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Integrated application of mineral fertilizer with farmyard and poultry manures on the growth and yield of cotton

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Abstract

Organic manures are considered as environment friendly approach, easy to use, having low cost, and capable of renewed foundation of plant nutrients. The purpose of using organic manures to improve fibre quality, keep environment safe and degradation shelter of soil. Field study was conducted to evaluate the effect of integrated application of nitrogen (N) and phosphorus (P) with farmyard manure (FYM) and poultry manure (PM) on cotton productivity and fiber worth. Treatments were arranged in randomized complete block design with three replications as, T_1= control (no manure and NP), T_2 = 112-56 NP kg ha^{-1}, T_3 = FYM 10 Mg+1/2 dose NP kg ha^{-1}, T_4= FYM 15 Mg+1/2 dose NP kg ha^{-1}, T_5= FYM 20 Mg+1/2 dose NP kg ha^{-1}, T_6= PM 10 Mg+1/2 dose NP kg ha^{-1}, T_7= PM 15 Mg+1/2 dose NP kg ha^{-1} and T_8= PM 20 Mg+1/2 dose NP kg ha^{-1}. The organic manures were incorporated 45 days before sowing. The results of current study showed the significant superiority of PM 20 Mg+1/2 dose NP kg ha^{-1}compared to other treatments. Furthermore; the results recorded taller plants (111 cm), more number of branches $plant^{-1}$ (17.7), more number of open bolls $plant^{-1}$ (27.2), maximum seed cotton yield (2573 kg ha^{-1}), higher ginning out turn (35.2 %), heavier seed index (9.92 g) and better staple length (28.5 mm). This research concluded that the integration of PM with NP fertilizer (PM 20 Mg+1/2 dose NP kg ha^{-1}) could be the best approach for enhancing and sustainability of cotton production.

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Introduction

Due to change of life pattern and increase in food and fibre demands of the increasing population of the world, the pressure significantly increased on the arable lands. The soil nutrient supplementation is required with all possible integrated sources to maintain fertility and productivity of soil (Mahajan *et al.*, 2008).

Low soil fertility in world including Pakistan is resulting in low crop productivity, which may cause the major reason for affecting food security (Iqbal*et al.*, 2017). Poor infrastructure, high chemical fertilizer costs and marketing problems are the major reasons for low crop production. There is need for increasing awareness for alternative agricultural practices, such as integration of organic manures with synthetic fertilizers, which helps to improve efficient utilization of chemical fertilizers, resulting in higher crop production (Mahajan *et al.*, 2008; Ali *et al.*, 2017). For small scale farmers, the organic manures could be the main source of nutrients, as they are locally available and cost effective.

Organic manures such as FYM and PM could help in the improvement of soil fertility, soil structure, water holding capacity and aeration of soil (Tadesse *et al.*, 2013; Joshi *et al.*, 2016; Ali *et al.*, 2017; Iqbal *et al.*, 2017). Furthermore, they also stimulates the activity of microorganisms that makes the availability of macro and micro nutrients through improved biological processes, which increase nutrient availability (Alabadan *et al.*, 2009; Kalhoro *et al.*, 2017). Organic manures are cost effective and renewable sources of essential plant nutrients that supplements synthetic fertilizers. Integration of organic manures with chemical fertilizers have long term effect on increasing crop productivity and maintaining soil health (Akbari *et al.*, 2011; Iqbal *et al.*, 2017).

Cotton (*Gossypium hirsutum* L.), is major cash fiber crop of Pakistan, and is an important source of foreign exchange. Our textile industry is dependent upon cotton. Use of cotton has been found for numerous purposes like making threads, mixing in other fibers, and extraction of oil from cottonseed. The oil content in the cottonseed ranges between 15-25 % depending upon varieties, after extraction of oil the seed cake is also good source of organic manure, and contains about 6 % N, 3 % P and 2 % potash (K) (Blaise *et al.*, 2003, 2005; Khan *et al.*, 2010).

