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RESPONSE OF MAIZE PHENOLOGY AND HARVEST INDEX TO TILLAGE AND POULTRY MANURE

Hafiz Muhammad Rashad Javeed[1,2], Muhammad Shahid Ibni Zamir[1,*], Muhammad Nadeem[2], Rafi Qamar[3], Muhammad Shehzad[4], Muhammad Aqeel Sarwar[1] and Shahid Iqbal[1]

[1]Department of Agronomy, University of Agriculture, Faisalabad; Pakistan;; [2]Department of Environmental Sciences, COMSATS Institute of Information Technology, Vehari, Pakistan; [3] Scientific Officer, Agronomy Section, Central Cotton Research Institute Sarkand, 67210; Sindh, Pakistan; [4]Department of Agronomy, The University of Poonch, Rawalakot, Azad Kashmir
[*]Corresponding author's email: ibnizamir@uaf.edu.pk

Agronomic practices can improve the phenological characteristics of crops leading to greater harvestable yield. Two year field experiment was carried out on a clay loam soil to quantify the effect of different tillage practices, zero tillage (T_1), minimum tillage (T_2), conventional tillage (T_3) and deep tillage (T_4), under the application of different levels of poultry manure (PM_1= zero, PM_2= 5, PM_3= 10, Mg ha^{-1}) on the phenology of maize in Faisalabad, Pakistan. Days to tasseling, days to silking, tassel length and ear height were measured at the physiological maturity while days to full maturity and harvest index were measured at crop harvest during both years of study. Significantly more number of days to tasseling (52.2 and 56.2) and silking (54.6 and 56.6), more days to maturity (112.5 and 118) and greater tassel length (47.7 and 51.2 cm) were measured in the zero tillage sown crop than the other tillage practices during 2010 and 2011, respectively. More ear height position on the maize stem (85.5 and 105.5 cm), grain yield (7.9 and 9.2 tons ha^{-1}) and maximum harvest index (46.5 and 48.3 %) were recorded in the deep tillage practice during the both years of study. Increasing poultry manure rate to the maize crop significantly increased the number of days to tasseling, days to silking and maturity, tassel length, ear height, grain yield and harvest index. This study results indicate that the tillage practices along with poultry manure application can help in achieving the full yield potential of a maize crop.

Keywords: Tillage practices, poultry manure, phenology, spring maize

INTRODUCTION

Among the different crop production factors tillage is one that contributes up to 20% in the total crop production (Ahmad *et al*., 1996). Deep tillage improved the maize root growth, root proliferation and nitrogen recovery efficiency (NRE) such that plant phenology was improved more than that for compacted or no tilled soil (Varsa *et al.*, 1997; Motavalli *et al.*, 2003). Similarly, the tillage practices improved crop yield than the no tillage (Borghei *et al*., 2008; Gul *et al.*, 2009; Marwat *et al.*, 2007) but Choudhary and Baker (1994) concluded that the zero tillage was an efficient method of crop establishment and promoted the crop yield (Mari and Changyin, 2006) than the conventional (One or two cultivations with normal cultivator followed by planking) and deep tillage (One or two cross deep ploughings with chisel plough followed by one cultivation with normal cultivator and finally followed by planking).

In Pakistani soil, the organic matter is less than 1% (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 manures and compost to the soil (Sarwar, 2005). Poultry manure provides faster release of nutrients as compared to all other organic matters and the losses of nutrients through leaching and volatilization are also less. Due to quick release of nutrients in the high cation exchange capacity soil, it recharges the soil organic matter in return of good soil health, more nutrients retention, and water holding capacity, improves soil micro flora and fauna and the water infiltration rate (Deksissa *et al.*, 2008). 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, the combine use of poultry manure and nitrogen sources increased the crop grain yield, water use efficiency and fertilizer use efficiency, which showed the synergetic relationship between organic matter and nitrogenous fertilizers (Bocchi and Tano, 1994). 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 treatments with lower levels of N, P, and K resulted in greater plant height, leaf area index and biomass of corn as well as grain yield (Boateng *et al.*, 2006).

Improvement of various phenological characteristics contributes to the good harvest index and better final crop yield. Therefore, the present study was designed to determine the effect of different tillage practices and poultry manure treatments along with synthetic fertilizers on maize phenology attributes under tropical conditions of Faisalabad, Pakistan.

