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INFLUENCE OF TILLAGE PRACTICES AND POULTRY MANURE ON GRAIN PHYSICAL PROPERTIES AND YIELD ATTRIBUTES OF SPRING MAIZE (*Zea mays* L.)

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Grains are the economical part of maize that demand proper management practices to achieve the crop potential. This study explored the influence of different tillage practices and poultry manure levels on the grain length, breadth, area, grains weight per cob and grain yield per $m^2$of spring planted maize. The experiment was set up using Randomized Complete Block Design (RCBD) with split plot arrangement having four tillage practices as main plot treatments; zero tillage, minimum tillage, conventional tillage and deep tillage. Sub plot treatments were three poultry manure levels; control (no poultry manure), poultry manure @ 5 Mg ha^{-1} and poultry manure @ 10 Mg ha^{-1}. Data indicated that the deep tillage practice significantly improved ($p>0.05$) the length, breath and area of maize grains over the other tillage practices in both years of study. Significantly higher grain yield was produced in deep tillage practice as compared to conventional, minimum and zero tillage practices. Increasing order of poultry manure dose treatments produced the bold and healthy seeds over the control treatment. A positive correlation between grain yield per m^2 vs physical properties of maize grain and grains weight per cob was recorded. The study concludes that the productive effect of integrated use of poultry manure and chemical fertilizers application on the maize grain yield.

Keywords: Tillage practice, poultry manure, spring maize, grain yield and zero tillage

INTRODUCTION

Tillage is mechanical manipulation of soil structure. The selection of tillage tools is heavily dependent on the characteristics of soil (e.g., texture, structure, moisture, friability, plasticity) and tillage operations (e.g., action, depth and width of disturbance, timing and duration). Deep tillage with sub-soiler resulted to more seed yield of sunflower in comparison of unloosed soil. Sub-soiler increased 24.5% and 13.0% more seed yield compared to other treatments during both year experiments (Botta *et al.*, 2006). However, sub-soiling corn grain yields did not differ significantly with surface-disking tillage with 4.98 Mg ha^{-1} grain yield in comparison with no-tillage (4.92 Mg ha^{-1}) (Hunt *et al.*, 2004). Higher grain yield and biomass yield was recorded in the chiseled soil over no till soil (Vetsch and Randall, 2004). Similarly, deep ploughing up to 40 cm gave significantly more grain yield as compared to shallower one (20 cm) (Wanas, 2006). Tillage practices affected the plant root growth (Lampurlanes *et al.*, 2001), grain yield and the economics of the farmers (Cavalaris and Gemtos, 2004). Deep tillage improved the root length, root proliferation and Nitrogen Recovery Efficiency (NER), i.e. higher NRE was recorded in the sub-soiling treatments than the compacted or no tilled soil treatment (Motavalli *et al.*, 2003). In addition, it broke down the hardpan and improved the soil physico-chemical properties (Motavalli *et al.*, 2003). Khattak *et al.* (2004) reported the 15% more grain yield in deep tilled plot (using mould board plough). They further stated that this might be due to low bulk density, improved soil moisture, higher cumulative infiltration rate and reduce soil strength. The phenological, growth, yield and yield related traits increased in the conventional tillage treatment than no till treatment (Gul *et al.*, 2009; Borghei *et al.*, 2008). Borghei *et al*. (2008) documented 9.7-13.5% more gain yield in sub-soiling at 50-55cm depth.

In Pakistani soils, the organic matter is less than 5% (Sarwar, 2005) because of high temperature, fast decomposition rate and the burning of the organic matter. Organic matter can be replenished by the addition of various natural manures and compost to the soil (Sarwar, 2005). Organic matter increases the soil fertility and productivity by improving the soil water and nutrients holding capacity, lowering the soil pH, improving the soil cation exchange capacity and ensuring the sustainability availability of nutrients (Deksissa *et al.*, 2008; Triplett and Dick, 2008). Plant residues have high C/N ratio, high lignin and polyphenol contents that decomposed and released nutrients slowly (Tian *et al*., 1992) while the poultry manure could be the better alternative as it decompose easily and available to the plants. Integration of poultry manures with synthetic chemical fertilizers can enhance the efficiency of nutrients uptake and availability to crop plant (Warren *et al*., 2006). Furthermore, Akanni and Ojeniyi (2008) confirmed poultry manure as effective nutrient sources for increasing yield and nutrient status of crops such as maize , amaranths, sorghum and pepper by improving soil micro and macro environment of plant rooting zone. The application of manure along with chemical fertilizer increases the solubility of SSP (single super phosphate) and delays P fixation (Garg and Bahla, 2008). Poultry manure provides the nutrients in very quick time as compared to all other organic matters and the losses of nutrients through leaching and volatilization are also very less. Due to quick release of nutrients, it recharges the soil organic matter in return of good soil health, more nutrients retention, and water holding capacity, improves soil micro flora and fana and the water infiltration rate (Deksissa *et al.*, 2008). Soil cations exchange capacity can be enhanced with increased rate of manure application in to the soil storage bin (Boateng *et al*., 2006). Poultry manure improves maize growth (Farhad *et al*., 2011). Poultry manure treatments along the lower level of NPK produced higher values for plant height, leaf area index and biomass of corn and crop grain yield (Boateng *et al.*, 2006). Integration of poultry manure with synthetic chemical fertilizers can enhance the efficiency of nutrients uptake and availability to crop plant (Warren *et al.*, 2006). The present study was designed to check the effect of different tillage practices and poultry manure treatments with synthetic fertilizers on the maize grain physical properties and yield attributes with the help of software “Image J”.

