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GROWTH AND YIELD RESPONSE OF MAIZE TO INTEGRATED USE OF *GLIRICIDIA SEPIUM*, FARM MANURE AND NPK FERTILIZERS

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ABSTRACT

A field study was carried out to evaluate the effect of some organic fertilizers such as *Gliricidia sepium,* farm manure and inorganic fertilizers like NPK applied alone and in different combinations on the growth and yield attributes of maize (*Zea mays* L.) at Coastal Agricultural Research Station, PARC, Karachi, during the year 2007-08. The experimental design was randomized complete blocks, replicated four times having eight fertilizer treatments, including control. All the organic fertilizers were applied at the time of land preparation. Results obtained showed that application of NPK combined with organic fertilizers helped in increasing the crop yield more than when fertilizers were applied separately.

Keywords: FM, *Gliricidia sepium,* INM, maize, NPK fertilizers, yield.

INTRODUCTION

Maize (*Zea mays* L.) stands at third position as staple food crop among the cereals after rice and wheat across the world. It is widely grown cereal and is categorized as primary staple food in many developing countries. Among the cereals, maize is grown throughout the year, hence called 'Queen of Cereals'. In Pakistan, maize occupies third position after wheat and rice with average annual grain production of 4.04 million tons and average yield of 3.62 tons ha^{-1} (GoP, 2011). The potential of any crop can only be fully exploited by the judicious use of inputs at proper growth stages. Post-green revolution period in Pakistan has seen a tremendous rise in use of fertilizers for enhancing productivity of field crops. This has resulted in the deterioration of land resources on one hand and contaminating the environment on the other hand along with raising the cost of

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production. Most of the nitrogenous fertilizers leach down to the root zone or pollute the groundwater causing certain diseases in plants and human (Cheema *et al.,* 2010). In order to balance this situation integrated nutrient management system might be practiced in which natural resources such as organic matter, minerals and microbes are used in combination with inorganic materials. Organic materials consist of animal wastes, farm manure (FM), poultry manure (PM), compost, crop residues and green manures, etc. which are best substitute of chemical fertilizers (Khan *et al.,* 2005). Application of organic manures has various advantages such as improving soil properties, water holding capacity, organic carbon content; apart from providing soil nutrients (Sharif *et al.,* 2004).

The addition of organic sources could increase maize yield through improving soil fertility and higher fertilizer use efficiency (Gangwar *et al.,* 2006). Higher and sustained yield could be obtained with judicious and balanced fertilization combined with organic manures for ecological balance, low cost cultivation, clean environment and nutritious food without affecting human health (Bhatti *et al.,* 2008). Farm manure is the decomposition of dung and urine of farm animals along with litter and left over material from roughages or fodder fed of cattle. On an average it contains 0.5% N, 0.2% P and 0.5% K (Rasool *et al.,* 2007).

Research conducted in Malawi, Zambia and Zimbabwe showed that *gliricidia* produces rich foliage biomass that was easily decomposed as green manure (Akinnifesi *et al.,* 2006; Mafongoya *et al.,* 2006; Makumba *et al.,* 2005) and readily used by cereal companion crops. In another study, Subramanian *et al.* (2005) reported that the leaves of *Gliricidia sepium* decompose relatively fast, providing nitrogen and potassium and also improved the soil moisture availability. While, Tennakoon and Bandara (2003) were of the view that nutrient content of goat manure and fresh foliage of *Gliricidia sepium* had a higher content of N than the other material. *Gliricidia sepium* was introduced at Coastal Agricultural Research Station, PARC, Karachi (Formerly known as Plant Introduction Centre) from Sri Lanka and flourished here well. It is a leguminous tree which sheds off its leaves before flower initiation during the month of January. These leaves could be used for manuring purpose. Keeping in view the importance, a field experiment was conducted with the objective of finding out the effect of organic fertilizers such as *Gliricidia sepium*, farm manure (FM) and inorganic fertilizers i.e. NPK fertilizers applied alone and in different combinations on the growth and yield attributes of maize under agro climatic conditions of Malir district, Karachi.

