Influence of Tillage and Poultry Manure on the Physical Properties of Grain and Yield Attributes of Spring Maize (*Zea mays* L.)

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Abstract

Grains are the economical part of maize that demand proper management practices to achieve the crop potential. The study explored the influence of different tillage practices and poultry manure levels on the grain length, breadth, area, grains weight per cob and grains yield per m^2 of maize at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan, during spring 2010 and 2011. The experiment was laid out in randomized complete block design with split plot arrangement, having four tillage practices as main plot treatments, 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 at the amount of 5 Mg ha^{-1} and poultry manure at 10 Mg ha^{-1}. Data indicated that the deep tillage practice significantly improved the maize grain physical properties and yield over the other tillage practices in both years of study. Increasing order of poultry manure dose treatments produced the good and healthy seeds over the control treatment. A positive correlation between grain yield, physical properties of maize grain and grains weight per cob was recorded.

Introduction

Tillage practices affected the plant root growth (Lampurlanes *et al.*, 2001), grain yield and the economics of the farmers (Cavalaris & Gemtos, 2004). Deep tillage improved the root length, root proliferation and nitrogen recovery efficiency (NRE), 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. Khattak *et al.* (2004) reported 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 commulative 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 soil, the organic matter is less than 5% 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 *p*H, improving the soil cation exchange capacity and ensuring the sustainability and availability of nutrients

(Deksissa *et al.*, 2008; Triplett & 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 decomposes easily and is available to the plants. 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 experiment was conducted at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan, during spring 2010 growing season and was repeated in spring 2011. The experiment site is located in subtropical region at latitude 31^0 N and longitude 73^0 E on the globe with 184 m altitude. Soil samples at depth of 0–0.30 m were taken manually with the help of soil auger before the commencement of experiments in both years (2010 & 2011). All the sub samples were completely mixed and a homogenous soil sample was 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 at 5 Mg ha^{-1} and poultry manure at 10 Mg ha^{-1}. The 1-year old poultry manure was used and subjected to chemical analysis before application in each year (Table 1).

TABLE 1
Chemical analysis of soil and poultry manure

Characteristics	*Unit*	*Composition* 2010	2011
A. Physico-chemical analysis of soil			
pH	–	7.9	7.7
EC	dSm^{-1}	1.12	1.20
Organic matter	%	0.62	0.78
Total nitrogen	%	0.060	0.069
Available P (P_2O_5)	mg/kg	7.38	7.32
Available K	mg/kg	290	294
B. Chemical analysis of poultry manure			
Nitrogen	%	2.02	2.06
Phosphorus (P_2O_5)	%	1.15	1.17
Potassium (K_2O)	%	1.71	1.73
Dry matter	%	72.85	74.03

Pioneer 32F10 was used as test variety during 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 were applied at the rate 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 the 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, 50 seeds were taken and spread on the white page containing a suitable scale. Each seed separated from each other to avoid possible error. A particular scale on a white page was marked at the one side of the page. The clear image of the selected maize grains was carefully taken with the digital camera and pasted in to the computer (1:1 JPEG image). The IMAGE J software was used to analyse 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 making the image binary.

Image J software measured the maize grain parameters after the conversion of pixels to mm. The average of 10 cobs from each plot harvested and shelled for the grains weight per cob was taken. All the plots were harvested and shelled separately and the grain yield on square area basis was calculated. 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).

Results

Tillage practices and poultry manure treatments significantly affected the grain physical properties during both years of study (2010 & 2011). Data presented in Fig. 1 indicated 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). 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 maize grain length was observed in 2011, with the longer grain in the tilled crop and the shorter grain in the no tilled crop (Fig. I).

Increased poultry manure dose significantly improved the maize grain length. The longer maize grain was recorded in the plot where the poultry manure at 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 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).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).

