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COMPOST AND NITROGEN APPLICATION INFLUENCE PHENOLOGY, GROWTH AND BIOMASS YIELD OF SPRING MAIZE UNDER DEEP AND CONVENTIONAL TILLAGE SYSTEMS

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ABSTRACT

The performance of spring maize (*Zea mays* L.) was evaluated using various compost and nitrogen levels under conventional and deep tillage system at the Agronomy Research Farm of the University of Agriculture, Peshawar during spring 2013. The experiment was laid out in randomized complete block design with split plot arrangement, having three replications. Combination of two tillage systems [(conventional tillage: 15 cm deep using cultivators; deep tillage: 45 cm using chisel plough)] and three compost levels (0, 1 and 2 t ha^{-1}) were allotted to main plots, while nitrogen levels (60, 90, 120 and 150 kg ha^{-1}) were allotted to sub plots in the form of urea. The results revealed that tillage systems had significantly affected all the parameters, except days to tasseling, silking and physiological maturity. Deep tillage had maximum plant height (176 cm), leaf area plant^{-1} (4099 cm^2) and biomass yield (11304 kg ha^{-1}) as compared with conventional tillage. Nitrogen application had significantly affected all parameters. Plots treated with 150 kg N ha^{-1} delayed tasseling (69 days), silking (76 days), physiological maturity (106 days) and produced taller plants (184 cm), higher leaf area plant^{-1} (4600 cm^2) and biomass yield (12712 kg ha^{-1}). Compost applied at the rate of 2 t ha^{-1} delayed tasseling (69 days), silking (76 days), physiological maturity (106 days) and produced maximum plant height (186 cm), leaf area plant^{-1} (4545 cm^2) and biomass yield (12317 kg ha^{-1}). On the basis of our results we concluded that application of compost at 2 t ha^{-1} + 150 kg N ha^{-1} under deep tillage system delayed phenology, improved growth and increased biomass yield in spring maize in the current study area.

(Key words: Spring maize, phenology, growth, biomass, nitrogen, compost and tillage systems)

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop in Pakistan after wheat and rice and is also known as "king of grain crops". In Khyber Pakhtunkhwa (KP) province it ranks 2nd after wheat in its importance. In 2010, maize was cultivated on an area of 981 thousand hectares with a total production of 36581 thousand tones in Pakistan, while during the same season its area of cultivation and production in KP was 512 thousand hectares and 1468 thousand tones, respectively (Ali *et al.,* 2012). Maize production is very low in the country and province due to low soil organic matter and poor crop establishment (Amanullah *et al.,* 2010). Use of composts in agricultural areas is increasing because these improve soil health and nutrient status (Farhad *et al*., 2011). Composting of manures is suggested in organic farming for human health due to decrease in phyto-toxic substances (Gil *et al*., 2007). Similarly compost is more intense in macro nutrients (Warren *et al*., 2006), micro nutrient (Shah and Anwar, 2003), narrow in C: N ratio (Zia *et al*., 2003) and is free from adverse characteristics (Hara *et al*., 2003). Moreover, composts also release phytotoxic compounds that suppressed weed germination (Liebman *et al*., 2004). Compost is more intense in macronutrients, micro nutrient, and narrow in C: N ratio and is free from adverse characteristics (Hara *et al*., 2003). Among the essential nutrients for plant growth, N plays a dominant role in plant growth as it is required for chlorophyll production, as a constituent of enzymes, proteins, nucleic acids and cell walls (Marschner, 1986). In Pakistan, there has been stagnation in maize yields. A number of recent soil fertility surveys have revealed that among the essential nutrient, soils are mostly deficient in N by 100%. Therefore, the proper management of nitrogen is critically important for good crop production (Khan *et al.,* 2011). An adequate supply of nutrients is essential for optimum growth and development of maize (Cox *et al*., 1993). The efficiency of utilization of applied N depends on its rates (Gromove *et al*., 1994). Chemical fertilizer application is one of the quickest and easiest ways of increasing yield unit^{-1} area. Experimental studies showed increased maize productivity, however, the problem with fertilizer nutrient supplementation is that it leads to pollution of groundwater after harvest and does not improved soil structure (Khaliq *et al.,* 2004). Tillage can affect soil environmental components that are important to plant growth, such as nitrogen pool status and N availability.