MATERIALS AND METHODS

A field experiment was conducted at the experimental field of Coastal Agricultural Research Station (CARS), PARC, Karachi, to assess the influence of integrated use of *Gliricidia sepium*, farm manure (FM) and NPK fertilizers on the growth and yield characters of maize. The experiment was comprised of following eight fertilizer treatments: T1= Control, T2= NPK, T3= 20 tons FM, T4= 15 tons *G. sepium* leaves, T5= 10 tons FM and 7.5 tons of *G. sepium* leaves, T6= Half NPK +10 tons FM, T7= Half RD NPK + 7.5 tons of *G. sepium* leaves and T8= Half

NPK +10 tons FM and 7.5 tons of *G. sepium* leaves. A field with uniform topography was selected for the experiment and composite soil samples were taken from 0-15 and 15-30 cm depths for analyzing physico-chemical properties. These samples were then air-dried, ground, sieved and analyzed for various physical and chemical characteristics of soil. The soil texture was determined as per method described by Bouyoucos (1962). The soil samples were subjected to analysis for pH, EC organic matter nitrogen by Kjeldahl method available P and K by AB-DTPA (Soltanpour and Schwab, 1985). Before sowing, the land was ploughed, followed by clod crushing and leveling for achieving good seedbed.

The experiment was laid out in a RCB Design with four replications. The plot size was of 3x3 m with row-to-row and plant-to-plant spacing of 75 and 30 cm, respectively. Farm manure and green manure (*G. sepium* leaves) were used as per treatments schedule. Both farm and green manures were incorporated and mixed well into the soil at the time of land preparation. The NPK fertilizers were used @ 120-90-60 Kg ha^{-1} as recommended dose for maize. All phosphorus and potassium as DAP (46% P_2O_5), and SOP (50% K_2O), respectively were applied during final land preparation and nitrogen as Urea (46% N) in three equal split applications. The seed of maize variety Akbar was sown using hand drill. All agronomic practices and plant protection measures were carried out to all treatments uniformly during the course of study.

The field was kept free from weeds by hand weeding. The growth and yield attributes were recorded from randomly selected five plants of each plot. The observations on germination percentage (%), plant height (cm), number of leaves, stem girth (cm), number of cobs $plant^{-1}$, number of grains cob^{-1}, 1000 grain weight (g) and grain yield (t ha^{-1}) were recorded. The data thus collected were subjected to statistical analysis using analysis of variance technique and LSD at 5% level with Mstat-C computer statistical software, following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Physico-chemical characteristics of experimental soil

The result of physical and chemical properties of the soils of the trial site states that the soil ranged from sandy loam to loam. The soil was low in organic matter content and alkaline in reaction. Nitrogen and phosphorus were found deficient, whereas, content of potassium was medium to high levels. The analysis of organic materials is given here as:

Table 1. Nutrient analyses of farm manure and *Gliricidia sepium*.

Organic manures	%N	%P	%K
Farm manure	0.60	0.44	1.00
Gliricidia sepium	0.86	traces	2.33

Growth parameters

Germination percentage (%)

It can be noted from the results that germination percentage (%) of the crop was not affected by chemical fertilizers and organic manures (Table 2). More than 85% of the germination was noted in control plots. However, seed germination percentage at constant rate was noted in all treatment plots which received chemical fertilizers or manures. The results suggested that the factors like soil moisture and environment required for seed germination were similar throughout the field and thus, the crop response was similar in all the treatments. These results were quite in line with Loecke *et al.* (2004) and Theodora *et al.* (2003) who concluded that plant emergence was not affected by manure treatments.

Table 2. Growth characteristics of maize (*Zea mays* L.) as affected by *Gliricidia sepium*, FM and NPK fertilizers.

Mineral fertilizers and organic manure treatments	Seedling emergence % (DAS)	Plant height (cm)	Stem girth (cm)	Number of leaves (plant^{-1})
T1 (Control)	86.00	189.35	5.00	14.1
T2 (NPK)	88.00	205.22	6.35	17.2
T3 (20 tons FM)	88.00	197.22	5.70	16.4
T4 (15 tons of *G. sepium* leaves)	88.00	191.80	5.20	16.0
T5 (10 tons FM and 7.5 tons of *G. sepium* leaves)	88.00	196.00	5.40	16.4
T6 (Half NPK+10 tons FM)	88.00	198.11	5.85	16.8
T7 (Half NPK+7.5 tons of *G. sepium* leaves)	88.00	202.00	5.33	16.2
T8 (Half NPK+ 10 tons of FM and 7.5 tons of *G. sepium* leaves)	88.00	204.12	6.30	17.0
LSD (P<0.05)	4.78	10.12	0.88	2.9