The seed cotton yield is affected by number of factors including soil selection, sowing time, inter-culturing, irrigation, plant nutrients and crop protection measures. Of these, nutrients have vital role in the production of cotton crop and could be maintained to some extent through the application of different organic manures. Integration of organic and inorganic manures is required for higher crop productivity (Das *et al.*, 2004; Iqbal *et al.*, 2017). Farmyard manures improve the fiber yield, ginning out turn in cotton crop and maintain the nutrient balance of the soil (Blaise *et al.*, 2005; Reddy *et al.*, 2017). Moreover, it is further reported that cotton yields were higher with the application of FYM and poultry manures (Hulihalli and Patil, 2004; Reddy *et al.*, 2017).

Integrated application of chemical fertilizer and organic manures is much better than single use of either synthetic fertilizer or organic manures in cropping systems. It reduces the risks of soil acidification, and improves the physico-chemical properties of soil (Tolessa and Friesen, 2002; Khan *et al.*, 2010). Integration of FYM with synthetic fertilizers could be the better practice for decreasing nutrient loss, thereby improving nutrient use efficiency and crop productivity for maintaining economic sustainability and environment protection (Ali *et al.*, 2017; Iqbal., 2017). Furthermore, organic manures enhanced the fertilizer use efficiency, when applied in combination with mineral fertilizers (Nalatwadmath *et al.*, 2003; Azraf-ul-Haq *et al.*, 2007).

Application of organic manures with combination of NPK resulted in reduction of the deleterious effects of alkaline water applied to sodic soils, resulting to

increase crop yield by decreasing sodicity of the soil (Rathod *et al.*, 2003; Khan *et al.*, 2010; Joshi *et al.*, 2016). PM are also seems to be very effective for supply of nutrients (Koenning *et al.*, 2003), which produced high seed cotton yield, the N and P content were proportional as compared to commercial inorganic NP (Millhollon *et al.*, 2003; Iqbal *et al.*, 2017). Fresh and composted forms of PM are better than commercial source of nitrogen and can improve the soil moisture content and organic matter, reduce soil losses and improve cotton growth and lint yield (Reddy *et al.*, 2004, 2017). Consequently, (Blaise *et al.*, 2003; Ali *et al.*, 2017) reported that organic source of fertilizers resulted high crop yields.

In general, the organic manures recorded higher gross monetary returns compared with inorganic fertilizers and have positive residual effects on succeeding crop (Blaise *et al.*, 2005), which leads to an increase in the soil organic carbon, and reduction of soil erosion (Iqbal, 2017). Furthermore, they also help in improving the soil productivity, and also at same time protecting the soil environment from nitrate (NO_3^-) pollution and soil degradation (Nyakatawa *et al.*, 2001; Ali *et al.*, 2017).

The useful effects of combined use of organic and inorganic manures improve crop yield as well as keeping soil health. Looking the economic importance of cotton crop and maintenance of fertility and nutrients status of soil. This research is an attempt to (i) assess the appropriate levels of FYM and PM with NP on quantitative and qualitative attributes of cotton crop and (ii) observe the relationship between farm manures and crop parameters.

Materials and methods

Site description

The field experiment was conducted at Student Farm, Department of Agronomy, Sindh Agriculture University, Tandojam, to study the effect of integrated application of NP with farm manures on the yield and fiber quality of cotton. Basic soil physico-chemical characters (0-15 and 15-30 cm) of the experimental site before fertilization is shown in Table 1.

Experimental design

The experiment was arranged in Randomized Complete Block Design (RCBD) having three replications and eight treatments i.e.,T_1= Control (no NP and FYM), T_2= NP recommended rate (112-56 kg ha^{-1}), T_3= FYM 10 Mg +1/2 dose NP recommended kg ha^{-1}, T_4= FYM 15 Mg +1/2 dose NP recommended kg ha^{-1}, T_5= FYM 20 Mg +1/2 dose NP recommended kg ha^{-1}, T_6= PM 10 Mg +1/2 dose NP recommended kg ha^{-1}, T_7= PM 15 Mg +1/2 dose NP recommended kg ha^{-1} , T_8= PM 20 Mg +1/2 dose NP recommended kg ha^{-1} and the plot size was $15m^2$. The observations were recorded plant height (cm), number of branches $plant^{-1}$, number of open bolls $plant^{-1}$, seed cotton yield (kg ha^{-1}), ginning out turn (G.O.T %), seed index (g) and staple length (mm).