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The effect of any tillage system on maintaining adequate nutrient levels in the soil system, particularly N for crop growth and production, is therefore critical to the sustainability of crop production systems (Ali *et al.,* 2012). The integration of appropriate tillage and N management systems for sustainable crop production thus, presents a significant challenge (Mehdi *et al.,* 1999). Maize emergence and growth are directly and indirectly influenced by tillage operations. Most of the farmers are using local made plough and its continuous use leads to the formation of plough pan or compact soil that hinders root growth and ultimately the shoot growth (Shah and Anwar, 2003). There was lack of research on the combine use of compost, nitrogen and tillage practices on maize crop in the study area. Therefore, this research was designed to investigate the combined effect of N and compost on maize phenology, growth and total biomass yield under conventional and deep tillage system.

MATERIALS AND METHODS

A field experiment was conducted to investigate the effects of compost and nitrogen on spring maize phenology and morphology under conventional and deep tillage system at the Agronomy Research Farm of the University of Agriculture, Peshawar, Pakistan during spring 2013.The experimental farm is located at 34.01° N latitude, 71.35° E longitude at an altitude of 350 m above mean sea level. The farm soil was silty clay loam and was mean deficient in available nitrogen with soil organic matter contents were less than 1% (Amanullah *et al.,* 2010). Experiment was laid out in randomized complete block design with split plot arrangement, having three replications. Tillage systems (conventional tillage: 15 cm depth with cultivators and deep tillage: 45 cm depth with chisel plough) and compost levels (0, 1 and 2 t ha^{-1}) were used as main plot factors, while nitrogen levels (60, 90, 120 and 150 kg ha^{-1}) as sub-plot factor. Each sub plot consisted of six rows, 4 m long and 70 cm apart. In both conventional and deep tillage systems, the soil was ploughed two times horizontally as well as vertically followed by planking to break the clods and level the field. The required nitrogen was applied in two splits i.e. 50% at sowing and 50% at 6^{th} leaf stage. The commercial compost 'Higo Organic Plus' was used before seed bed preparation. Chemical analysis of Higo Organic Plus used is given in table 1. A uniform basal dose of 60 kg P ha^{-1} as single super phosphate and 50 kg K ha^{-1} as sulphate of potash was applied and mixed with soil during seed bed preparation. Maize variety 'Azam' was used in the experiment. Days to tasseling were calculated from the date of sowing to the date when 75% tasseling appeared in each subplot. For days to silking, when 75% silking was appeared in each subplot, that date was noted to subtract from date of sowing. Days to physiological maturity were recorded from the date of sowing till date when all the plants got physiological matured in each subplot. Data on plant height (cm) at physiological maturity was recorded with the help of meter rod by selecting ten plants randomly from each subplot and then average was worked out. Leaf area $plant^{-1}$ was calculated by the following formula. Leaf area $plant^{-1}$ = Leaf length x Leaf width x 0.75 x number of leaves $plant^{-1}$. Data on biomass yield was recorded by harvesting four central rows in each subplot, the material were sun dried for several days and weighed, and then converted into kg ha^{-1}.

Data was statistically analyzed according to Steel and Torrie (1980) and means were composed using LSD test ($P < 0.05$).

RESULTS AND DISCUSSION

Days to tasseling

Mean value for days to tasseling (Table 2) indicated that compost (C) and nitrogen (N) had significant effects on days to tasseling while tillage systems and all the interaction were found non significant. Mean values of compost revealed that tasseling were delayed (69 days) at 2 t C ha^{-1} while early tasseling (67 days) were observed in control plots. Ali *et al.* (2012) also supports our finding as reported delay in tasseling with the application of organic fertilizer at higher dose. Plot treated with 150 kg N ha^{-1} took significantly more days to tasseling (69 days), while early tasseling (67 days) was found at 60 kg N ha^{-1}. Delayed tasseling in compost and nitrogen amended plots may be attributed to vigorous vegetative growth and increased in use of nitrogen. Hamad *et al.* (2011) and Inamullah *et al.* (2011) also reported delayed in tasseling with increase in nitrogen rate. Delay in days to tasseling of maize was also observed in our earlier study (Amanullah *et al.,* 2009a). Days to tasseling was significantly delayed with increase in nitrogen rate and increase in number of nitrogen splits (Amanullah *et al.,* 2009a).