Plant height (cm)

Data pertaining to the plant height of maize variety Akbar as influenced by different chemical and organic fertilizers reveal that plant height was significantly affected by chemical fertilizers and organic manures (Table 2). The maximum plant height (205.22 cm) was recorded from plots which received full NPK only, followed by half NPK+FM+G.S (204.12 cm) while, minimum plant height (189.35 cm) was recorded from treatment where no fertilizer was applied. Half NPK along with *G. sepium* also increased plant height (202.00 cm). An increase in plant height might be due to the adequate availability of nutrients required for plant growth and development. This supports the integrated use of chemical and organic nutrient sources for an improvement in excellent vegetative growth of plant. These results are in agreement with those of Shah *et al.* (2009) and Achieng *et al.* (2010) who reported that application of mineral N alone or with organic N significantly increased the height of maize plants.

Table 3. Yield response of maize (*Zea mays* L.) to *Gliricidia sepium*, FM and NPK fertilizers.

Fertilizer and manure treatments	Number of cobs (plant^{-1})	Number of grains (cob^{-1})	1000-grain weight (g)	Grain yield (t ha^{-1})
T1 (Control)	0.50	255.33	165.77	1.10
T2 (NPK)	1.70	452.11	226.15	3.23
T3 (20 tons FM)	1.30	445.60	217.00	2.28
T4 (15 tons of *G. sepium* leaves)	1.25	441.22	210.22	2.13
T5 (10 tons FM and 7.5 tons of *G. sepium* leaves)	1.42	448.30	220.90	2.18
T6 (Half NPK+10 tons FM)	1.51	450.56	225.40	2.92
T7 (Half NPK+7.5 tons of *G. sepium* leaves)	1.22	440.22	200.15	2.75
T8 (Half NPK+ 10 tons FM & 7.5 tons of *G. sepium* leaves)	1.60	460.23	227.50	3.02
LSD (P<0.05)	0.22	22.50	12.10	0.32

Stem girth (cm)

The data (Table 2) indicated increase in stem girth in all the treatments, except control. The maximum stem girth was recorded from plants grown with full NPK only, followed by half NPK+FM+G.S. Half NPK along with FM and FM only produced stem girth of 5.85 and 5.70 cm, respectively. While, minimum stem girth was recorded in treatment, where no fertilizer was applied. Increase in stem girth is a reflection of retention of appreciable amount of assimilates in the stem for leaf production. This might be due to the better nutrient uptake and development of the plants due to the combined application of mineral fertilizer and organic manures. It was also due to the increase in nitrogen content of soil, which was responsible for overall enhancement of growth, increase in metabolic activities, assimilation rate and cell division within the plant (Cyrus *et al.,* 2010; Lawogbomo and Lawogbomo, 2009).

Number of leaves per plant

The data (Table 2) regarding the effect of different sources of inorganic and organic nutrients with various combinations on number of leaves per plant of maize variety Akbar reveal that the maximum number of green leaves (17.02 plant^{-1}) was recorded, where full NPK only was applied, followed by half NPK+FM+G.S (17.00 cm). While, minimum number of green leaves per plant (14.01) was recorded from control treatment. Half NPK along with FM also increased the number of leaves per plant (16.08). A significant effect on production of leaves was noted in plants where FM+G.S and FM only were applied. An increase in number of green leaves might be due to the chlorophyll content of leaves, which improved significantly with the availability of essential nutrients at all growth stages of maize. The results are in agreement with the findings of Namakha *et al.* (2008) and Mahmood *et al.* (2001) who also found that it might be due to optimum and regular supply of nitrogen to plants from soil during growth period with more assimilation rate and its integral part of protein and the building blocks of plant.

Yield and yield attributes

Number of cobs per plant

Data with respect to number of grains per cobs (Table 3) reveal that all the plants grown in all the treatments produced at least one cob except T8. Statistical analysis of the data reveals that an increase in number of cobs per plant was noted in plots which received chemical as well as organic fertilizers. However, maximum number (1.70 and 1.60 of cobs per plant) was noted in treatments where full NPK only and half NPK+FM+G.S were applied, respectively. Organic manures and inorganic fertilizer combinations resulted in more number of cobs per plant, possibly due to least N losses and availability of nutrients throughout the growing season of the crop. Control plots resulted in less number of cobs (0.50). The increase in number of cobs might be attributed to the availability of more nitrogen and other nutrients from both inorganic and organic source

required for plant development at least up to cob formation. These results suggested that adequate supply of nutrients from both organic and inorganic fertilizers throughout vegetative growth was necessary for proper cob development in maize. These results are in line with Chapagain (2010) and Zhang *et al.* (1998) who reported that combined application of organic manure and mineral fertilizer to maize crop could be as effective as commercial N fertilizer for yield response.