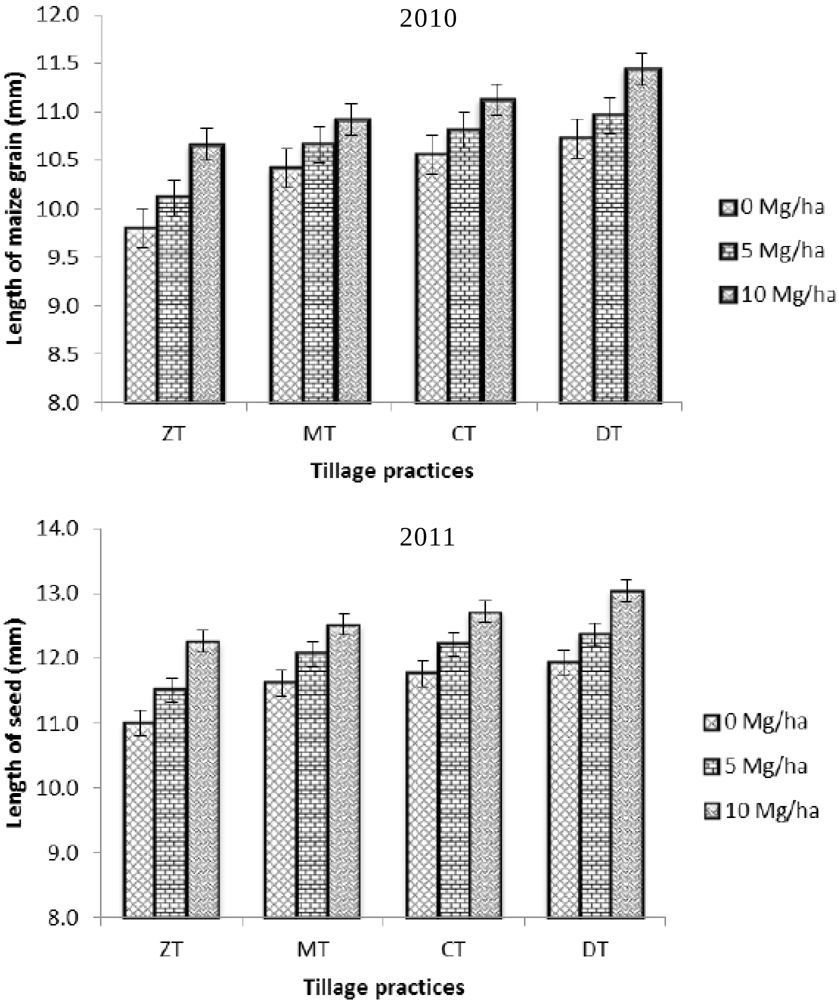

Fig.1. Influence of different tillage practices and poultry manure treatments on the length of maize grain

Minimum grain breadth was recorded in the zero tilled sown crop in 2010 (8.58 mm). During 2011, similar data pattern was observed as in 2010 (Fig. 2). Poultry manure treatments also increased the grains breadth in the increasing order of poultry manure dose (Fig. 2). In 2010, 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 was significantly affected by the tillage practices and poultry manure treatments in both years of study (Fig. 3). During 2010, 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)

