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Cotton Production Through Integrated Plant Nutrition System

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Abstract: A field experiment was conducted to study the prospects of cotton cultivation by adopting EM technology through "Fermenter biofertigation" alongwith mineral and organic sources of nutrients. Mineral fertilizers were used at N 170: P_2O_5 85: K_2O 60 kg ha^{-1} as Urea, DAP and SOP, respectively, alone and ½ and ¼ of this, in combination with Fermenter water. Organic sources included FYM + Sugarcane Filter Cake (SFC) at 10 Mg ha^{-1} and Fermenter water, both alone and in combination. Mineral NPK applied alone was found to be the best giving maximum yield and net return. However, economic analysis suggested the use of ½ mineral NPK alongwith EM biofertigation whereby a poorer farmer can get substantial and comparable yield and higher rate of return. Application of EM biofertigation was found to increase the efficiency of both organic and mineral nutrient sources but alone was proved to be ineffective for yield increasing.

Key words: Cotton, IPNS, mineral fertilizers, organic fertilizers, fermenter bio-fertigation

Introduction

Cotton is not only a major source of foreign exchange but also it sustains other industries particularly ginning, textile and seed oil expellers. The chemical fertilizers have been a significant source of readily available nitrogen and other plant nutrients for maximizing yield and quality of crops (Ahmad *et al.*, 1996). However, there are some problems in using chemical fertilizers such as adulteration, low supply/unavailability at the time of need and of course, very high investment due to ever increasing high cost making the system unsustainable (FAO, 1978). Their costs and other constraints frequently deter the farmers to use fertilizers in recommended quantities. The use of organic materials to enhance crop production has been practiced for centuries but for the past three decades, organic manure share took a back seat, because pure organic farming can neither cope with the increased demand of plant nutrition for more food and fiber (Ahmad *et al.*, 1996), nor with the huge quantities of organic manure needed for nutrient responsive, short statured varieties (NFDC, 1998; FAO, 1998). Another hope of managing the nutrients supply to planting system is soil inoculation with N_2-fixing bacteria. The investigations, however, revealed that inoculum alone could not bring the soil eco-system fully in favour of plant nutrient supply (Hussain *et al.*, 1999). Because of these and some other constraints, there seems no option but to exploit an alternate system, which can augment and in some cases replace the existing system.

Integrated Plant Nutrition System (IPNS) is an alternate system to maintain and increase the soil fertility for sustaining increased crop production through optimizing all possible, organic and inorganic sources of plant nutrients required in an integrated manner so that to reduce the cost of production getting more benefits (Tendon, 1992). The beneficial use of combined application of organic and inorganic nutrient sources is well established, however, contrasting results are also documented. Field trial network program on IPNS in the country reported marked contrasting single season responses to organic amendments (NFDC, 1998). Similarly, Ibrahim *et al.* (1992) and FAO (1995) have reported the organic materials as inferior sources of nutrients compared to mineral sources.

Beneficial effects of EM (Effective Microorganisms) application were reported for the improvement of yield as well as quality of the crop by Higa and Wididana (1991), Sangakkara *et al.* (1995) and Parr and Hornick (1995). So there is need for more investigation to develop IPNS recommendations to ensure food security and attain self-sufficiency through improvement in yield and quality of crop. Present study was undertaken to evaluate the potential of organic and biological means of plant nutrients in combination with chemical fertilizer for economical and sustainable crop production and to improve the yield of cotton crop.

Materials and Methods

An experiment was conducted during 1997-98 in the research area of Soil Science Department, University of Agriculture, Faisalabad; by using Randomized Complete Block Design (RCBD) with four replications in a field with characteristics indicated in Table 1.The treatments applied were as follow:

T_0	Control (without any organic or inorganic amendment)
T_1	Recommended NPK fertilizers at 170: 85: 60 kg ha^{-1}
T_2	½ Recommended fertilizer + Fermenter water
T_3	¼ Recommended fertilizer + Fermenter water
T_4	Fermenter water only
T_5	FYM + SFC at 10 Mg ha^{-1}
T_6	FYM + SFC at 10 Mg ha^{-1} + Fermenter water

The organic materials (FYM + SFC) were incorporated three weeks prior to cotton sowing in allocated plots. Half N and full dose of P and K were applied in the form of Urea, DAP and SOP, respectively to the allocated plots while remaining half was applied in two equal splits, i.e. at first and second irrigation. However, in the case of Fermenter water treatments, one half of the irrigation water was passed through Fermenter in which extended EM (one part Basic EM + 1 part molasses + 20 parts water on volume basis and allowing to multiply for three days after mixing) was applied at least two weeks before every irrigation for fermentation of organic waste (Higa and Kinjo, 1991). The general protocol of experiment including plant protection measures, cultural practices and irrigation were carried out as and when needed up to the