Land preparation

The Land was prepared with two deep plowing followed by clod crushing, and well leveled with the help of leveler for proper distribution of irrigation water. After soaking dose, the land was plowed to eradicate the weeds and for achieving proper seed bed preparation for sowing of seeds. The seeds were sown by drilling method with the help of hand drill. The distance between row to row (75.0 cm) and plant to plant (22.5 cm) were maintained. Urea and DAP fertilizers were applied at the rate of 112 and 56 kg ha^{-1} locally recommended dose of N and P, respectively. The P was incorporated during sowing, while N was applied in three splits viz; during sowing, and at second and fourth irrigation. FYM and PM were incorporated 45 days before sowing. However, the nutrient composition of FYM and PM was made as basis for organic manure application (Table 2). First irrigation was applied 28 days after sowing and other subsequent irrigations at different critical growth stages of crop. Hand weeding in early stage of crop and inter culturing was done after second irrigation with the help of spade to reduce weed infestation.

Statistical analysis

All the data were compiled with MS Excel (version 2010) and analyzed by using statistics (version 8.1). Sigma plot (version 10.0) was used to prepare graphs.

Results and discussion

Plant height at maturity (cm)

The results indicate that maximum plant height of cotton was 111.03 cm under application of 20 Mg ha^{-1}PM + ½ dose NP ha^{-1}, followed by 15 Mg ha^{-1}PM + ½ dose NP ha^{-1}(99.80 cm). The minimum plant height (53.93 cm) was observed in the control plots, where no fertilizer or manure was applied (Fig.1). Plant height is a most important growth parameter, and contributes to an increase in the yield components. Different manure levels were statistically significant at 1 % level. Our results are supported by other studies reported that organic manures had great association with the plant height of cotton crop (Balasubramanian and Muralibaskaran, 2000; Nehra *et al.*, 2006). Likewise, the integration of PM with inorganic fertilizers resulted in increased plant height (Joshi *et al.*, 2016).

Table 1. Basic physico-chemical properties (0-15 cm and 15-30 cm) before fertilization.

Parameter	Soil depth	
	0-15 cm	15-30 cm
Particle size distribution		
Sand %	14.5	16.2
Silt %	45.5	43.3
Clay %	40.0	40.5
Texture class	Silt clay loam	Silt clay loam
pH	8.03	7.97
Electric conductivity (dS m^{-1})	0.42	0.35
Calcium carbonate (%)	15.3	14.6
Soil organic carbon (%)	0.94	0.76
Total N (%)	0.07	0.05
AB-DTPA extractable P (mg kg^{-1})	3.46	2.13
AB-DTPA extractable K (mg kg^{-1})	187	171

Number of sympodial branches per plant

Application of 20 Mg ha^{-1} PM + ½ dose NP ha^{-1} produced maximum sympodial branches per plant (17.66), followed by 15 Mg ha^{-1} PM + ½ dose NP ha^{-1} (15.46). The lowest numbers of sympodial branches were (7.73 plant^{-1}) in control plots, where no fertilizer or manure was applied (Fig.1). More number of sympodial branches contributes to higher seed cotton production. Application of FYM with chemical fertilizer considerably increased number of branches plant^{-1}, which may probably increase crop yield (Blaise *et al.*, 2003, 2005). Furthermore, it was reported that combined application of PM with synthetic NP fertilizer also increased the number of branches plant^{-1} (Venugopalan and Tarhalkar, 2003; Joshi *et al.*, 2016).

Table 2. Average chemical analysis of FYM and PM.

Parameter	FYM	PM
Total nitrogen (%)	0.55	1.81
Total organic carbon (%)	9.59	24.0
C/N ratio	19.2	13.1
Total phosphorus (%)	0.21	0.98
Total potassium (%)	0.53	1.37

Number of open bolls per plant

Application of 20 Mg ha^{-1} PM + ½ dose NP ha^{-1} produced maximum (27.20) number of open bolls plant^{-1}, followed by 15 Mg ha^{-1} PM + ½ dose NP ha^{-1} (23.46). The minimum number of open bolls plant^{-1} (12.16) was found in the control plots, where no fertilizer or manure was applied (Fig.1). The number of open bolls plant^{-1} directly effect on the seed cotton yield. Numbers of open bolls were (27.20 plant^{-1}), where recorded in 20 Mg ha^{-1} PM + ½ dose NP ha^{-1}. It was significantly higher than all other treatments. The maximum number of open bolls plant^{-1} is mainly

associated with better crop growth and more branches plant^{-1} probably due to integrated nutrient management (Blaise *et al.*, 2003, 2005; Nehra *et al.*, 2006). These results are in concurrence with (Venugopalan and Tarhalkar, 2003), found that integrated nutrient management for cotton crop ensure better boll formation and development, thereby increase seed cotton yield.