Number of grains per cob

Data pertaining to the number of grains per cob of maize variety Akbar as affected by different inorganic and organic sources revealed that the maximum number of grains per cob (460.23) was recorded in plants grown with half NPK+FM+G.S, followed by full NPK only. While, minimum grains per cob (255.33) was recorded in treatment where no fertilizer was applied. Half NPK along with FM and FM+G.S. also produced positive response for increasing number of grains per cob (450.56 and 448.30), respectively. Probable reason for maximum number of grains cob^{-1} could be due to mineral fertilizer and mineralization of organic manures throughout the growing period, which resulted in maximum grain production. These results are supported by Ayeni and Adetunji (2010) who concluded that addition of NPK improves soil physico-chemical properties that consequently increases yield and yield components of corn.

1000 grain weight (g)

The data regarding the effect of different treatments of inorganic and organic nutrient sources with various combinations on 1000-grain weight of maize variety Akbar revealed that the maximum 1000-grain weight (227.50 g) was recorded where half of the NPK+FM+G.S, followed by full NPK only (226.15) were applied. While, minimum 1000-grain weight (165.77 g) was recorded in treatment where no fertilizer was applied. Half NPK along with FM and FM+G.S, also produced positive response for increasing 1000-grain weight (225.40 and 220.15 g, respectively). The grain yield usually depends upon various factors such as status of soil fertility, water availability, crop management, agronomic practices, environmental factors and plant genetic characteristics. The results of this study show that treatments received N from organic and mineral sources produced maximum 1000-grain weight. Yield improvement under these treatments might be due to enhanced use of N, water and other associated soil improving benefits of organic sources, which made plants more efficient in photosynthetic activity. Decrease in required 1000-grain weight in control treatment might be due to low availability of nitrogen and other nutrients (Khan *et al.,* 2009). These results are in agreement with the findings of Achieng *et al.* (2010) and Shah *et al.* (2009) who were of the view that increase in 1000-grain weight was mainly due to the balanced supply of nitrogen in combination with P and K and maximum N use efficiency from both inorganic and organic sources during the grain filling, development and growth stages.

Grain yield (t ha^{-1})

Grain yield per unit area is a function of interaction among various yield contributing factors, which are affected differentially by the growing conditions and crop management practices. Grain yield is the end result of many complex morphological and physiological processes that occur during the growth and development of a crop. Data pertaining to the grain yield (Table 3) indicate that addition of NPK only affected the grain yield of maize significantly than all other treatments. Maximum grain yield (3.23 t ha^{-1}) was obtained where full NPK dose was applied, followed by half NPK+FM+G.S (3.02 t ha^{-1}). Whereas, minimum grain yield (1.10 t ha^{-1}) was recorded in treatment where no fertilizer was applied. Application of half NPK along with FM remained at third with grain yield of 2.92 t ha^{-1}. These results are in agreement with those of Onasanya *et al.* (2009) and Lelei *et al.* (2009) who found that the production of grain yield might be due to better growth, development and dry matter accumulation with proper supply of nutrients to plant and increase in the availability of other plant nutrients with the respective source of nitrogen application.

CONCLUSION

It can be concluded from the present study that integrated use of organic manures and chemical fertilizers is beneficial for maize crop. In order to harvest higher yield, it is important that organics have to be applied in adequate quantity. Due to ever increasing cost of chemical fertilizers their use in combination with organic sources has become imperative for sustained crop production. Organic manures such as farm manure and *Gliricidia sepium* along with NPK fertilizers significantly influenced the number of grains plant^{-1} and 1000-grain weight. Addition of farm manure with NPK affected almost all the growth and yield parameters, while application of organic manure (farm manure or *Gliricidia sepium*) could not prove as best when applied separately. Growth and yield parameters were significantly higher in NPK treated plots. There is a need for further investigation on application of *Gliricidia sepium* for more than one season.

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