Table 1: Physico-chemical characteristics of soil at the experimental site

Particle size distribution (%)			Textural Class	pH_s	EC_e	Total	Available	Extractable
				---	dS m^{-1}	Nitrogen	Phosphorus	Potassium
Sand	Silt	Clay				%	--- mg kg^{-1} ---	
63.85	15.95	20.20	Sandy Clay Loam	7.69	1.25	0.04	6.68	98.44

harvest of crop.

Data thus collected for various characteristics were analyzed statistically by "Analysis of Variance" technique and the treatment means were compared by the Duncan Multiple Range (DMR) test at 5% probability (Steel and Torrie, 1980). The economic analysis for various treatments was computed following the method described by CIMMYT (1988):

$$\text{VCR} = \frac{\text{Value of increased yield obtained}}{\text{Variable cost}}$$

Net return = Value of increase in yield obtained-Variable cost

Results and Discussion

a) Yield and growth components: Data regarding the effect of various treatments on yield and growth components of cotton crop is presented in Table 2. Statistical analysis of the data showed a significant increasing trend in yield and growth components with organic and inorganic nutrient sources over control. Maximum plant height that was 14.7% more over control was recorded in plots where recommended mineral fertilizers were applied. This considerable increase in plant height by NPK application was due to readily and quickly available nutrients in higher quantities to plants. The effect of half recommended fertilizers applied in combination with Fermenter Water (FW) on plant height was found to be statistically at par to the recommended fertilizers application. The results obtained perhaps, were due to the presence of organic nutrients and biomass added with every irrigation and so microorganisms may have developed their population in dynamic state. Ahmad *et al*. (1996) reported similar findings that enrichment of bio-fertigation using EM increased 60% availability of major nutrients (NPK).

Statistical summary of the data revealed that ½ NPK fertilizers + FW and FYM + SFC + FW showed similar effect on sympodial branches but significantly differed from FYM + SFC, ¼ NPK fertilizer + FW and FW alone which were at par among themselves. A perusal of the data depicted that maximum and statistically similar number of bolls were counted in plots where recommended NPK fertilizers or ½ NPK + FW were applied. These were followed by FYM + SFC + FW while least values were recorded in control plots. The effect of recommended NPK fertilizer on seed cotton weight boll^{-1} was found to be statistically similar to ½ NPK fertilizer + FW biofertigation and FYM + SFC + FW biofertigation but sharply differed from rest of the treatments.

The statistical analysis depicted that maximum values for seed cotton yield were found in plots where recommended dose of NPK fertilizers were applied that was 77.66% more over control and it was found statistically equal to ½ NPK fertilizer in integration with biofertigation of FW but differed sharply with other treatments. Effect of chemical fertilizers on crop yield was studied by Qayyum *et al.* (1984) who reported that seed cotton yield was highly correlated with nitrogen rates. Similar results were obtained by Memmon and Chaudhry (1975), Hassan *et al*. (1979), Dhonde (1985) and Haq *et al*. (1998). These findings were also in line with those of Zubair *et al*. (1994) who reached the conclusion that growth parameters yield and protein contents increased significantly with increase in fertilizer rates. Application of ¼ NPK

Table 2: Effect of various treatments on growth parameters and yield of cotton crop (Average of four repeats)

Treatment	Plant Height (cm)	Sympodial	No.of bolls	Seed cotton wt. (g)	Yield (kg ha^{-1})
T_0	97.6e	13.1d	25.5d	3.31d	1493.1e
T_1	111.9a	21.8a	40.5a	4.14a	2652.7a
T_2	110.3ab	20.5b	39.2a	4.08a	2524.0a
T_3	103.2cd	18.1c	30.8c	3.81c	1853.6
T_4	101.4d	17.1c	29.8cd	3.73cd	1755.7d
T_5	104.8c	18.1c	31.5c	3.96b	1970.7c
T_6	108.3b	19.8b	36.4b	4.05ab	2331.9b
LSD Value	1991	1030	2046	0.09396	1456