Table 3. Correlation coefficient (r) values of different crop parameters as affected by integrated application of NP with farm manures.

Parameters	Plant Height (cm)	Sympodial branches plant^{-1}	Open bolls plant^{-1}	Seed Cotton Yield (kg ha^{-1})	G.O.T %	Seed Index (g)	Staple length (mm)
Plant Height (cm)	1						
Sympodial branches plant^{-1}	0.98	1					
Open bolls plant^{-1}	0.98	0.97	1				
Seed Cotton Yield (kg ha^{-1})	0.90	0.84	0.90	1			
G.O.T %	0.93	0.92	0.92	0.78	1		
Seed Index (g)	0.99	0.97	0.98	0.93	0.91	1	
Staple length (mm)	0.97	0.96	0.94	0.85	0.90	0.97	1

Seed cotton yield (kg ha^{-1})

The highest seed cotton yield was observed (2572.66 kg ha^{-1}) under application of 20 Mg ha^{-1} PM + ½ dose NP ha^{-1}, followed by 15 Mg ha^{-1} PM + ½ dose NP ha^{-1} (2484.0 kg ha^{-1}). The lowest seed cotton yield (1442.33 kg ha^{-1}) was observed in the control plots, where no fertilizer or manure was applied (Fig.2).

Seed cotton yield is very important and considered as economic yield of cotton crop.

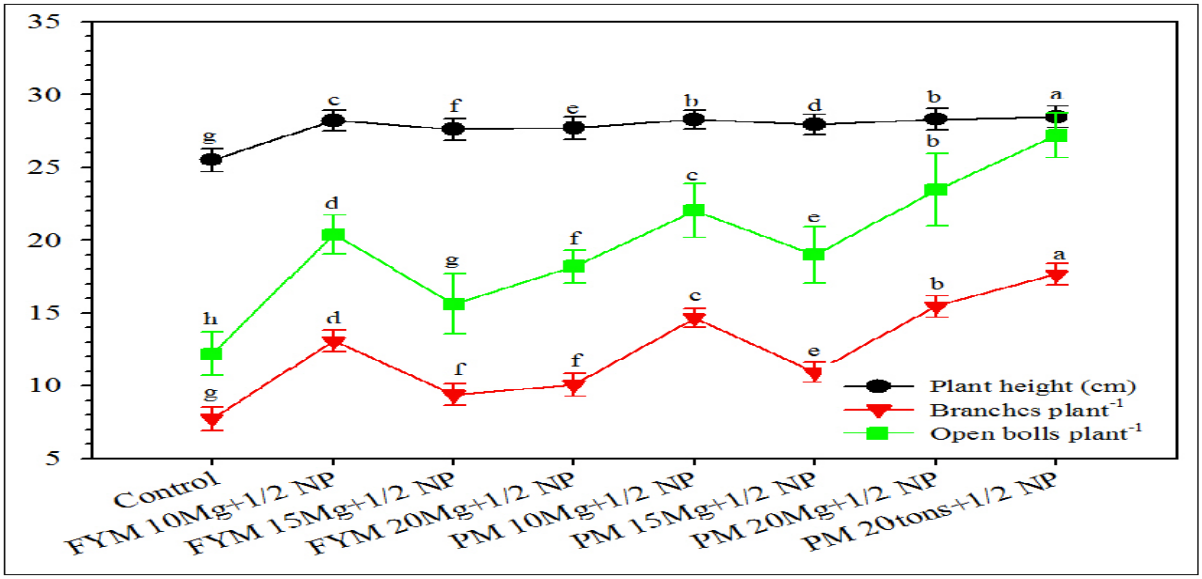

Fig. 1. The mean of triplicates of plant height (cm), number of branches pant^{-1}, and number of open bolls plant^{-1}, under different organic and inorganic fertilizations. Vertical bars indicates standard error of triplicates, and different alphabet letters the significant difference ($p<0.05$).

