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PHENOLOGY AND YIELD COMPONENTS OF MAIZE AS INFLUENCED BY DIFFERENT FORMS OF DAIRY MANURE WITH SUPPLEMENTAL NITROGEN MANAGEMENT

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Abstract
Dairy manures being a fundamental part of sustainable farming which enhances both soil fertility and productivity by providing both macro and micro nutrients as well as soil organic matter that retains soil moisture and nutrients conservation. The objectives of the study were to evaluate response of different forms of dairy manure with supplemental nitrogen application timing on growth and phenology of maize. The experiment was laid out in randomized complete block design having three factors, different forms of dairy manures (fresh and composted), their levels (3, 4 and 5 t ha^{-1}) and nitrogen application timing (full at sowing, full at V6 stage and half at sowing + half at V6 stage). The experimental results stated that among different forms of dairy manures, composted dairy manure applied at 5 t ha^{-1}delayed days to tasseling, silking and physiological maturity as compared to fresh dairy manure. Composted dairy manure at higher level produced higher ears m^{-2}, lengthy ears, more rows ear^{-1}, higher grains row^{-1} and increase grain yield over fresh dairy manure. Among different nitrogen application timing, nitrogen applied in two splits i.e half at sowing + half at V6 stage delayed days to tasseling, silking and physiological maturity and resulted higher ears m^{-2}, longer ears, maximum rows ear^{-1}, more grains row^{-1}and higher grain yield than nitrogen applied fully at sowing and V6 stage. Conclusively, application of composted dairy manures at the rate of 5 t ha^{-1} along with nitrogen in two splits improved phenology and growth of maize under agro-ecological condition of Peshawar.

Key words: Compost, Nitrogen, Phenology, Yield traits and Maize.

INTRODUCTION

Maize (*Zea mays* L.) is an extensively planted crop in most of the countries and is the third most important cereal crop after wheat and rice in Pakistan. It is a day neutral crop and sown twice a year in spring and summer. Bibi et al. (2010) reported that maize is a multipurpose crop (e.g. used as human food, animal's and poultry feed, and in industrial products). A hundred gram of fresh grains of maize contains 361 calories of energy, 9.4 g protein, 4.3 g fats, 74.4 g carbohydrates, 1.8 g fibers, 1.3 g ash and vitamins etc. in mg (Ali et al., 2014). In Pakistan 90-97% of total maize is cultivated in Khyber Pakhtunkhwa (KPK) and Punjab. It is cultivated on 56% of the total area and contributed 63% to the total production in KPK. It

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contributes 2.1% to the value added in agriculture and 0.4% to GDP. In Pakistan it was cultivated on an area of 1142.5 thousands ha with the production of 4936.8 thousand tons whereas the national average yield was 4321 kg ha^{-1}. It was raised on an area of 463 thousand hectares with the production of 909.7 thousand t. The average yield was 1965 kg ha^{-1} in KPK (MNFSR, 2015).

Nitrogen is currently an exorbitant and pricey element for the production of maize in the developing nations (Khan et al., 2013). In most areas unavailability of nutrients at key growth stages of maize negatively affect the crop phenology and decrease maize yield (Moser et al., 2006 and Grant et al., 2002). Our soil are deficient in nitrogen due to certain reasons which involve leaching, volatilization and runoff of these essential nutrients. Likewise, Amanullah et al. (2009) stated that application of nitrogen only at sowing can increase leaching and volatilization problems. Decrease nutrients availability in the soil is a major issue that affect crop growth and productivity (Li et al., 2001). To prevail over the situation, the use of organic sources for nitrogen and also timely application of nitrogen at different stages is the best possible solution to the problem. Application of pricey chemical fertilizer can be only reduced by replacing it with available organic manures (Hegde, 1998). Organic manures has both micro and macro nutrients due to which it vary from inorganic manures (Delate and Camberdella, 2004). Addition of FYM to the soil have been practiced for many years and it has positively improved crop productivity and enhanced soil fetility, intensify organic matter and appreciate microbial activity (Blair et al., 2006; Kundu et al., 2007). Shafi et al. (2007) stated that increasing nitrogen increased maize growth. The uptake of nitrogen was higher at vegetative stages of the crop and higher nitrogen uptake was noted at silking stage.