Days to silking

Data regarding days to silking are presented in table 2 showed that with increasing compost level days to silking delayed. Mean values of compost showed that silking were delayed (76 days) at 2 t C ha^{-1},while early silking (74 days) were observed in control plots. With increase of nitrogen level, days to silking delayed significantly and therefore, the highest level of nitrogen (150 kg ha^{-1}) delayed in silking (76 days), while early silking (74 days) was recorded at 60 kg N ha^{-1}. Higher nutrients availability and favorable soil conditions due to compost application may cause vigorous crop growth and hence delayed silking. The results are in line with those of Ali *et al.* (2012), who reported late silking due to increase in organic fertilizer. Inamullah *et al.* (2011) also concluded delayed silking with higher nitrogen doses. Delay in days to silking of maize was also observed in our earlier study (Amanullah *et al.,* 2009a). Days to silking was significantly delayed with increase in nitrogen rate and increase in number of nitrogen splits (Amanullah *et al.,* 2009a).

Days to physiological maturity

Days to physiological maturity was significantly affected by compost, nitrogen and interaction between C x N showed in table 2, while tillage system had not significant effect on physiological maturity. Physiological maturity was delayed (106 days) at 2 t C ha^{-1}, while early physiological maturity (104 days) was observed in control plots. Plots treated with 120 or 150 kg N ha^{-1} delay physiological maturity (106 days), while early physiological maturity (14 days) was recorded at 60 kg N ha^{-1}. Interaction between C x N (Fig. 1) revealed that days to physiological maturity delayed with increasing compost from 0 to 2 t ha^{-1} in all nitrogen levels but linear increase was recorded in days to physiological maturity when treated with 150 kg N ha^{-1} and 2 t C ha^{-1}. These findings are in agreement with those of Ali *et al.* (2012), who investigated that phenological events like tasseling, silking and maturity in maize were significantly delayed by increasing rate of mineral N as well as organic fertilizer. Hamad *et al.* (2011) reported delayed in physiological maturity with increase in nitrogen rate. Delay in days to physiological maturity of maize was also observed in our earlier study (Amanullah *et al.,* 2009a). Days to physiological maturity was significantly delayed with increase in nitrogen rate and increase in number of nitrogen splits (Amanullah *et al.,* 2009a).

Plant height (cm)

Data regarding plant height showed in table 2 that with increasing compost level plant height increased and taller plant height (186 cm) were achieved at 2 t C ha^{-1},while dwarf plant (162 cm) were observed in control plots. Tillage system had significant effect on plant height. Maximum plant height (176 cm) was recorded in deep tillage, while minimum plant height (173 cm) was noted in conventional tillage. Mean values for nitrogen showed that maximum plant height (184 cm) was obtained at 150 kg N ha^{-1},while minimum plant height (164 cm) was recorded in those plots treated with 60 kg N ha^{-1}. Interaction among T x C x N (Fig. 2) revealed that plant height increased with increasing N levels in all compost level and tillage system but linear increase in plant height, when supplied with compost at the rate of 2 t ha^{-1} and nitrogen 150 kg ha^{-1} under deep tillage system. The increase in plant height with high level of compost and nitrogen was mainly due to the reason of more availability of nutrients throughout the growing season. These results agree with those of Amanullah *et al.* (2009b), who reported that nitrogen enhances vegetative growth and plant height. Taller plants were observed by Cheema *et al.* (2010) applying nitrogen 75% from urea and 25% from organic source. Farhad *et al.* (2009) also concluded taller plants with increase in the rate of organic matter added to the soil. Wasaya *et al.* (2012) also reported taller plants with the application of deep tillage (Chisel plough).