In present investigations, the seed cotton yield ha^{-1} affected significantly at 1 % probability level and highest seed cotton yield (2572.66 kg ha^{-1}) observed under application of 20 Mg ha^{-1} PM + ½ dose NP ha^{-1} (Nayakatawa *et al.*, 2001). The results of our study are confirmed by other studies, concluded that incorporation of FYM with NP fertilizers generally produce more seed cotton yield (Endale *et al.*, 2002; Rabb*et al.*, 2002; Hulihalli and Patil, 2004). Furthermore, combination of FYM with synthetic

NPK fertilizers significantly increased seed cotton yield (Hulihalli and Patil, 2004; Blaise *et al*., 2005). Other recent studies reported that integration of organic manures with inorganic fertilizers considerably increased crop yield compared to single use of either organic manures or synthetic fertilizers (Joshi *et al*., 2016; Ali *et al*., 2017; Iqbal *et al*., 2017; Reddy *et al*, 2017).

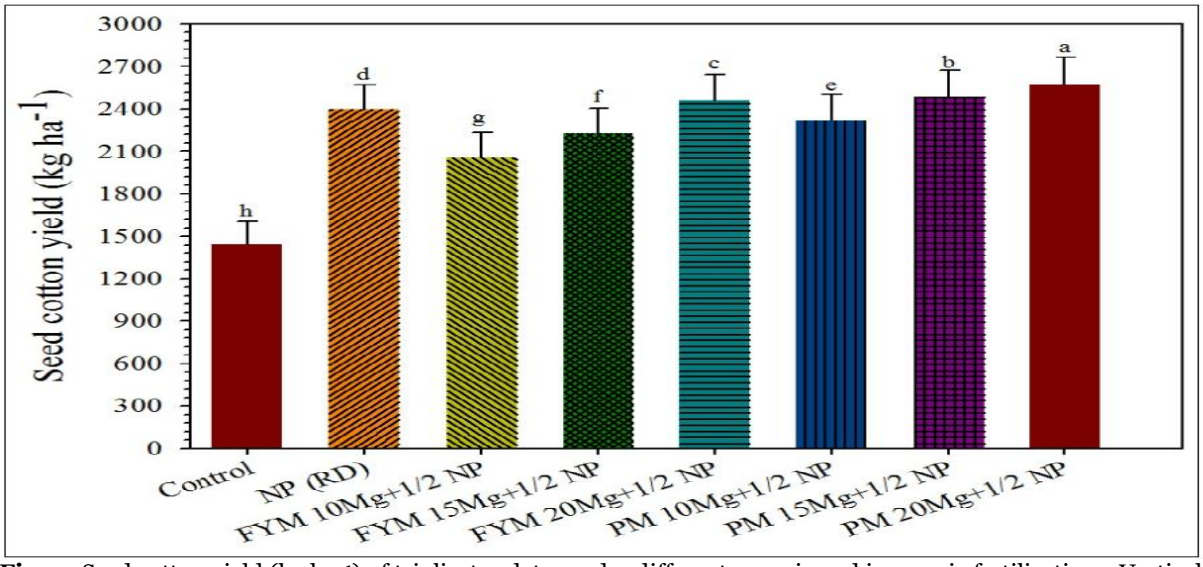

Fig. 2. Seed cotton yield (kg ha-¹) of triplicates data, under different organic and inorganic fertilizations. Vertical bars indicates standard error of triplicates, and different alphabet letters the significant difference ($p<0.05$).

Ginning out turn (G.O.T. %)

Ginning out turn is considered as a very important quality character in cotton production. The G.O.T. was relatively higher (35.16 %) under application of 20 Mg ha^{-1}PM + ½ NP ha^{-1} (Fig. 3). Similar results reported by other studies experienced that application of FYM with inorganic manure generally produce higher G.O.T. % of cotton crop (Malik and Reddy, 2002; Blaise *et al*., 2003, 2005). These result are supported that integrated use of organic manures with chemical fertilizer extensively produced higher G.O.T compared to single use synthetic fertilizers (Charjan and Dhawale, 2005; Mitchell and Tu, 2005).