Composting is a natural decomposition of organic matter into humus with the help of microorganism. Addition of compost will not only reduce the cost of production for farmers but also reduces pollution and nutrients loss due to run-off and leaching (Nyamangara et al., 2003). Compost is a rich source of nutrients, it improves soil physical and chemical properties of soil and improve crop productivity because of its availability of nutrients throughout the growing season (Hussain et al., 2001). It will also reduce the production cost for farmers by replacing the costly chemical fertilizers (Sarwar et al., 2007). Compost increases the seed germination and enhances microflora population (Marten, 2000).

Keeping in view the importance of organic manures and nitrogen application at different stages of the crop, the current study was accomplished to assess the effect of different forms of dairy manures and supplemental nitrogen management on growth and yield of maize.

MATERIALS AND METHODS

Field experiment was performed to investigate response of maize to fresh and on-farm composted dairy manures with supplemental N-fertilizer at the Agronomy research farm, The University of Agriculture Peshawar, during summer 2015.The experimental field was irrigated before sowing and then ploughed to incorporate the manures and to prepare a fine seed bed for sowing. The experiment was conducted in randomized complete block design with four replications. The size of plots was 3.5 m × 4 m with row to row distance of 70 cm. There were 19 plots having (treatment combination of three levels of fresh dairy manure, composted dairy manure and fertilizer N application timing with one control) per replication. The experiment was consisted of three factors i.e. Manures (fresh and on-farm composted dairy manures), levels of manures (3,4 and 5 t ha^{-1}) and fertilizer-N application timing. Nitrogen was applied at the rate of 100 kg ha^{-1} with different application timings (full at sowing, full at V6 stage and half at sowing + half at V6 stage). Recommended dose of phosphorus (90 kg ha^{-1}) in the form of single super phosphate was applied at the time of seed bed preparation. The maize variety cultivated was Azam.

Compost preparation: In order to prepare compost pit was made about 75 cm deep. The composting materials was brought to the pit and sprayed with BIOAAB (beneficial microbes) to speed up the microbial activity and decomposition process. The composting material (fresh dairy manure) was dumped in pit in moist condition then it was covered with plastic and buried in the soil for three weeks. The composted material was turned over completely after 1st and 2nd week to speed up the decomposition process and ensure uniformity. Compost was applied before sowing and incorporated in the trail field.

Table 1. Analysis of composite soil sample taken from trail field before sowing.

Property	Units	Concentration
Sand	%	28.4
Silt	%	66.2
Clay	%	5.4
Textural class	-	Silt loam
pH	-	7.56
Electrical conductivity (EC_e)	d Sm^{-1}	1.76
Lime	%	16.5
Organic matter content	%	0.73
Total nitrogen content	%	0.08
AB-DTPA extractable P	mg kg^{-1}	2.25

Soil analysis: Soil was taken at a depth of 0-30 cm from trail field. A composite sample was taken from it, air dried, grinded and sieved through 2mm sieve and was analyzed for various physiochemical characteristics such as pH, EC, texture, lime, organic matter, AB-DTPA extractable phosphorus and total nitrogen. The soil under investigation was silt loam in textures, low in organic matter, total N and AB-DTPA extractable P contents. The soil was alkaline in reaction moderately calcareous and non-saline (Table 1).

Parameters studied: Days to emergence, days to tasseling, days to silking, days to physiological maturity were recorded by counting the number of days from sowing till 75% emergence, 75% tasseling, 75% silking and 75% physiological maturity respectively. Ears m^{-2} were recorded by counting the number of ears in each plot and were converted. Ear length was determined by measuring the length of ear from base to tip without shank with the help of measuring tape. Grains row ear^{-1} was recorded by counting the number of rows in five randomly selected ears and average was worked out. Grains row^{-1}were calculated by counting the number of grains in three rows in five randomly selected ears and average was calculated. Grain yield was recorded by harvesting three central rows from each plot, the harvested plants were sun dried and the ears were collected from all the plants. Grains were removed and weighed.

Statistical analysis: The recorded data were analyzed statistically using ANOVA techniques suitable for randomized complete block design and means were compared using LSD test upon significance at 5% level of probability (Jan et al., 2009).

RESULTS AND DISCUSSION

Days to emergence: Different forms of manures and their levels as well as nitrogen application timing had no significant effect on days to emergence of maize (Table 2). The comparison of control with the treated plots and all the interactions were found insignificant for days to emergence of maize.All the treatments had notaffected days to emergence of the crop and this might be due to unavailability of nutrients at that stage or this might be due to the less potential of the crop for uptaking of the nutrients at that stage. Our results are in disagreement with (Black et al., 1974, Brandy and Weil 2002) which resulted that increase in nitrogen level enhance days to emergence of maize. Rosan et al. (1997) revealed early germination with increase in nitrogen levels.