Leaf area plant^{-1} (cm^2)

Mean value of compost level (Table 2) revealed that leaf area plant^{-1} significantly increased with increasing compost level so that the maximum leaf area plant^{-1} (4545 cm^2) was obtained at 2 t C ha^{-1}, while minimum leaf area plant^{-1} (3392 cm^2) was obtained in control plots. Tillage systems had significant effect on leaf area plant^{-1}. Maximum leaf area plant^{-1} (4099 cm^2) was recorded with deep tillage system, while minimum leaf area plant^{-1} (3906 cm^2) was recorded with conventional tillage system. With increase of nitrogen level leaf area plant^{-1} increased significantly and therefore, the highest level of nitrogen (150 kg ha^{-1}) produced maximum leaf area plant^{-1} (4600 cm^2), while minimum leaf area plant^{-1} (3419 cm^2) was recorded when plots treated with 60 kg N ha^{-1}. Interaction among T x C x N (Fig. 3) indicated that leaf area plant^{-1} increased significantly with increasing N and compost level with both tillage systems but linear increase in leaf area plant^{-1} was recorded when crop treated with compost 2 t ha^{-1} and nitrogen at the rate of 150 kg ha^{-1} with deep tillage system. The increase in leaf area at higher N rate might have increased leaf area expansion rate as a result of faster cell division and greater cell expansion and increased photosynthate formation. Amanullah *et al.* (2009b) reported higher leaf area with higher nitrogen rate. Aikins *et al.* (2012) found increase in leaf area with the application of deep tillage implements. Efthimiadou *et al.* (2010) also support our findings and reported increase in leaf area with organic fertilizer.

Biomass yield (kg ha^{-1})

Biomass yield was significantly affected by compost, tillage, nitrogen and interaction among C x T x N. Maximum biomass yield (12317 kg ha^{-1}) was recorded with the application of 2 t C ha^{-1} while minimum biomass yield (9151 kg ha^{-1}) was produced by control plots. Tillage system had significant effect on biomass yield. Maximum biomass yield (11304 kg ha^{-1}) was produced with deep tillage system, while minimum biomass yield (10123 kg ha^{-1}) was produced with conventional system. With increase of nitrogen level increased biomass yield significantly and therefore, the highest level of nitrogen (150 kg ha^{-1}) produced maximum biomass yield (12712 kg ha^{-1}), while minimum biomass yield (8948 kg ha^{-1}) was recorded when plots treated with 60 kg N ha^{-1}. Interaction among T x C x N (Fig. 4) indicated that biomass yield increased significantly with increasing N and compost levels with both tillage systems but linear increase in biomass yield was produced by crop treated with compost 2 t ha^{-1} and nitrogen at the rate of 150 kg ha^{-1} with deep tillage system. The increase in biomass yield with higher level of compost and nitrogen could be due to balanced supply of nutrients throughout the development of plant. Cheema *et al.* (2010) reported maximum biomass yield at 75% mineral N and 25% organic N application. Iqbal *et al.* (2013) examined that N fertilization at 240 kg ha^{-1} with deep tillage was required for near maximum production (90%) of corn biomass yields. These results relate with Wasaya *et al.* (2012), who reported that biomass yield of maize improved due to good soil conditions provided to crop for better growth and development by loosening the soil with deep tillage system. Amanullah and Khan (2015) reported increase in the yield and yield components of maize with compost applied at sowing time than early application of compost. Amanullah *et al.* (2015) reported that increased in compost level increase yield and yield components of maize.

It was concluded from this research work that application of compost at the rate of 2 t ha^{-1} + 150 kg N ha^{-1} under deep tillage system delayed phenological development, produced taller plants and higher leaf area plant^{-1} that resulted in significantly higher biomass yield in spring maize.