MATERIALS AND METHODS

***Experimental layout and treatments*:** Two year field experiment was conducted at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during the growing seasons of 2010 and 2011. The experimental site is located in subtropical region at 31° north latitude and 73° east longitude on the globe with 184 m altitude. Soil samples at a depth of 0 to 30 cm were taken manually with a soil auger (with diameter of 3 inches) before the sowing the experiment in both years (2010 and 2011). All the sub-samples (three sub-samples from each experimental sub-plot) were completely mixed to form a homogenous soil sample is formed. Then this soil sample was subjected to various physico-chemical analyses (Table 1).

The experiment was carried out in randomized complete block design with split plot arrangement and replicated thrice. The tillage practices were kept in the main plots; zero tillage T_1 = seeds were sown with help of dibbler without ploughing; T_2 = one cross cultivation with normal cultivator followed by planking; T_3 = 3 cross cultivations with normal cultivator followed by planking; T_4 = two cross deep ploughing with chisel plough followed by one cultivation with normal cultivator and finally followed by planking. The sub plot treatments composed of three poultry manure levels viz control [PM_1: no poultry manure, PM_2: poultry manure at 5 Mg ha^{-1} and PM_3: poultry manure at 10 Mg ha^{-1}]. One year old poultry manure was used and subjected to chemical analysis before application in each year (Table 1). The irrigations were applied according to crop needs and requirements that depend upon the environmental conditions (e.g. temperature) during both years of study.

***Crop sowing*:** Maize hybrid, Pioneer 32F10 was cultivated on March 9, and February 25, during 2010 and 2011, respectively. The net plot size was 10 m × 4.5 m with row to row distance of 75 cm and plant to plant distance of 22 cm for maintaining 81510 plants ha^{-1}. The crop was sown by using seed rate of 25 kg ha^{-1}. Recommended rate of nutrients requirements for a maize crop were applied using a mixture of poultry manure and chemical fertilizers. Synthetic fertilizer in the control poultry manure treatment was applied at the rate of 380 kg nitrogen, 280 kg phosphorous, 192 kg potash per ha^{-1} (recommended dose) and a detailed summary of applied NPK is shown in Table 2. Whole of Phosphorous, potassium 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. Hand hoeing was done after the 1st and 2nd irrigations to control weeds. Meteorological data of both years of crop duration was taken from the meteorological cell situated at 0.4 km working under the Department of Crop Physiology, University of Agriculture, Faisalabad Pakistan (Fig.1).

***Statistical analysis*:** 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 A. Physico-chemical analysis of soil

Characteristics	pH	EC (dSm^{-1})	Organic matter (g kg^{-1})	Total nitrogen given (g kg^{-1})	P (ppm)	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	291

B. Chemical analysis of poultry manure (g per kg)

Compositions	Nitrogen (g kg^{-1})	Phosphorous (P_2O_5) g kg^{-1}	Potassium (K_2O) g kg^{-1}	Dry matter (g kg^{-1})
2010	20.2	11.5	17.1	728.5
2011	20.6	11.7	17.3	740.3

Table 2. Application of nitrogen, phosphorus and potassium (kg ha^{-1}) during both years of study

Nutrient	PM_1		PM_2		PM_3	
	2010	2011	2010	2011	2010	2011
Nitrogen	380	275	275	2725	168	163
Phosphorus	280	280	220	216	159	151
Potassium	192	192	100	98	7	1

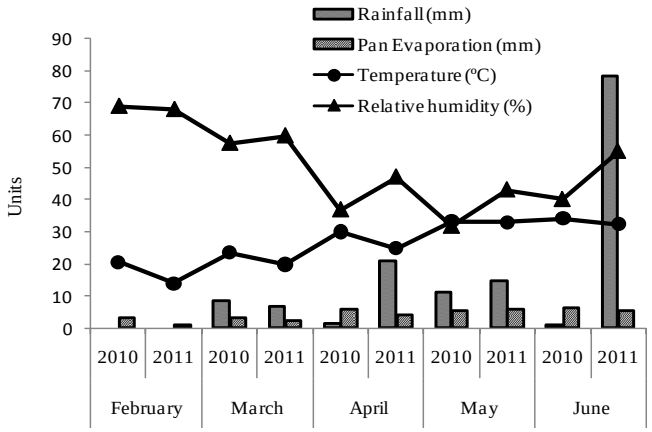

Figure 1. Meteorological data during the crop growth season (2010 & 2011)