Days to tasseling: Different forms of manure, their levels as well as N application timings significantly affected days to tasseling of maize (Table 2). The comparison of control vs. rest was also found significant for days to tasseling of maize. All the interactions were found non-significant for days to tasseling. Mean values of the data showed that application of composted dairy manure delayed days to tasseling (54 days) as compared to fresh dairy manure (53 days). Manure applied at the rate of 5 t ha^{-1}delayed days to tasseling (54days).Days to tasseling was earlier (53 days) with manure application at the rate of 4 and 3 t ha^{-1}. Nitrogen applied to maize in two equal splits took more days to tasseling (54 days) as compared with lesser days to tasseling (53 days) when N was applied fully at sowing time and V6 stage. The comparison revealed that delayed tasseling (53 days) was observed in the fertilized plots (rest) as compared to control plots (51 days).The delaying in days to tasseling might be due to the slow release of nutrients from organic sources and N application at appropriate stage which extend the growth cycle of the crop. Our results are comparable with Amanullah et al. (2009) who reported that increase in nitrogen delay tasseling in maize. These results are also in line with those of Hammad (2012) that addition of nitrogen at later stages delayed tasseling in maize.

Days to silking: Days to silking of maize was significantly affected by different forms of manures, their levels and N application timings (Table 2). The comparison of control vs. rest was also found significant for days to silking of maize. All the interactions were found non-significant for days to silking. Analysis of the data showed that silking was delayed (59 days) with incorporation of composted dairy manure as compared to the fresh dairy manure (58 days). Days to silking increased persistently with increasing manure levels, Manure applied at the rate of 5t ha^{-1}took more days to silking (59 days) which are statistically at par with manure applied at 4 t ha^{-1}. Days to silking were lesser (58 days) with manure application at the rate of 3 t ha^{-1}. Nitrogen applied in two splits took more days to silking (59 days) and lesser days to silking (58 days) were taken with application of N fully at sowing and V6 stage. The planned mean comparison indicated more days to silking (59 days) in the fertilized plots as compared to non-fertilized plots (57 days). This delaying in days to silking might be due to more nitrogen availability for the whole season from organic source because of the slow release of nutrients from organic sources which extend the vegetative growth of the crop and ultimately delay days to silking. Our result are in agreement with Rizwan et al. (2003), Sharif et al. (2004) and Hance et al. (2008) who stated that availability of N at proper amount and time increased days to silking.

Days to physiological maturity: Number of days to physiological maturity of maize was significantly affected by different forms of manures, their levels and N application timing (Table 3). The comparison of control vs. rest was found significant for days to physiological maturity of maize. All the interactions were found non-significant. Mean values of the data indicated that composted dairy manure delayed maturity (95 days) as compared to the fresh dairy manure (94 days). Concerning manure levels, manure applied at the rate of 5 t ha^{-1} took more days to physiological maturity (96 days). The days to physiological maturity were lesser (93 days) with manure application at the rate of 3 t ha^{-1}. Nitrogen applied in two splits took more days to maturity (95 days) and lesser days to maturity (94 days) were recorded with application of N fully in single dose. The comparison indicated more days to physiological maturity (94 days) in the fertilized plots as compared to non-fertilized plots (88 days).This might be due to increase in nutrients with increase in compost rates and adequate micro and macro nutrients throughout the growing season. Shrestha (2013) reported that increase nitrogen extend the vegetative stage which ultimately delay the maturity of crop. Our results are dissimilar to Shah et al. (2009) who reported that compost had no effect on days to maturity and this might be due to varietal characteristics. Hammad (2012) stated that nitrogen addition at later stages of the crop delay physiological maturity of the crop.

Ears m^{-2}: Different forms of manures and their levels as well as nitrogen application timing had not significantly affected ears $m^{-2}$of maize (Table 3). All the interactions were found non-significant whereas the comparison of control vs. rest was found significant for ears m^{-2} of maize. Analysis of the data revealed that increased ears m^{-2} (5.5) was noticed in the fertilized plots as compared to control (4.3). The application of manures to the field had a positive effect on ears m^{-2} as compared to control. The control plots had less ears and thus decrease the yield of maize. These results are in agreement with Malaiya et al. (2004) who proved that maximum ears were produced with combination of nitrogen and manure as compare to unfertilized plots. Dixit and Gupta (2000) and Sarwar et al. (2008) stated that application of organic manures like compost enhances the crop growth and increase tillers m^{-2} in rice and wheat which increase the productivity of the crop.