Table 1. Chemical composition of commercial compost Higo Organic Plus used in the experiment

N	P	K	C/N	OM	OC	pH	EC	Zn	Cu	Fe	Mn
--------	--------	--------	--------	%	--------	--------	dSm^{-1}	--------	mg kg^{-1} (ppm)	--------	--------
2.8	3.0	3.0	4.5	40	11.7	7.1	8.6	145	56	380	228

Table 2. Days to tasseling, silking, physiological maturity, plant height, leaf area plant^{-1}and biomass yield of maize as affected by compost and nitrogen under conventional and deep tillage system

Treatment	Days to tasseling	Days to silking	Days to physiological maturity	Plant height (cm)	Leaf area plant^{-1} (cm^2)	Biomass yield (kg ha^{-1})
Tillage systems						
Conventional	68	75	105	173b	3906 b	10123 b
Deep	68	75	105	176a	4099 a	11304 a
LSD	ns	ns	ns	*	*	*
Compost (t ha^{-1})						
0	67 c	74 c	104 c	162 c	3392 c	9151 c
1	68 b	75 b	105 b	175 b	4072 b	10673 b
2	69 a	76 a	106 a	186 a	4545 a	12317a
LSD	0.33	0.31	0.32	1.13	39	537
Nitrogen (kg ha^{-1})						
60	67 c	74 c	104 c	164 c	3419d	8948 d
90	68 b	75 b	105 b	172 c	3741c	9850 c
120	69 a	7a a	106 a	179 b	4252b	11345 b
150	69 a	76 a	106 a	184 a	4600a	12712 a
LSD	0.24	0.22	0.23	1.17	51	436
Interactions						
T x C	ns	ns	ns	ns	ns	ns
T x N	ns	ns	ns	ns	ns	ns
C x N	ns	ns	*	ns	ns	ns
T x C x N	ns	ns	ns	*	*	*

Mean followed by the same letters within columns are not different statistically.

ns = non-significant at 5% level of probability * = significant at 5% level of probability

Fig. 3. Leaf area plant^{-1} of maize as affected by tillage, compost and nitrogen

Fig. 4. Biomass yield of maize as affected by tillage, compost and nitrogen

REFERENCES

Aikins, S. H. M., J. J. Afuakwa and O. Owusu-Akuoko, 2012. Effect of four different tillage practices on maize performance under rainfed conditions. Agric. Biol. J. N. Am. **3**(1): 25-30.

Ali, K., F. Munsif, Iftikhar-Ud-Din, A. Khan and N. Khan, 2012. Maize penology as affected by tillage practices and nitrogen sources. Agric. Sci. Res. J. **2**(8): 453-458.

Amanullah and Adil Khan. 2015. Phosphorus and compost management influence maize (*Zea mays*) productivity under semiarid condition with and without phosphate solubilizing bacteria. Frontiers in Plant Science (Plant Biotic Interactions). **6**: 1083 (open access).

Amanullah, I. Khan, A. Jan, M.T. Jan, S.K. Khalil, Z. Shah and M. Afzal, 2015. Compost and nitrogen management influence productivity of spring maize (*Zea mays* L.) under deep and conventional tillage systems in Semi-arid regions. Comm. Soil Sci. Plant Analysis. **46** (12):1566-1578.

Amanullah, R. A. Khattak and S. K. Khalil, 2009a. Effects of plant density and N on phenology and yield of maize. J. Plant Nutrition. **32**(2): 246-260.

Amanullah, K. B. Marwat, P. Shah, N. Maula and S. Arifullah, 2009b. Nitrogen levels and its time of application influence leaf area, height and biomass of maize planted at low and high density. Pak. J. Bot. **41**(2): 761-768.

Amanullah, M. Zakirullah and S. K. Khalil, 2010. Timing and rate of phosphorus application influence maize phenology, yield and profitability in Northwest Pakistan. Int'l. J. Plant Prod. **4** (4):283-294.

Cheema, M. A., W. Farhad, M. F. Saleem, H. Z. Khan, A. Munir, M. A. Wahid and F. Rasul, 2010. Nitrogen management strategies for sustainablemaize production. Crop and Environ. **1**(1): 49-52.