* Values in ( ) are percent increase over control

Table 3: Economic analysis

Treatments	Seed cotton yield (kg ha^{-1})	Variable cost	Income	Value of increased yield	Net return	VCR*
		--Rs. ha^{-1}	--			
T_0	1493.1	-	37327.5	-	-	-
T_1	2652.7	(2170 + 2121.6 + 1291.2)	66317.5	28990.0	23407.14	5.19
T_2	2524.0	(2791.43 + 274)	63100.0	25772.5	22707.07	8.41
T_3	1853.6	(1395.72 + 274)	46340.0	9012.5	7342.78	5.40
T_4	1755.7	274	43892.5	6565.0	6291.0	23.96
T_5	1970.7	800	49267.5	11940.0	11140.0	14.93
T_6	2331.9	(800 + 274)	58297.5	20970.0	19896.0	19.53

* Value Cost Ratio

i. Unit price of seed cotton = Rs. 25 kg^{-1}

ii. Unit cost of mineral N (from urea = Rs. 365 bag^{-1}) = Rs. 15.87 kg^{-1}

iii. Unit cost of mineral P_2O_5 (from DAP = Rs. 574 bag^{-1}) = Rs. 24.96 kg^{-1}

(33.26kg N provided by 3.69 DAP bags needed to fulfill 85 kg ha^{-1} P_2O_5 requirement)

iv. Unit cost of mineral K_2O (from SOP = Rs. 538 bag^{-1}) = Rs. 21.52 kg^{-1}

v. Unit cost of FYM (at 7 Mg ha^{-1}) = Rs. 50 ton^{-1}

vi. Unit cost of SFC (at 3 Mg ha^{-1}) = Rs. 150 ton^{-1}

vii. Unit cost of Fermenter water = Rs. 68.5 irrigation^{-1} ha^{-1}

(at 150L Ext. EM + 1 Mg FYM irrigation^{-1} 5 ha^{-1})

a. Unit cost of Basic EM = Rs. 40 L^{-1}

b. Unit cost of Molasses = Rs. 3 L^{-1}

c. Unit cost of Ext. EM = Rs. 1.95 L^{-1}

(1:1:20 ratio of Basic EM: Molasses: Water, respectively) fertilizer in combination with FW was not proven so effective and it was statistically equal to FW alone. This effect might be due to the decreased amounts of nutrients.

While comparing the effect of organic amendments and biofertigation of FW, both alone and in combination, on seed cotton, maximum yield were recorded in plots where both organic and biofertigation were integrated followed by organic source alone. A partial explanations for the increased seed cotton yield with biofertigation of FW applied in combination with FYM+SFC might be the result of higher level of microbial activity which enhanced organic matter decomposition and release of plant available nutrients. Hussain *et al*. (1996) reported that significant effect of EM applied with organic amendments was not limited to the release of plant nutrients through microbial activity but that the increase in plant nutrient availability prevented deficiencies at critical stages of growth. The results are also in full agreement with those reported by Hussain *et al*. (1996) and Haq *et al*. (1998). These results are also supported by Rashid *et al*. (1994) who reported that standard fertilizer dose showed statistically equivalent yield of wheat to Diazotrophic inoculum+half N of standard dose.

b) Economic consideration and conclusions: The economic analysis using variable costs and income from various treatments for cotton crop are depicted in Table 3 which show that the greatest costs were associated with chemical fertilizers application followed by ½ recommended fertilizer with Fermenter biofertigation, while organic sources (FYM+SFC) in conjunction with Fermenter biofertigation resulted a variable cost of Rs. 1074 as against the Rs. 800 for organic sources alone. Lowest variable costs were observed by using Fermenter biofertigation alone. The NPK fertilizers treatments also produced the highest gross and net income, however, ½ NPK fertilizers+FW resulted a comparable gross and net income but yielded higher VCR (8.14) than recommended NPK (VCR = 5.19). The organic sources with Fermenter biofertigation produced a gross income Rs. 58297.5 and net income Rs. 19896.0 as compared to organic sources (FYM+SFC) alone where a gross income Rs. 49267.5 and net income Rs. 11140.0 was produced where as VCR (19.53) for organic sources (FYM+SFC) with Fermenter biofertigation was also higher than VCR (14.93) of organic source (FYM+SFC) alone.

It can be inferred that the fertility of soil can be improved with addition of chemical as well as with the organic sources of plant nutrients. Maximum net return and maximum yield was recorded in case of mineral fertilizer application where the variable cost involved is also maximum; therefore, a resourceful farmer can adopt this treatment. As the majority of our farming community is poor having no access to apply the recommended dose of fertilizers, they can choose the integrated form of ½ NPK+fermenter biofertigation where they can get substantial return and yield close to the maximum with lesser investment and partial dependence on chemical fertilizers which are scarce and involve greater energy/expenses.

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