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Remunerative Microbial Strategy for Enhancing Productivity through Biotech Approach in Farmer's Favour

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ABSTRACT

With varied recommendations on the application of chemical fertilisers in quantity and frequency and their further liberal use by farmers increased the cost of inputs, created surface and underground pollution, expedited the rate of salinisation of soil, resulting in less productivity in the immediate future and least productivity in three decades. To reverse this trend, biotech approach comprising of application of soil conditioner (SC), plant growth regulator (PGR), a consortium of four biofertilisers, drip irrigation, besides the application of fly ash has been attempted. It has reduced the cost of banana cultivation by reducing the dose of chemical fertilisers by 50 % and increased its use efficiency by drip irrigation. Application of SC and consortium of biofertilisers afforded sustained release of nutrition to banana plantation, giving substantially high yield of banana compared to control and 50 % extra realisation compared to availability through routine agricultural practices. While scope exists for site specific optimisation of input of chemical fertilisers, this attempt opens an avenue for self entrepreneurship to students holding land and consultancy to landless students. Such practice using biotech inputs provides a fair chance of converting large tracks of barren and saline soils under high irrigation crops such as sugarcane, banana and rice into fertile soils. Besides, it opens avenues for commercial production of SC, PGR and Consortium of biofertilisers.

Key words: soil conditioner, PGR, consortium of biofertilisers, IPNM, sustainable strategy

INTRODUCTION

In Maharashtra, 37,400 ha of land are under cultivation for *Basarai* variety of banana, the most popular commercial variety, providing 21.2 Lakh MT of banana per annum [11]. It ranks first in the area under cultivation as well as quantum of banana produced by accounting for 21 % of total productivity. Theoretically, the amount of fertiliser supplementation to soil should be based on its nutritional status, foliar analysis for uptake of N, P, K and S and the yield potential of land under cultivation. However, in practice Banana Research Station, Jalgaon, different researchers in this fruit crop and farmers cultivating banana from the last 3-4 decades have either recommended or followed different quanta as well as frequency of application for fertilising the soil. This has resulted in as much as 100 % difference

between the recommended and used doses of fertilisers. The net result of these adhoc practices has been increasing salinity of soil and gradually reducing output of banana per ha. A survey of farmers in Raver and Yawal *Tehsils*, maximum producers of banana in Jalgaon district, revealed that average yield of banana bunch was 22-25 Kg in 1975, 17-20 Kg in 1985 and 12-15 Kg in 1995. These results on output of banana have been alarming since the cost of fertilisers, manual labour, irrigation and electricity have gone up on one hand and productivity has slided down on the other hand, compelling the farmers to wonder if banana production would be remunerative in future. To address this question and to arrest soil salinity, Rest of the Maharashtra Development Board, Mumbai had asked us to look into this problem and devise an eco- and farmer-friendly strategy of producing banana on sustained basis. Efforts made in this direction are summarised in the present communication.

MATERIALS AND METHODS

Elite cultivars of Banana (*Musa paradisiaca*) dwarf Cavendish variety of Eumusa series, locally known as *Basarai* (*Shrimanti*, meaning high yielding) were procured from Faizpur (Dist. Jalgaon). Soil conditioner (SC) was prepared using wild grass and lawn cuttings, ligninase-rich fungal culture to expedite decomposing and solid state fermentation technology as per Ramamurthy *et al*. [13].

Plant growth regulator (PGR) was prepared from upgraded corn gluten (75 % protein) as per Sharma *et al*. [17] and applied (6 ml in 1L distilled water) by corm drenching, at the rate of 1L per 35-40 corms.

A consortium of biofertilisers, *Azotobacter* sp., *Aspergillus* sp., *Thiobacillus thiooxidans* and ecto-mycorrhiza, *Tricholoma imbricatum* were cultivated in optimised production media under optimal conditions for 24-30 hrs., blended and used in field trials at the rate of 6 ml per plantlet. Fly ash obtained from Bhusawal Thermal Power Station, Dist. Jalgaon was used as a source of Ca, PO_4 and micro-nutrients.