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Table 2. Days to emergence, tasseling, silking and physiological maturity of maize as affected by fresh and on-farm composted dairy manure, their levels as well as N application timing.

Dairy manures (M)	Days to emergence	Days to tasseling	Days to silking
Fresh	7	53	58
Composted	7	54	59
Significance	Ns	***	***
Manure levels (L) (t ha^{-1})			
3	7	53 b	58 b
4	7	53 b	59 a
5	7	54 a	59 a
LSD (0.05)	Ns	0.62	0.57
N application timing (AT)			
Full at sowing (S)	7	53 b	58 b
Full at V6 stage (V6)	7	53 b	58 b
1/2 at S + 1/2 at V6	7	54 a	59 a
LSD (0.05)	Ns	0.62	0.57
Control vs. rest			
Control	8	51	57
Rest	7	53	59
Significance	Ns	***	***
Interactions			
M x L	Ns	Ns	ns
M x AT	Ns	Ns	ns
L x AT	Ns	Ns	ns
M x L x AT	Ns	Ns	ns

Means of each category followed by different letter(s) are statistically different from each other
ns = Non significant
**** = Significant at 1% level of probability*

Ear length (cm): Ear length (cm) of maize as affected by different forms of manure their levels as well as nitrogen application timing (Table 3). The planned mean comparison of control vs. rest was found significant while all the interactions were found non-significant for maize. Statistical analysis of the data revealed that composted dairy manure produced lengthy ears (15.9) as compared fresh dairy manure (15.2). Regarding manure levels, manure applied at 5 t ha^{-1} produced lengthy ears (16.2) followed by (15.5) with manure at 4 t ha^{-1} while shorter ears (14.9) were produced with manure application at 3 t ha^{-1}. Among nitrogen application timing, nitrogen applied in two equal splits i.e half at sowing and half at V6 stage produced longer ears (16.0) which are statistically similar (15.7) with nitrogen applied full dose at V6 stage whereas shorter ears (14.9) were observed with N applied fully at sowing. The planned mean comparison of control vs. rest indicated that longer ears (15.5) were observed with fertilized plots as compared to non-fertilized plots (14.2). Our results are at par with (Amanullah et al., 2014 and Kandil, 2013) they resulted that increasing amount of nitrogen increases ear length of maize. The longer ears are due to the availability of more nitrogen and other essential nutrients from both dairy manures and inorganic nitrogen. These results are similar to the findings of Chapagain (2010) who experienced that application of nitrogen from organic and inorganic both sources enhanced crop growth, ear length and yield of maize.

Grain rows ear^{-1}: Different manure forms and their levels as well as nitrogen application timing had significantly affected grain rows ear^{-1} of maize (Table 4). The comparison of control vs. rest was also found significant while all the interactions were found non-significant for maize. Mean values of the data stated that more grain rows ear^{-1}(14.4) were observed with composted dairy manure as compared to fresh dairy manure (13.9). Among different manure levels, manure applied at 5 t ha^{-1} produced more number of grain rows ear^{-1} (14.7) while lower grain rows ear^{-1} were noted with manure applied at 3 t ha^{-1} (13.9). Regarding nitrogen application timing, N applied in two splits i.e half each at sowing and V6 stage experienced increase grain rows ear^{-1}(14.4) which are statistically at par with nitrogen applied fully at V6 stage whereas less (13.9) were experienced with nitrogen applied fully at sowing. The planned mean comparison of control vs. rest stated that fertilized plots had higher grain rows ear^{-1}(14.2) as compared to control (12.8). The increased in rows ear^{-1} of maize might be due to the availability of nitrogen throughout the growing season. Composted dairy manure had nitrogen in already available form for the crop due to which the number of rows ear^{-1} were increased by increasing the diameter of ears with compost as compare to fresh dairy manure. Split application of inorganic nitrogen reduces the losses of nitrogen and increase crop growth. Our results are similar with the findings of Ali et al. (2015). Tamayo et al. (1997) stated that application of compost produced higher number of rows per ear due to availability of nutrients at appropriate time especially at grain setting.