MATERIALS AND METHODS

The field experiments were conducted at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during spring 2010 growing season and same was repeated in spring 2011. The experiment site is located in subtropical region at 31° north latitude and 73° east longitude on the globe with 184 m altitude. The samples at depth of 0-0.30 m were taken manually with the help of soil auger before the sowing of experiments in both years (2010 & 2011). All the sub samples were completely mixed and a homogenous soil sample is formed. Then this soil sample was subjected to various physico-chemical analysis (Table 1). The experiment was carried out in Randomized Complete Block Design (RCBD) with split plot arrangement keeping the tillage practices in the main plots; zero tillage (Direct seed sowing with dibbler), minimum tillage (one cultivation with normal cultivator followed by planking), conventional tillage (2-3 cultivations with normal cultivator followed by planking) and deep tillage (two deep ploughing with chisel plough + one cultivation with normal cultivator followed by planking). Sub plot treatments were three poultry manure levels; control (no poultry manure), poultry manure @ 5 Mg ha^{-1} and poultry manure @ 10 Mg ha^{-1}. The one year old poultry manure was used and subjected to chemical analysis before application in each year (Table 1). The seed was dibbled when the field was at the proper moisture contents. The irrigations were applied according to crop needs and requirements.

Pioneer 32F10 was used as test variety during the both years of study. The net plot size was 10 m × 4.5 m with R × R 75 cm and P × P 22 cm maintaining 81510 plants ha^{-1}. The crop was sown by using seed rate of 25 kg ha^{-1}. Recommended nutrients requirements of maize crop were applied both from poultry manure and chemical fertilizers after the poultry manure analysis. At first, the crop requirement was fulfilled from poultry manure and then the remaining from the chemical fertilizers. Nitrogen, Phosphorous and Potash was applied @ of 380, 210 and 162 kg ha^{-1} in the form of Urea, Di-ammonium Phosphate (DAP) and Murate of Potash (K_2SO_4), respectively. Whole of phosphorous, potash and half of nitrogen was applied at the time of sowing while remaining half of nitrogen was top dressed at the time of 2nd irrigation. Hoeing was done twice with help of a hand hoe after 1st and 2nd irrigation to curtail the weeds problem.

Digital imagery (Adamsen *et al.*, 2000) and analysis procedures (Rasband, 2004) were used to capture, process and measure the several physical traits of maize grain grown under different soil management strategies. Ten cobs from each treatment were selected and shelled. Randomly, fifty seeds were taken and spread on the white page containing a suitable scale. Each seed separated from each other to avoid the possible error. Marked a particular scale on the white page (we used 2 cm for the physical analysis of maize grains) at the one side of the page. Carefully took the clear image of the selected maize grains with the digital camera and pasted in to the computer (1:1 JPEG image). Used the “IMAGE.J” software to analysis the seed samples for length, breadth and area of seeds after some steps i.e., removing any black spot on the white page other than the seeds, cleaning of the page image, set scale, set measurements and make the image binary. Image J software measured the maize grain parameters after the conversion of pixels to mm. Ten cobs from each plot harvested and shelled for the grains weight per cob and then average is taken. All the plots are harvested and shelled separately and then grain yield on square area basis was calculated. The data were statistically analyzed using the Statisitca 10.1V software (StatSoft Inc., 2012) and the significant treatments means were separated using Tukey’s test at 5% probability level (StatSoft Inc., 2005b).