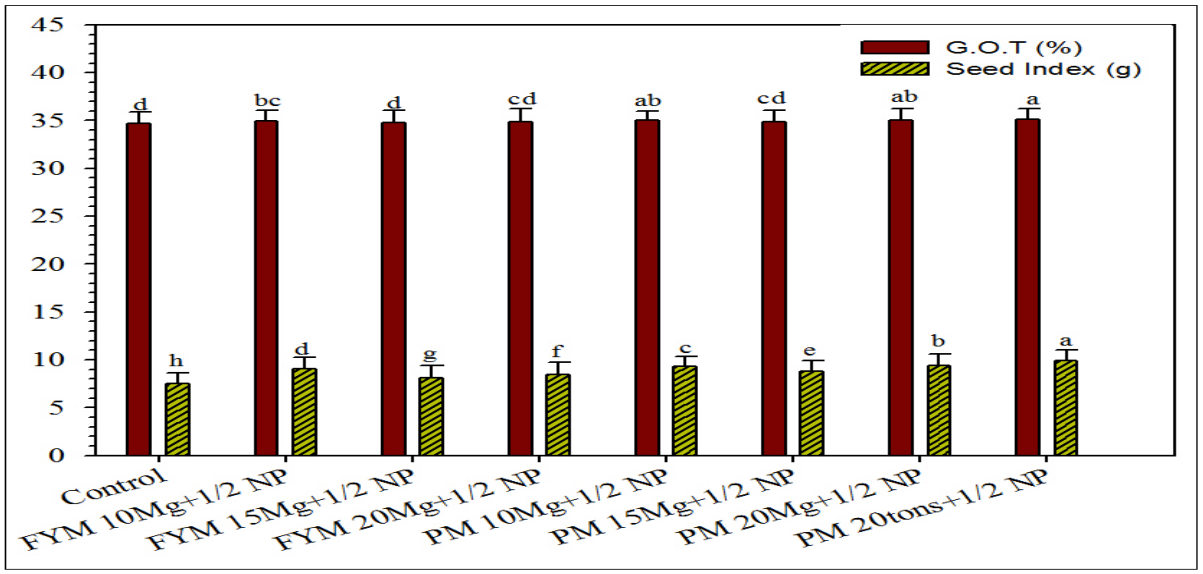

Fig. 3. G. O. T (%) and Seed index (g) under different organic and inorganic fertilizations. Vertical bars indicates standard error of triplicates, and different alphabet letters the significant difference ($p<0.05$).

Seed index (g)

Seed index is very important parameter in cotton, and in present investigation the heavier seed index (9.92 g) was recorded under application of 20 Mg ha^{-1} PM + ½ NP ha^{-1} (Fig.3).The results of present study are supported by other studies, reported that application of poultry manures with NP significantly increased the seed index (Wiltcher *et al.*, 2000; Endale *et al.*, 2002). Furthermore, the combined use of organic and inorganic manures substantially increased seed weight (Das *et al.*, 2004; Ali *et al.*, 2017; Reddy *et al.*, 2004, 2017).

