting.

The data regarding soil pH showed that all the treatments were statistically equal and had same effects on soil pH. The mean maximum value 8.44 of pH was observed in $T_6$ (zero tillage + saw dust mulch) which is at par with $T_8$ (bar harrow tillage + wheat straw mulch) [8.43], $T_5$ (zero tillage + wheat straw) [8.38], $T_{10}$ (subsoiler tillage) [8.36], $T_{12}$ (subsoiler tillage + saw dust mulch) [8.33] and $T_2$ (conventional tillage + wheat straw) [8.31] in that order. The mean minimum value 8.09 was observed in $T_1$ (conventional tillage) which is statistically equal with those of all other treatments. Greater increase in soil pH was observed where mulch was applied with tillage than controlled treatments. These results are in close agreement with those of Ossom and Matsenjwa (2007).

**Table 2 - Effect of organic mulches and tillage on quality and soil physical properties**

| Treatments | Oil content % | Protein content % | O. matter concentration % | Soil pH | Bulk density $Mgm^{-3}$ | Ec $dSm^{-1}$ |
|---|---|---|---|---|---|---|
| **$T_1$** | 5.82 a | 8.12 g | 0.72 c | 8.09 d | 1.41 bcd | 1.77 a |
| **$T_2$** | 5.80 a | 8.31 fg | 0.77 bc | 8.31 abc | 1.48 a | 1.89 a |
| **$T_3$** | 5.47 b | 8.37 f | 0.39 g | 8.21 cd | 1.35 efg | 1.10 c |
| **$T_4$** | 5.43 b | 8.82 e | 0.82 b | 8.23 cd | 1.45 ab | 1.41 b |
| **$T_5$** | 4.95 de | 9.24 c | 0.61 d | 8.36 abc | 1.41 bc | 0.86 de |
| **$T_6$** | 4.90 def | 9.32 c | 0.54 e | 8.44 a | 1.34 fg | 0.98 cd |
| **$T_7$** | 5.22 c | 9.02 de | 0.34 g | 8.38 abc | 1.37 cdef | 0.87 de |
| **$T_8$** | 4.78 ef | 9.54 b | 0.39 g | 8.43 ab | 1.36 def | 1.39 b |
| **$T_9$** | 5.09 cd | 9.17 cd | 0.39 g | 8.26 bcd | 1.31 g | 0.62 f |
| **$T_{10}$** | 4.50 g | 10.26 a | 1.07 a | 8.36 abc | 1.35 efg | 0.75 ef |
| **$T_{11}$** | 4.74 f | 10.23 a | 0.52 e | 8.27 abc | 1.35 efg | 0.98 cd |
| **$T_{12}$** | 4.72 f | 10.19 a | 0.45 f | 8.33 abc | 1.39 cde | 0.88 de |

Data presented in *Table 2* indicated that tillage practices and mulches have significant effect on soil bulk density. The mean maximum value 1.48 was observed in $T_2$ (conventional tillage + wheat straw mulch), followed by 1.45, 1.45, 1.41, 1.41, 1.39, 1.37, 1.36, 1.35 and 1.35 in $T_4$ (zero tillage), $T_1$ (conventional tillage), $T_5$ (zero tillage + wheat straw), $T_{12}$ (subsoiler tillage + saw dust mulch), $T_7$ (bar harrow tillage), $T_8$ (bar harrow tillage + wheat straw mulch), $T_{10}$ (subsoiler tillage) and $T_{11}$ (subsoiler tillage + wheat straw mulch) while the mean minimum value of soil bulk density was observed in $T_9$ (bar harrow + sawdust) [1.31], followed by $T_6$ (zero tillage + saw dust) that was at par with those of $T_3$ (conventional tillage + saw dust mulch). These results are also in compliance with Reddy *et al.* (2002) who concluded that the incorporation of crop residues like wheat straw combined with fertilizer and tillage practices improved soil physical characteristics (infiltration rate, bulk density and hydraulic conductivity). Bulk density is significantly decreased by enhancing tillage practices (Khurshid *et al.*, 2006). The soil having 3-20 cm layer significantly increased the bulk density. The deep tillage treatments decreased bulk density significantly than in no tilled soils because of increasing pore size distribution and hard layer breakage (Diaz-Zortia *et al.*, 2002).

Both tillage practices and organic mulch have significant effect on electrical conductivity (Ec) of soil. The perusal of the data related to Ec is presented in *Table 2*. The mean maximum value of Ec 1.89 $dSm^{-1}$ was observed in $T_2$ (conventional tillage + wheat straw mulch) that was statistically at par with those of $T_1$ (conventional tillage) [1.77 $dSm^{-1}$], followed by 1.41 $dSm^{-1}$ and 1.39 $dSm^{-1}$ in $T_4$ (zero tillage) and $T_8$ (bar harrow + wheat straw) while the minimum value of Ec was observed in $T_9$ (bar harrow + saw dust) [0.62 $dSm^{-1}$] which was statistically at par with those of $T_{10}$ (subsoiler tillage), followed by $T_7$ (bar harrow tillage) [0.87 $dSm^{-1}$] and $T_{12}$ (subsoiler tillage + saw dust mulch) [0.88 $dSm^{-1}$]. Wheat straw mulch in combination with tillage gave higher electrical conductivity of the soil than saw dust mulch and controlled treatments. It was observed that soil physical properties that are influenced by conservation tillage and mulching include bulk density, infiltration and water retention, Ec, soil compaction (Osunbitan *et al.,* 2004). Soil suitability is necessary for sustaining plant growth. The biological activity and soil suitability is function of soil physical and chemical properties (Ec, hydraulic conductivity) which depends on the quality and quantity of soil organic matter (Lukman and Lal, 2008). Chaudhry *et al.* (2004) reported that by using mulch the electrical conductivity of soil decreases 53% as compare to unmulched treatments.

## CONCLUSIONS

The results of the experiment suggested that the zero tillage + wheat straw mulch ($T_5$) should be used in wheat-rice cropping system to improve the soil fertility and crop productivity. This treatment would reduce the farmer's initial cost of production and also help to sustain the soil ecosystem.

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