Table 1. Physico-chemical analysis of soil and poultry manure

A. Physico-chemical analysis of soil

Characteristics	pH	EC (dSm^{-1})	Organic matter (%)	Total nitrogen (%)	Available P(ppm)	Available K(ppm)
2010	7.9	1.12	0.62	0.062	7.38	290
2011	7.7	1.20	0.78	0.069	7.32	294

B. Chemical analysis of Poultry manure

Compositions	Nitrogen %	Phosphorous (P_2O_5) %	Potassium (K_2O) %	Dry matter %
2010	2.02	1.15	1.71	72.85
2011	2.06	1.17	1.73	74.03

RESULTS

Tillage practices and poultry manure treatments significantly affected the maize grain physical properties during the both years of study (2010-11). Data presented in the Fig. 1 indicates that longer maize grain was recorded in the deep tillage treatment (11.04 mm) followed by the conventional tillage (10.83 mm) and minimum tillage treatments (10.66 mm).

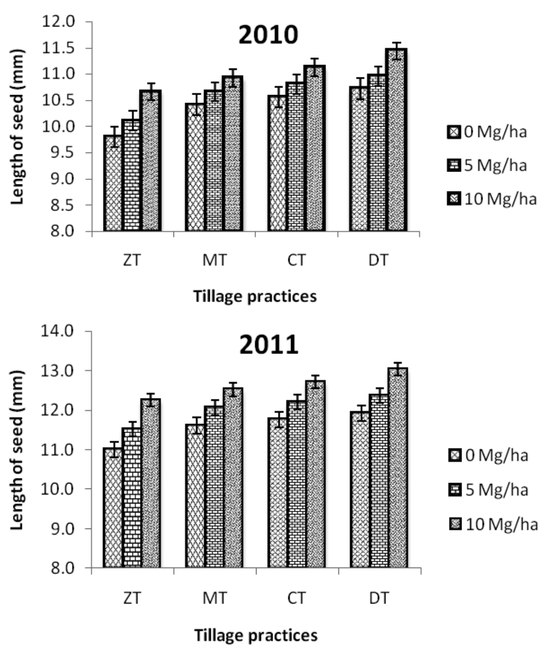

Figure 1. Effect of tillage practices and poultry manure on the length of seed

The shorter maize grain among the tillage practices was recorded in the treatment where the crop was sown by zero tillage practice in 2010 (10.19 mm). Almost similar data trend regarding to maize grain length was observed in 2011 with longer grain was in the tilled crop and the shorter grain was in the no tilled crop (Fig. 1). Increased poultry manure dose significantly improved the maize grain length. The longer maize grain was recorded in the plot where the poultry manure @ 10 Mg ha^{-1} was applied (11.03 mm) followed by the 5 Mg ha^{-1} poultry manure treatment (10.63 mm). Significantly shorter maize grain was observed in the control treatment where no poultry manure was applied (10.37 mm) during 2010. Almost similar data fashion prevailed in 2011 (Fig.1). Breadth of maize grains significantly increased in increasing order of tillage practices during the year 2010 and 2011 (Fig. 2).

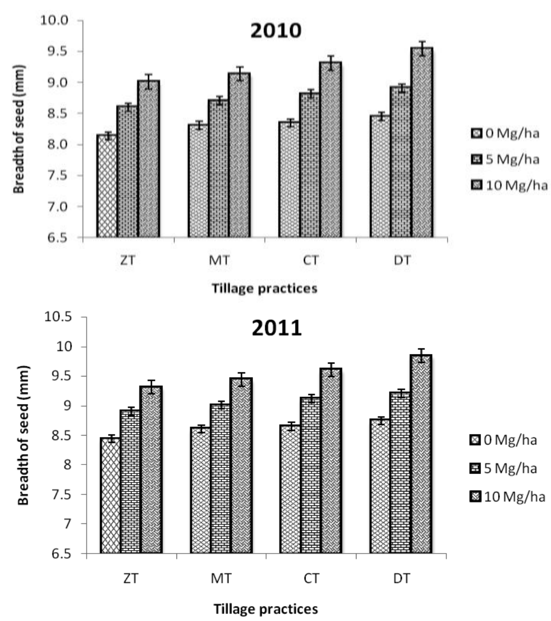

Figure 2. Effect of tillage practices and poultry manure on the breath of seed

The maximum maize grain breadth was noted in the deep tillage sown crop (8.97 mm) followed by the conventional (8.83 mm) and minimum tillage sown crop (8.72 mm). The minimum grain breadth was recorded in the zero tilled sown crop in 2010 (8.58 mm). During 2011, the similar data pattern was observed as in the year 2010 (Fig. 2). Poultry manure treatments also increased the grains breadth in the increasing order of poultry manure dose (Fig. 2). In 2010, the maximum grain breadth was observed in 10 Mg ha^{-1} poultry manure treatment (9.25 mm) followed by the 5 Mg ha^{-1} poultry manure treatment (8.76 mm) while the minimum grain breadth was found in the control treatment (8.31 mm). Almost similar data trend was noted in 2011.