Grains row^{-1}: Grains row^{-1} of maize was significantly affected by different forms of manure their levels as well as nitrogen application time (Table 4). The comparison of non-fertilized with fertilized was found significant for grains row^{-1} of maize. All the interactions were found insignificant for grains row^{-1}. Mean values of the data indicated that composted dairy manure produced significantly higher grains row^{-1} (29.7) as compared to the fresh dairy manure (28.4). Regarding manure levels, manure applied at the rate of 5 t ha^{-1} produced higher grains (30.1) row^{-1}. The grains number was lower (28.0) with manure application at the rate of 3 t ha^{-1}. Nitrogen applied in two splits produced more grainsrow^{-1}(29.8) and lesser grains (28.4) were produced with application of N in single dose both fully at sowing and V6 stage. The comparison of control vs. rest revealed more number of grains row^{-1} (29.1) in the fertilized plots as compared to control plots (23.6). The increase in number of grains row^{-1} of maize might be due to the extended grain filling duration, availability of essential nutrients at critical stages and longer ears. Ali et al. (2015) stated that increase in nitrogen doses increases the grains ear^{-1}. Grains ear^{-1} increased with application of compost at the rate of 5 t ha^{-1}. Pandey et al. (2000) reported that increased in seed weight is due to the increase in grains ear^{-1} and decrease in unproductiveness of ears of maize. Bekeko et al. (2013) revealed that application of nitrogen to the crop increases seeds ear^{-1}. Kumar et al. (2002) reported that application of organic manure with inorganic nitrogen increase the number of grains in maize.

Grain yield (kg ha^{-1}): Grain yield of maize was significantly affected by different manure forms, their levels as well nitrogen application timing (Table 4). The planned mean comparison of control vs. rest and the interaction M x L was also found significant. Mean values of the data indicated that composted dairy manure produced significantly higher grain yield (3890.9) as compared to the fresh dairy manure (3494.0). Regarding manure levels, manure applied at the rate of 5 t ha^{-1} produced higher grain yield (3953.8). The grain yield was lower (3391.8) with manure application at the rate of 3 t ha^{-1}. Nitrogen applied in two splits produced more grain yield (3894.1) and lesser grain yield (3494.3) was recorded with application of N in single dose fully at sowing. The comparison of control vs. rest revealed more number of grain yield (3692.4) in the fertilized plots as compared to control plots (2627.5). The interaction

M x L stated that grain yield increased linearly from 3 to 5 t ha^{-1} with both fresh and composted dairy manure but the increased was more prominent with composted dairy manure as compared to fresh dairy manure (Fig. 1). The increase in grain yield might be due to the slow release of nutrients and also due to availability and release of nutrients at appropriate time. The increased in number of grains per ear with composted dairy manure at higher levels increase the grain yield. These results are in line with Tamayo et al. (1997) who stated that increase in rows per cob and grains per row increases the grain yield. Our results are also in comparison with Loecke et al. (2004) who stated that grain yield of maize increased with composted manure as compared to fresh manure. Magdoff (1991) reported that application of nitrogen at appropriate time enhanced grain yield of maize.

Table 3. Days to physiological maturity, cobs m^{-2} and cob length (cm) of maize as affected by fresh and on-farm composted dairy manure, their levels as well as N application timing.

Manures	Days to maturity	Cob m^{-2}	Cob length (cm)
Fresh dairy manure	94	5.4	15.2
Composted dairy manure	95	5.5	15.9
Significance	**	ns	***
Manure levels (t ha^{-1})			
3	93	5.4	14.9 c
4	94	5.5	15.5 b
5	96	5.6	16.2 a
LSD (0.05)	0.99	ns	0.4
N application timing			
Full at sowing (S)	94	5.5	14.9 b
Full at V6 stage (V6)	94	5.5	15.7 a
1/2 at S + 1/2 at V6	95	5.5	16.0 a
LSD (0.05)	0.99	ns	0.4
Control vs. rest			
Control	88	4.3	14.2
Rest	94	5.5	15.5
Significance	***	***	***
Interactions			
M x L	ns	ns	Ns
M x AT	ns	ns	Ns
L x AT	ns	ns	Ns
M x L x AT	ns	ns	Ns

Means of each category followed by different letter(s) are statistically different from each other
ns = Non significant
*** = Significant at 1% level of probability

Table 4. Grain rows ear^{-1}, grains row^{-1} and grain yield (kg ha^{-1}) of maize as affected by fresh and on-farm composted dairy manure, their levels as well as N application timing.