Cox, W. J., S.Kalonge, D. J. R. Cherney, and W. S. Red, 1993. Growth, yield and quality of forage maize under different nitrogen management practices. Agron. J. **5**: 341-347.

Efthimiadou, A., D. Bilalis, A. Karkanis and B. F. Williams, 2010. Combined organic/inorganic fertilization enhance soil quality and increased yield, photosynthesis and sustainability of sweet maize crop. AJCS. **4**(9):722-729.

Farhad,W., M. F. Saleem and M. A. Cheema, 2011. Effect of poultry manure levels on the productivity of spring maize (*Zea mays* L.). J. Ani. Plant Sci. **19**(3):122-125.

Gil, M. V., M. T.Carballo and L. F. Calvo,2007. Fertilization of maize with compost from cattle manure supplemented with additional mineral nutrients. Waste Manage. **28**: 1432-1440.

Gromove, A. A., V. F. Abaimer, N. D. Kanhove and V. B. Schukin, 1994. The effect of increasing calculated dose of fertilizers in cereal fallow-row crop rotation on southern Chernozem in the Orenburg Region. Agron.Khimiya, **6**: 59-66.

Hamad, H. M., A. Ahmad, A. Wajid and J. Akhter, 2011. Maize response to time and rate of nitrogen application. Pak. J. Bot. **43**(4): 1935-1942.

Hara, M., H. Ishikawa and Y. Furuichi, 2003. Manufacturing conditions and handling improvement effects of pelletized compost from swine manure using a uniaxialextruder. Japanese J. Soil Sci. Plant Nutri. **74**: 1-7.

Inamullah, N. H. Shah, N. Rehman, M. Siddiq and Z. Khan, 2011. Phenology yields and their correlations in popular local and exotic maize hybrids at various nitrogen levels. Sarhad J. Agric. **27** (3): 363-369.

Iqbal, M., A. G. Khan, A. Hassan and K. R. Islam, 2013. Tillage and nitrogen fertilization impact on irrigated corn yields, and soil chemical and physical properties under semiarid climate. J. Sustainable Watershed Science & Management **1**(3): 90-98.

Khaliq, T., T. Mahmood and A. Masood, 2004. Effectiveness of farmyard manure, poultry manure and nitrogen for corn (*Zea mays*) productivity. Int. J. Agric. Biol. **2**: 260-263.

Khan, H. Z., S. Iqbal, A. Iqbal, N. Akbar and D.L. Jones, 2011. Response of maize (*Zea mays* L.) varieties to different levels of nitrogen. Crop Environ. **2**: 15-19.

Liebman, M., F. D. Menalled, D. D. Buhler, T. L. Richard, D. Sundberg, C. Cambardella and K. Kohler, 2004. Impacts of composted swine manure on weed and corn nutrient uptake, growth, and competitive interactions. Weed Sci. **52**: 365-375.

Marschner, H. 1986. Mineral nutrition of higher plants. Academic Press Inc., San. Diego, USA. 148-173.

Mehdi, B. B., C. A. Madramootoo and G. R. Mehuys, 1999. Yield and nitrogen content of corn under different tillage practices. Agron. J. **91**: 631-636.

Shah, Z. and M. Anwar, 2003. Assessment of solid waste for nutrient elements and heavy toxic metals. Pakistan J. Soil Sci. **22**: 1–10.

Steel, R. G. D. and J. H. Torrie, 1980. Principles and procedures of statistics. 2ndEd. McGraw Hill, New York.

Warren, J. G., S. B. Phillips, G. L. Mullins, D. Keahey and C. J. Penn, 2006. Environmental and production consequences of using alum-amended poultry litter as a nutrient source for corn. J. Environ. Qual. **35**: 172-182.

Wasaya, A., M. Tahir, A. Tanveer and M. Yaseen, 2012. Response of maize to tillage and nitrogen management. J. Anim. Plant Sci. **22**(2): 452-456.

Zia, M. S., S. K. Khalil, M. Aslam and F. Hussain, 2003. Preparation of compost and its use for crop production. Sci. Tech. Dev. **22**: 32-44.

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