Area of maize grain significantly affected by the tillage practices and poultry manure treatments in the both years of study (Fig. 3).

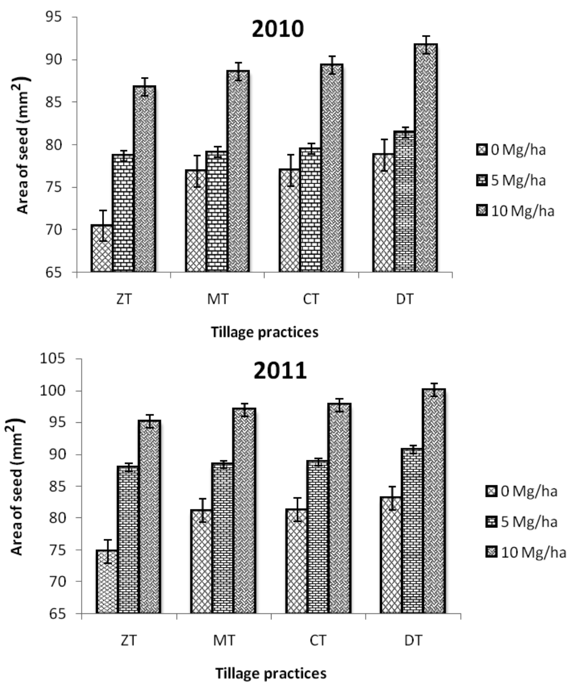

Figure 3. Effect of tillage practices and poultry manure on the area of seed

During 2010, the maximum maize grain area was recorded in the deep tillage sown crop (83.97 mm^2) followed by the conventional tillage sown crop (81.93 mm^2) that was at par with those of minimum tillage sown crop (81.51 mm^2). The minimum maize grain area was noted in the zero tillage sown crop (78.62 mm^2). Almost similar data fashion was in the 2011 with the maximum area was in the deep tillage sown crop (91. 30 mm^2) that was statistically at par with those of conventional tillage sown crop (89.27 mm^2) followed by the minimum tillage sown crop (88.84 mm^2). The minimum area (85.95 mm^2) was recorded in the zero tillage sown crop (Fig. 3). The poultry manure treatments significantly increased the area of maize grain in the year 2010 and 2011. The maximum maize grain area was recorded in the plot where 10 Mg ha^{-1} poultry manure was applied (89. 09 mm^2) followed by the 5 Mg ha^{-1} poultry manure treatment (79.67 mm^2). The minimum maize grain area was found in the control treatment where no poultry manure was applied in 2010 (75. 76 mm^2). Similar data set was noted in the year 2011(Fig. 3).

Statistically the maximum grains weight per cob was observed in the deep tillage treatment (137.62 g) which could not reach the level of significance ($p > 0.05$) with those of conventional tillage treatment (134.07 g) that was at par with those of minimum tillage treatment (130.93 g). The minimum grains weight per cob was in the zero tillage treatment (123.20 g) in 2010. Almost similar data chemistry was recorded during 2011 (Table 2). Poultry manure significantly increased the grains weight per cob with maximum grains weight per cob was noted the 10 Mg ha^{-1} poultry manure treatment (145.19 g) followed by the 5 Mg ha^{-1} poultry manure treatment (131.78 g). The minimum grains weight per cob (117.39 g) was in the control treatment (no poultry manure) during 2010. Similar data trend was noted in second year of study (2011). Tilled sown crop produced the heavier grains over the no tillage sown crop.

Table 2. Influence of different tillage practices and poultry manure treatments on the grains weight per cob and grain yield per m^2

Treatments	Grains weight cob^{-1} (g)		Grain yield m^2	
	2010	2011	2010	2011
Tillage practice (TP)				
Zero tillage (ZT)	123.20 c	143.2b	678.08c	876.56b
Minimum tillage (MT)	130.93 b	145.1ab	856.71b	1176.80a
Conventional tillage (CT)	134.07ab	150.75ab	887.45b	1198.49a
Deep tillage (DT)	137.62 a	151.77 a	945.78a	1267.23a
LSD	5.943	7.950	72.501	88.760
Poultry manure treatments (PM)				
Control (No poultry manure)	14.87c	16.17c	664.35c	779.56c
PM @ 5 Mg ha^{-1}	15.88b	16.78b	887.09b	1081.45b
PM @ 10 Mg ha^{-1}	16.83a	17.64a	912.16a	1109.89a
LSD	0.075	0.089	21.653	33.459
Interaction (T × PM)	ns	ns	ns	ns

ns: non-significant; Values with different letters in a column differ significantly at $P<0.05$.