RESULTS AND DISCUSSION

***Days to tasseling and silking*:** Physiologically, the number of days to tasseling and silking often change when plants are exposed to environmental stresses like high temperature, moisture stress and deficiency or imbalanced availability of nutrients (Anderson and Bullock, 1998). In 2010, the zero tillage treatment showed a statistically higher number of days to tasseling (52.2) and silking (54.6) as compared to tilled soil. The number of days to tasseling and silking consistently decreased with increased tillage, and this was evident across both years (Table 3). The zero tillage plots required almost four more days to tasseling and silking than the deep tilled plots. It might be due to delayed seedlings emergence, more root penetration resistance and compacted soil conditions in zero tillage treatments and plants took the more time to complete tasseling and silking. These results are in line with those of Khan and Parvej (2010) who reported that a greater number of days to silking of maize were observed in the no-tilled plots compared to tilled plots. Plants treated with PM at 10 Mg ha^{-1} required more number of days to tasseling (51.5) and silking (54) than the 5 Mg ha^{-1} (49.9 and 52.4) treatment, which was statistically similar to the control treatment (49.3 and 51.5) in 2010. The same response was observed in 2011 (Table 3). The more days of tasseling and silking in PM at 10 Mg ha^{-1} might be due to more nutrients availability which delayed the tasseling and silking growth stage. The poultry manure doses significantly affected the days of tasseling (Farhad *et al.*, 2011) which might be due to more provision of nutrients by the poultry manure. Similarly, Ogbomo and Remison (2009) stated that the increased poultry manure amount prolonged crop biomass due to greater availability of nutrients which led to longer duration of crop and hence more number of days to silking. Seasonal effect was positive with non-significant interaction of tillage practices and poultry manure (T × PM) in both years study.

***Tassel and ear height*:** Tassel is the male part of the maize and develops earlier than the female part of the crop. Table 3 shows that in 2010 the tassel length decreased with increased tillage from T_1 to T_3 and results were similar in 2011. Khan and Parvej (2010) concluded that the maximum tassel length was noted in the zero tillage treatment while the minimum tassel length was recorded in the tilled plots. The possible reason of longer tassel length in the zero tilled plots could be the late start of seeds germination than the tilled plot and plants were late in phenological stages.

In 2010, the poultry manure at 10 Mg ha^{-1} (35.3 cm) resulted in longer tassel than 5 Mg ha^{-1} (34.1 cm) poultry manure treatment and control (33.6 cm) where no dose of manure was applied. Similar results were also observed in second year trial (2011). The longer tassel in the treatment which was received PM at 10 Mg ha^{-1} that might be due to more

Table 3. Influence of different tillage practices and poultry manure treatments on the days to tasseling, silking and tassel length of maize

Treatments	Days to tasseling		Days to silking		Tassel length (cm)	
	2010	2011	2010	2011	2010	2011
A. Tillage practices (T)						
T_1	52.16a	56.19a	54.59a	56.59a	36.68a	39.19a
T_2	50.50b	54.60b	52.84b	55.84ab	34.05b	38.56a
T_3	49.87c	54.37b	52.40b	55.40b	33.26c	36.77b
T_4	48.55d	52.65c	50.89c	53.89c	33.19c	36.33b
$LSD_{(0.05)}$	0.424	0.419	1.004	0.942	0.762	1.774
B. Poultry manure (PM)						
PM_1	49.34b	53.43b	51.55b	54.30b	33.56b	37.07b
PM_2	49.96b	54.17b	52.45b	55.20b	34.05b	37.56ab
PM_3	51.51a	55.76a	54.04a	56.79a	35.27a	38.51a
$LSD_{(0.05)}$	0.794	0.795	1.110	0.943	0.636	1.277
T×PM	NS	NS	NS	NS	NS	NS

Means not sharing the different letters in a column is statistically non-significant @ P < 5 % according to LSD; NS= Non-significant

balanced and sustainable availability of nutrients to the plant body, the plant got the significantly more tassel length. In addition, PM at 10 Mg ha^{-1} may increase the water holding capacity of the soil and hence increased the water use efficiency of the plant in the form of longer tassel. These results are in accordance with those of Farhad *et al.* (2011) who stated that the tassel length was increased as the poultry manure doses were also increased.

With regards to ear height, ear was located at higher position (85.5 cm) in deep tillage (T_4) sown crop as measured from the stem base which was statistically similar with those of T_3 (84.9 cm) and the minimum ear height position was noted in T_1 (81 cm) in 2010. However in the 2011, the same fashion of data was recorded but the difference in the values of the both the years might be due to the more favorable environmental conditions in 2011 (Fig. 1). Higher position of ear on the stem was might be due to better conditions for crop growth and development both soil and environmental conditions. These findings are in line with those of Liu and Wiatrak (2011) who observed a positive correlation between plant height and ear height.