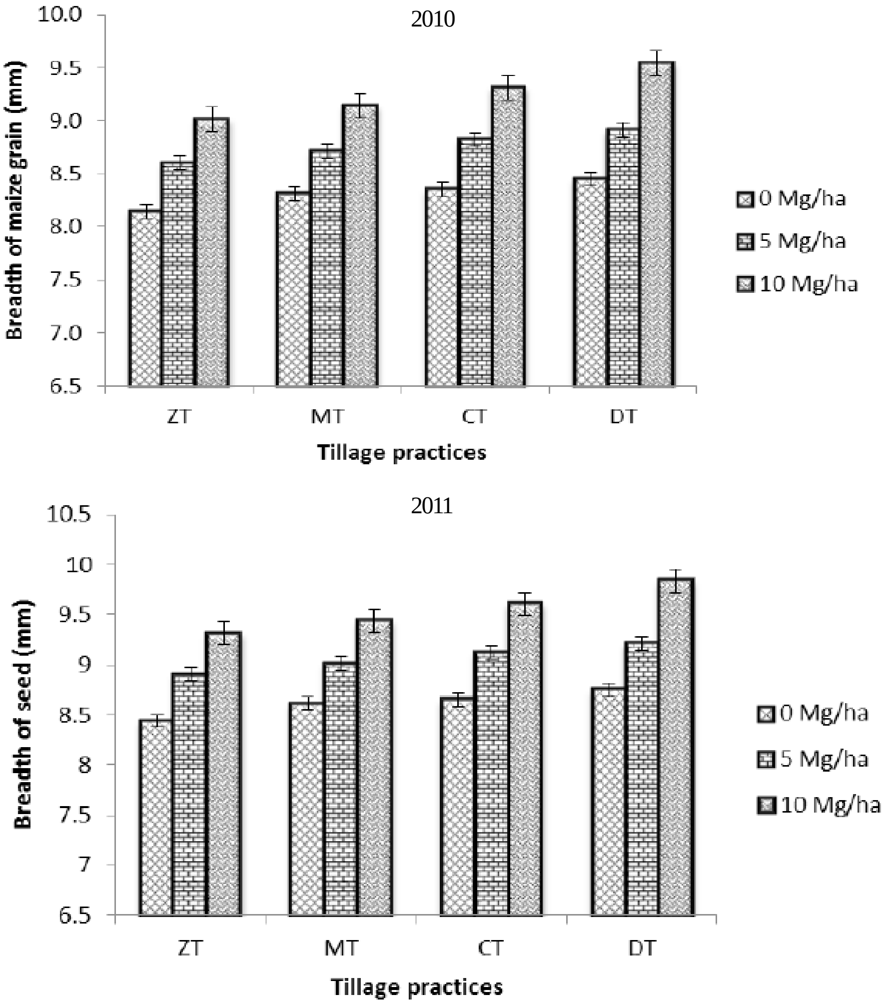

Fig. 2. Influence of different tillage practices and poultry manure treatments on the breadth of maize grain

that was at par with those of minimum tillage sown crop (81.51 mm^2). Minimum maize grain area was noted in the zero tillage sown crop (78.62 mm^2). Almost similar data fashion was in 2011, with the maximum area in the deep tillage sown crop (91. 30 mm^2) 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). 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. 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). Minimum maize grain area was found in the control treatment where no poultry manure was applied in 2010

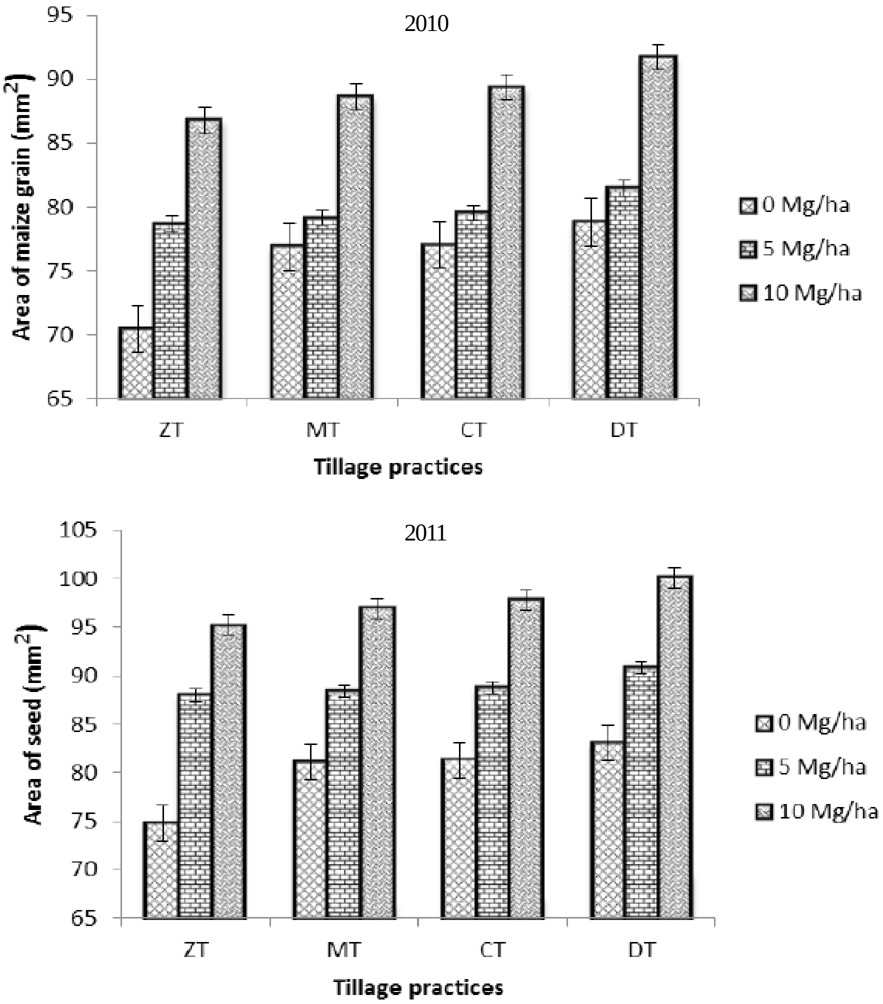

Fig. 3. Influence of different tillage practices and poultry manure treatments on the area of maize grain ZT= Zero tillage, MT= Minimum tillage, CT= Conventional tillage, DT= deep tillage

(75. 76 mm^2). Similar data set was noted in the year 2011(Fig. 3).