Significantly maximum grain yield per m^2 was recorded in the deep tillage sown crop (945.78 g) followed by the conventional tillage sown crop (887.45 g) that could not reach the level of significance with those of minimum tillage sown crop (8565.71 g). The minimum grain yield per m^2 was noted in the zero tillage crop (678.08 g) in 2010. Almost similar data trend was in the 2011 (Table 2). The poultry manure @ 10 Mg ha^{-1}produced maximum grain yield per m^2 (912. 16 g) followed by the 5 Mg ha^{-1}(887.09 g) while the minimum grain yield per m^2(664.35 g) was in the control treatment in 2010. Similar data fashion was observed during 2011.

DISCUSSION

Data of the both years research indicated that the physical properties of maize grain, i.e. length, breadth, and area of maize grain and yield attributes were significantly improved in the tilled sown maize crop as compared to no tilled sown maize crop. The healthy maize grains in the deep tillage treatment might be due to more deep rooting system that may uptake more nutrients, mineral and water from the soil and hence improved the grains physical properties. Moreover, the chisel plough may be broke down the hardpan of soil which ensured the availability of the more nutrients especially nitrogen for the better growth and development of maize plant canopy (Ghosh *et al.*, 2006; Astier *et al.*, 2006) that may store more photosynthates in the form of longer grains, more grains breadth and higher area of the maize grains. The lower maize grains physical properties might be due to cooler soil temperature which may delay the seeds germination and less leaf area index (Vetsch and Randall, 2004) and less crop photosynthates area was produced that resulted in to less carbohydrate accumulation in the maize grains. The lower grains weight per cob and grain yield in zero tillage treatment could be due to unhealthy soil conditions for the plants (Hamza and Anderson, 2005), more soil mechanical impedance (Micucci and Taboada, 2006) and more mechanical injury to the roots (Passioura, 2002) in the zero tillage treatment which stopped the plant roots to go into deeper soil profiles for more nutrients and minerals. These findings are supported by those of Zorita (2000). They noted the higher grain yield trend was shifted from deep tillage crop to a zero tillage crop.

Improved physical properties of maize grain were observed in the increasing order poultry manure treatments which may be due to more nutrients and water availability to the crop as compared to the chemical fertilizers treatment. These results are supported by those of Rajindran *et al.* (2003) and Khaliq *et al.* (2004). They stated that the integrated application of organic and inorganic application of fertilizers significantly improved the grain yield and yield related components. Higher crop growth rate in the poultry manure treatments might be due to better utilization of available nutrients in the soil during the crop growth period as compared to control which resulted in higher leaf area index (Carpenter and Board, 1997) and increased the crop growth rate of maize crop over the synthetic fertilizers that may synthesize more photosynthates and finally bold grains was achieved (Ali *et al.*, 2012). Similarly, Ayoola and Makinde (2009) obtained higher grain yield in poultry manure plots and lower in synthetic fertilizers plot and in control.

The correlation between physical properties of maize grain and grain yield was significant during both years of research (Table 3). The Table 3 depicted that there is positive correlation between the grain yield m^2 Vs the length of maize grain, breadth of maize grain and area of maize grain in the both years of study. Similarly, correlation analysis also showed the positive association between the grain weight per cob and grain yield m^2 during the both growing seasons (Table 3). Wasaya *et al.* (2011) documented a strong and positive relationship between grains weight per cob and grain yield.

Table 3. Correlation coefficient among the physical properties of maize grains, grains weight per cob and grain yield (m^{-2})

Parameters		R^2	
X-Range	**Y-Range**	**2010**	**2011**
Length of grain	Grain yield m^2	0.081**	0.078**
Breadth of grain	Grain yield m^2	0.079**	0.071**
Area of grain	Grain yield m^2	0.088**	0.085**
Grains weight cob^{-1}	Grain yield m^2	0.091**	0.087**

***Conclusion*:** The results regarding to this research study concluded the deep tillage practice significantly increased the grain yield and yield related traits as compared to conventional, minimum and zero tillage practices. In addition to former, the farmers should add the poultry manure along with the chemical fertilizer to improve the yield of spring yield. Moreover, the poultry manure at the rate of 10 Mg ha^{-1} gave better results than the 5 Mg ha^{-1} and control treatments. The poultry manure enhanced the availability and utility of nutrients to the maize crop.

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