As the plant height was increased the ear position was also shifted from lower to higher position of the plant stem body. Same data trend was observed in poultry manure treatments. The data of 2010 (Table 4) suggested that the higher position of ear height was noted in 10 Mg ha^{-1} poultry manure treatment (87.5 cm) followed by 5 Mg ha^{-1} treatment (81.9 cm) which was at par with those of control treatment (81.3 cm). For 2011, a similar data trend was recorded regarding the poultry manure treatments and control treatment. The longer ear height from the base of the stem at higher dose of poultry manure (at the rate of 10 Mg ha^{-1}) might be due to more plant height and more physiological growth of the plant as compared to lower dose of poultry manure and control treatments. Ayoola and Makinde (2009) concluded that the more ear height was recorded in poultry manure applied plot as compared with the inorganic fertilized and control plots. Similarly with the increase of nitrogen, the ear height was also significantly increased (Idikut *et al*., 2009). The interaction of tillage and poultry manure was found non-significant (Table 4) with significant seasonal effect which might be due to more rainfall and less temperature in 2011 as compared to 2010 (Fig. 1).

***Grain yield, days to maturity and harvest index*:** Days to maturity were the average time with in which the physiological harvesting time crop is achieved. Table 4 showed that in 2010, the maximum days to maturity were taken by T_1 treatment (112.5) which was statistically similar with those of T_2 treatment (109.6) followed by T_3 (107.7). The deep tillage (T_4) sown crop (106) took the lowest days for its maturity as compared to minimum tillage (T_3) and no tilled (T_1) crop plots. In 2011, the same trend was observed and significantly higher days to maturity were in the zero tillage (T_1) sown crop followed by the minimum tillage (T_2) which was statistically at par with those of conventional tillage sown crop (T_3) and the lower days for maturity were noted by the crop sown in the deep tillage plot (T_4). The higher days to maturity in the zero tillage sown crop could be due to more moisture and cool temperature inside the soil layers while the deep tillage had ploughed deeply and the soil is exposed to the sun rays and crop is matured at their proper time. These results are in close agreement with those of Khan and Parvej (2010) who noted that a greater number of days to maturity were recorded in a zero tillage-sown crop as compared to a tilled-sown crop.

Poultry manure treatments significantly affected the number of days to maturity in both years of study. In 2010, the crop which was sown at 10 Mg ha^{-1} poultry manure matured late

Table 4. Influence of different tillage practices and poultry manure treatments on the ear height, days to maturity, and harvest index of maize

Treatments	Ear height (cm)		Days to maturity (days)		Harvest index (%)	
	2010	2011	2010	2011	2010	2011
A. Tillage practices (T)						
T_1	81.01c	101.01c	112.52a	118.02a	40.42d	44.58c
T_2	82.75b	102.75b	109.66b	115.16b	45.50c	47.87b
T_3	84.99a	104.99a	107.75bc	114.42b	45.78b	48.29b
T_4	85.52a	105.52a	106.01c	111.51c	46.52a	49.29a
$LSD_{(0.05)}$	0.916	1.468	2.131	2.670	0.265	0.715
B. Poultry manure (PM)						
PM_1	81.26b	101.25b	106.25b	111.13c	44.16b	46.94b
PM_2	81.99b	101.99a	106.74b	112.99b	44.19b	47.59a
PM_3	87.46a	107.46a	113.96a	120.21a	45.33a	47.98a
$LSD_{(0.05)}$	0.864	0.990	0.967	0.896	0.455	0.397
T×PM	NS	NS	NS	NS	NS	NS

Mean not sharing the different letters in a column is statistically non-significant @ P < 5 % according to LSD; NS= Non-significant