Manures	Grain rows ear^{-1}	Grains row^{-1}	Grain yield
Fresh dairy manure	13.9	28.4	3494.0
Composted dairy manure	14.4	29.7	3890.9
Significance	**	***	***
Manure levels (t ha^{-1})			
3	13.9 b	28.0 c	3391.8 c
4	14.2 b	29.1 b	3731.7 b
5	14.4 a	30.1 a	3953.8 a

Continued table 3……..			
LSD (0.05)	0.4	0.8	95.6
N application timing			
Full at sowing (S)	13.9 b	28.4 b	3494.3 c
Full at V6 stage (V6)	14.3 a	29.0 b	3688.9 b
1/2 at S + 1/2 at V6	14.4 a	29.8 a	3894.1 a
LSD (0.05)	0.4	0.8	95.6
Control vs. rest			
Control	12.8	23.6	2627.5
Rest	14.2	29.1	3692.4
Significance	***	***	***
Interactions			
M x L	ns	Ns	*
M x AT	ns	Ns	Ns
L x AT	ns	Ns	Ns
M x L x AT	ns	Ns	Ns

Means of each category followed by different letter(s) are statistically different from each other
ns = Non significant
**** = Significant at 1% level of probability*

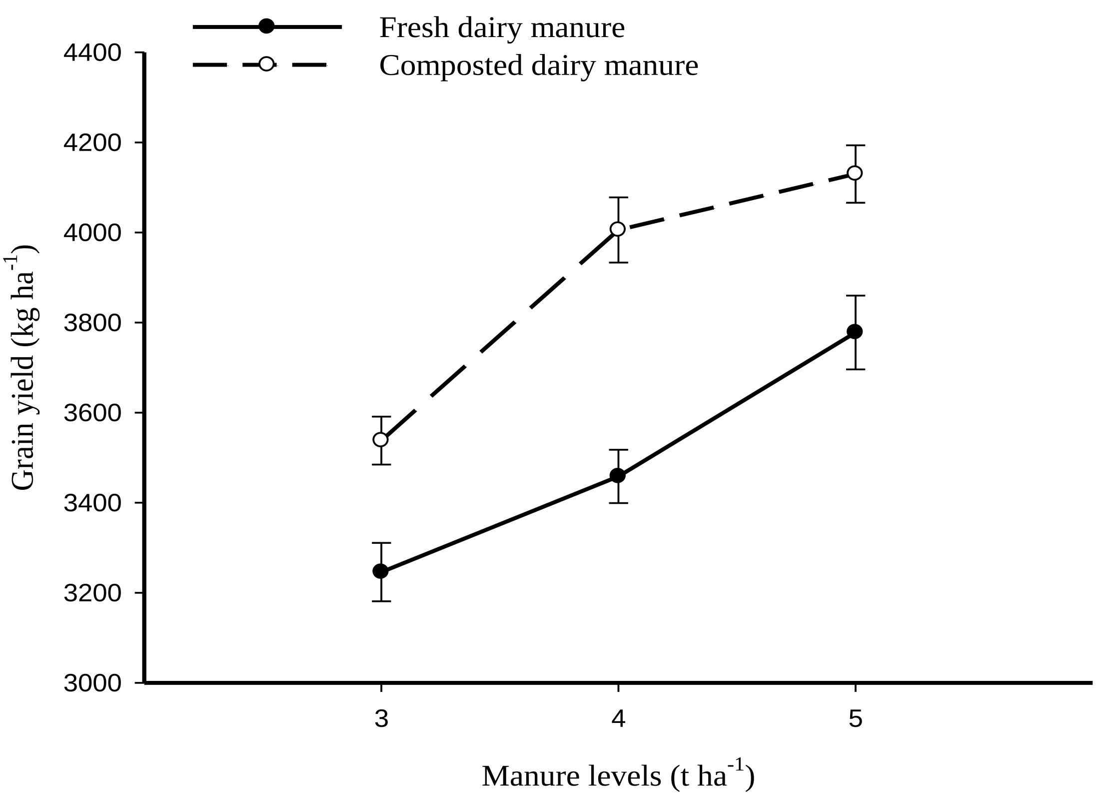

Figure 1. M x L interaction for grain yield (kg ha^{-1}) of maize

CONCLUSION

It is concluded from the experiment that composted dairy manure at 5 t ha^{-1}positively enhanced the growth and yield of maize crop. Among nitrogen application timing, nitrogen applied in splits improved the growth and productivity of maize.

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