Statistically 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). Minimum grains weight per cob was in the zero tillage treatment (123.20 g) in 2010. Almost similar data trend was recorded during 2011 (Table. 2). Poultry manure significantly increased the grains weight per cob with maximum grains weight per cob noted in the 10 Mg ha^{-1} poultry manure treatment (145.19 g) followed by the 5 Mg ha^{-1} poultry manure treatment (131.78 g). Minimum grains weight per cob (117.39

g) was in the control treatment (no poultry manure) during 2010.

TABLE 2

Influence of different tillage practices and poultry manure treatments on the grains weight per cob and grain yield per m²

Treatments	*Grains weight cob⁻¹ (g)*		*Grain yield m⁻²*	
	2010	*2011*	*2010*	*2011*
Tillage practices (TP)				
T_1	15.06c	16.22b	678.08c	876.56b
T_2	16.07b	17.04a	856.71b	1176.80a
T_3	16.14ab	17.05a	887.45b	1198.49a
T_4	16.17a	17.13a	945.78a	1267.23a
LSD	0.069	0.133	72.501	88.760
Poultry manure treatments (PM)				
P_1	14.87c	16.17c	664.35c	779.56c
P_2	15.88b	16.78b	887.09b	1081.45b
P_3	16.83a	17.64a	912.16a	1109.89a
LSD	0.075	0.089	21.653	33.459

T_1= Zero tillage, T_2= Minimum tillage, T_3= Conventional tillage, T_4= Deep tillage, P_1= control (No poultry manure), P_2= Poultry manure = 5 Mg ha^{-1}, P_3= poultry manure = 10 Mg ha^{-1}

Similar data trend was noted in 2011. Tilled sown crop produced the heavier grains over the no tillage sown crop. 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) but could not reach the level of significance with those of minimum tillage sown crop (8565.71 g). 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 at the rate of 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 minimum grain yield per m^2 (664.35 g) was in the control treatment in 2010. Similar data trend was observed during 2011.

Discussion

Data of both years research indicated that the physical properties of maize grain, i.e. length, breadth, 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 might uptake more nutrients, mineral and water from the soil and, hence, improved the grains physical properties. The chiseled sown crop broke down the hardpan of soil which ensured the more nutrients, especially nitrogen, for better growth and development of plant canopy (Ghosh *et al.*, 2006; Astier *et al.*, 2006) that may store more

TABLE 3

Correlation coefficient among the physical properties of maize grains, grains weight per cob and grain yield (m⁻²)

Parameters		*r²*	
X-Range	Y-Range	2010	2011
Length of maize grain	Grain yield m²	0.081**	0.078**
Breadth of maize grain	Grain yield m²	0.079**	0.071**
Area of maize grain	Grain yield m²	0.088**	0.085**
Grains weight cob⁻¹	Grain yield m²	0.091**	0.087**

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 might delay the seeds germination and less leaf area index (Vetsch & Randall, 2002), and less crop photosynthates area was produced that resulted in 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 & Anderson, 2005), more soil mechanical impedance (Micucci &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 zero tillage crop.

Improved physical properties of maize grain were observed in the increasing order of poultry manure treatments. The higher amount of poultry manure provided more nutrients and water availability to the crop as compared to the chemical fertilizers treatment which was in favour of healthy grains. 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 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 the control which resulted in higher leaf area index (Carpenter & Board, 1997) and increased the crop growth rate of maize over the synthetic fertilizers that may synthesize more photosynthates until good grains were achieved (Ali *et al.*, 2012). Similarly, Ayoola & 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). Table. 3 showed that there is positive correlation between the grain yield m^2Vs, the length of maize grain, breadth of maize grain and area of maize grain in both years of study. Similarly, correlation analysis also showed the positive association between the grain weight per cob and grain yield m^{-2} during both growing seasons (Table. 3). Wasya *et al.* (2011) documented a strong and positive relationship between grains weight per cob and grain yield.

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