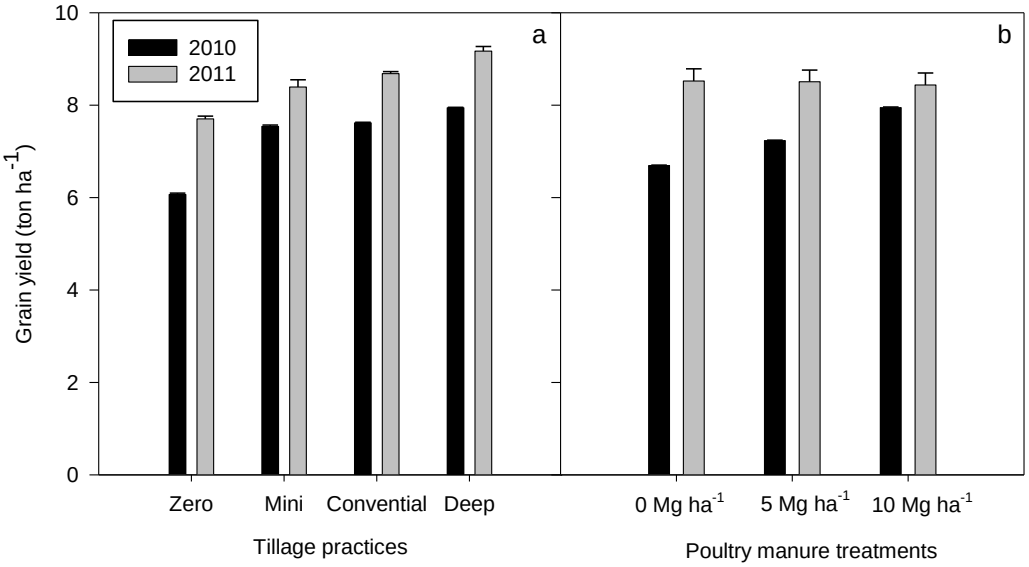

Figure 2. Maize grain yield as affected by tillage (a) and poultry manure (b) treatments during 2010 and 2011

as compared to 5 Mg ha^{-1} and control while in the 2011, the higher days to maturity were recorded in poultry manure at 10 Mg ha^{-1} followed by poultry manure at 5 Mg ha^{-1} (Table 4). The lower number of days to maturity was noted in the control plot where no poultry manure was applied. The higher days to maturity might be due to greater water holding capacity in plots which received the higher rate of poultry manure (10 Mg ha^{-1}). These results are supported by those of Waseem *et al.* (2012) who reported that more days to maturity were recorded in poultry manure nitrogen source over the other nitrogen sources i.e. farm yard manure, press mud of sugarcane, compost and control.

Deep tillage practices resulted in the higher grain yield (8.6 ton ha^{-1}), followed by the conventional tillage practice(8.3 ton ha^{-1}) that was similar with minimum tillage (8.2 ton ha^{-1}) as shown in Figure 2. Zero tillage practices resulted in the lower grain yield (5.5 ton ha^{-1}) with zero poultry manure in 2010 and similar trend in recorded data observed during 2011 (Fig. 2a). The poultry manure increased the grain yield and maximum grain yield was recorded (7.9 ton ha^{-1}) in PM_3 treatment which was followed by PM_2 treatment (7.5 ton ha^{-1}). The lower grain yield was observed in controlled poultry manure treatment (PM_1: 6.95 ton ha^{-1}) during 2010 and similar results were obtained during 2011 as shown in Figure 2b.

As far as harvest index was concerned; higher harvest index was calculated in deep tillage sown crop (T_4: 46.5%) followed by conventional tillage sown crop (T_3: 45.8%) and minimum tillage crop (45.5%) [T_2]. The lower harvest index was recorded in the zero tillage sown crop (T_1: 40.4%) in 2010. Almost similar data trend was recorded during 2011 (Table 4). More harvest index in deep tillage might be due to good grain yield and biological yield in the both years of maize crop. These results are in inconsonance with those of Ahadiyat and Ranamukhaarachchi (2008). They stated that the deep tillage produced a higher harvest index than shallower tillage systems.

In 2010, 10 Mg ha^{-1} PM produced significantly higher harvest index (45.3%) as compared to 5 Mg ha^{-1} treatment (44.2%) which was statistically similar with those of the control (44.2%). In 2011, almost similar data trend was recorded (Table 4). Higher harvest index in poultry manure treatments might be due to healthier crop growth and better grain yield. These results confirm those of Farhad *et al.* (2011). They stated that with increase in the poultry manure doses, a significant increase of harvest index was observed which might be due to more nutrients for good grain yield and more biological output. The interaction between the tillage practices and poultry manure was found non-significant in both years cropping season (2010 and 2011).

***Conclusion*:** The current research concluded that the deep tillage practices and poultry manure at the rate of 10 Mg ha^{-1} along with the synthetic fertilizers significantly increased maize physiological attributes, grain yield and harvest index as compared to conventional, minimum and zero tillage practices. Farmers can use the deep tillage along with the suggested dose of poultry manure to enhance the maize growth and final crop harvest.

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