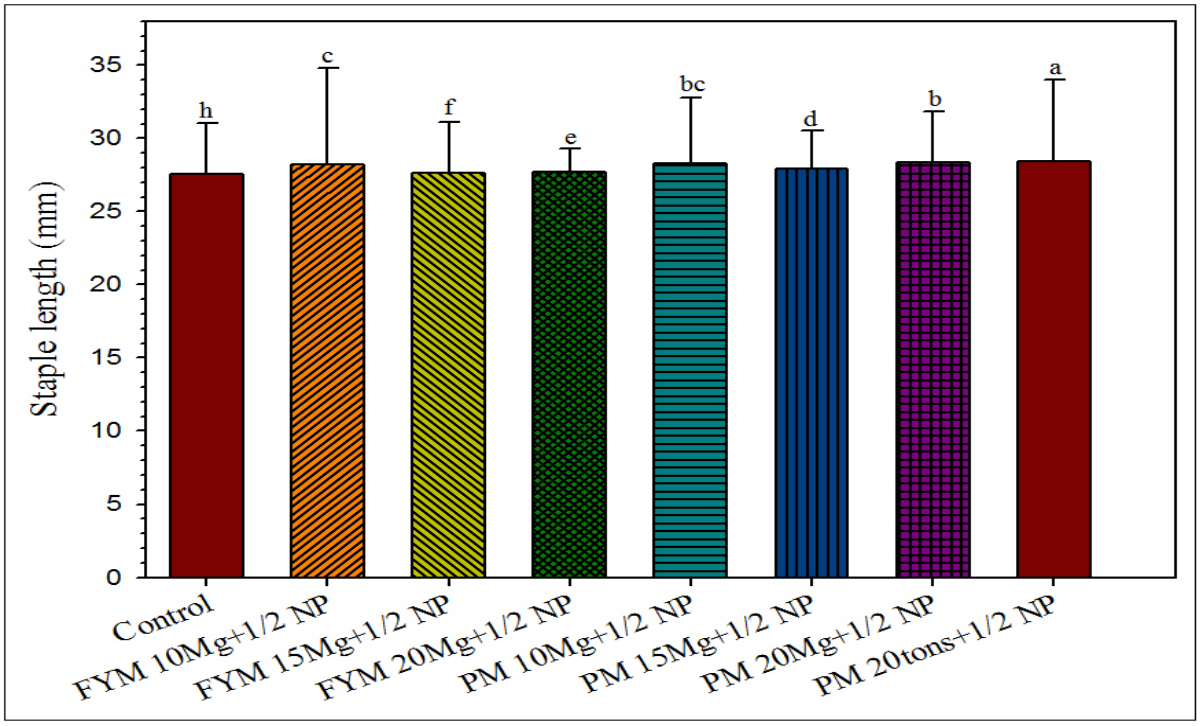

Fig.4. Staple length (mm) the triplicates data with standard errors, under different organic and inorganic fertilizations. Vertical bars indicates standard error of triplicates, and different alphabet letters the significant difference ($p<0.05$).

Staple length (mm)

Staple length is considered as one of the most important quality characters in cotton production, and the results for staple length were highly significant at 1 % probability level. The better staple length (28.46 mm) was observed under application of 20 Mg ha^{-1} PM + ½ NP ha^{-1} (Fig.4). Our results are supported by other researchers that application of PM with inorganic fertilizer resulted in better staple length (Nyakatawa *et al.*, 2001; Malik and Reddy, 2002; Mitchell and Tu, 2005). The observations of current study are also confirmed by other studies concluded that integration of both synthetic fertilizer and farm manure levels had significant effect on staple length and fiber fineness of cotton (Blaise *et al.*, 2005; Charjan and Dhawale, 2005).

Correlation of cotton crop parameters with seed cotton yield

The analysis results of correlation coefficient are presented (Table 3). Statistically results at 1% probability level of plant height, number of branches, number of open bolls, seed cotton yield, G.O.T. seed index, staple length were positively highly significant (Table 3), at 1% probability mean maximum plant height, number of branches, number of open bolls, seed cotton yield, G.O.T. seed index, staple length were 111.03 cm, 17.66 plant^{-1}, 27.20 plant^{-1}, 2572.66 kg ha^{-1}, 35.16 %, and 9.92 g respectively was under application of 20 tons ha^{-1} poultry manure + ½ NP ha^{-1}. Followed by 15 tons ha^{-1} poultry manure + ½ NP ha^{-1} was 99.80 cm, 15.46, 23.46, 2484.0 kg ha^{-1}, 35.16 %, and 9.43 g respectively (Table 3).

Conclusion

The integration of farm manures with NP demonstrated better approach for better production of cotton crop, compared to single use of NP fertilizers. It has been concluded that increase in the level of manures also increased the values of all crop growth and productivity parameters.

The integration of PM with NP fertilizers further enhanced these parameters. Among the tested fertilizer and manure levels, the integrated application of 20 Mg ha^{-1} PM + 1/2 dose NP was the most efficient treatment for achieving satisfactory values of quantitative and quantitative parameters of cotton crop. It is also expected that farm manures are helpful to maintain the soil fertility as well as improving water-holding capacity of soil for succeeding crop.

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