Plantation was undertaken on pre-ploughed medium black, shallow, sandy soil, low in nitrogen and phosphorus and very high in potassium contents, keeping a distance between two plants as well as two rows of 1.52 m, in July, 1998 after 2-3 showers of Monsoon. The above biotech inputs (SC, PGR and consortium of biofertilisers) were applied as a one-time input at the time of plantation as per the computerised programme using random block design (RBD) to derive statistically meaningful results (Table 1). Each plot had 4 rows, 5 plants in each row, thus totalling 20 plants. The experiment was carried out in triplicate.

After one month, rate of survival was counted and in subsequent months growth profiles were monitored by measuring height, girth, No. of leaves as per Deo *et al*. [4] and chlorophyll content as per Jayaraman [7]. So also, analysis of soil was made for mycorrhiza population.

To conserve chemical fertilisers and prevent pollution, fly ash was applied at varying rates (2.5 and 5.0 MT/hectare). After 8 weeks, urea was applied through drip irrigation on daily basis to provide 50 % of the dose recommended by Soil Testing Laboratory, Jalgaon up to the end of 6^{th} month, while single super phosphate (SSP) and muriate of potash (MOP) were applied through soil as a two-time input i.e. half of total dose at the time of plantation and remaining half after 2^{nd} month. Drip irrigation was resorted to after two months when frequency of Monsoon reduced. The chemical fertiliser input and irrigation quantum were optimised on the basis of composition and texture of soil, amount of soil conditioner, potential of biofertilisers for contributing nutrition and fly ash applied. The costs of chemical fertilisers and other things taken here into consideration are although specifically prevailing at the time of comparison, but now should be considered as tentative; as those always change according to ever-increasing inflation rates. Rest of the post-plantation care was taken as per standard agricultural practices followed by the farmers.

RESULTS AND DISCUSSION

The above study was undertaken with an objective to (i) reduce fertilisers/pesticides inputs in favour of farmers, (ii) minimise electricity and labour cost of banana cultivation, again in the interest of farmers, (iii) arrest the rate of water level going down, increase in salinity and pollution on surface and in aquifers in the long range interest of society and government and (iv) enhance the output of banana in quality and quantity in favour of customers.

While the above problems faced by farmers, government and society were worth taking cognisance, they were of alarming nature at national level where 3.95 million ha area was under cultivation of banana, yielding totally 100.5 Lakh MT banana. Since nutritional requirement of banana plantation are very high as compared to other horticultural crops [22], researchers recommended certain doses and due to greed for higher productivity and over confidence by virtue of growing banana over decades, farmers applied dramatically varied doses of fertilisers as is obvious from Table 2.

While balanced fertilisation at different physiological stages of crop is a key factor for optimum yield of banana [16], it was baffling to us from the figures recommended in literature as to which dose would be optimal so that productivity was maximum at less cost and least pollution. However, split application of fertilisers emphasised by Rajeevan [12] fits into the concept of variable requirement as a function of physiological state propounded by Shanmugam and Velayutham [16]. With the recommended dose, Pawar *et al*. [11] observed significant increase in height and diameter of pseudostem, No. of leaves and days for flowering. This indicated that a large amount of fertilisers have been utilised for the growth of biomass, without any increase in banana fruits. This has been borne out in their subsequent studies where 1,913 kg urea, 2,200 kg SSP and 1,469 kg MOP were used for comparable productivity of banana and reduced biomass.

In totality, observations by different researchers (Table 2) suggested variability in the dose of fertilisers applied for optimal productivity. This gave us an indication that a dose could be reduced if it is compensated partially by soil conditioner and partially by a consortium of biofertilisers. Therefore, our experimental strategy placed maximum emphasis on soil conditioner which provided (i) soft texture to soil for easy root penetration, (ii) more water holding capacity, (iii) integrated nutrition for immediate energy requirements after plantation and (iv) organic carbon matrix for stabilising biofertilisers. From its analysis, it appeared to provide 15-20 % NPK requirement of plantation (Phirke, 2002). That (i) *Azotobacter* could minimally provide nutrition equivalent to 109 kg urea (Venkataraman & Tilak, [24]), (ii) PSMs contributed nutrition equivalent to 313 kg SSP (Gaur *et al*., [6]), (iii) mycorrhizae contributed nutrition equivalent to 550 kg SSP (DARE/ICAR Annual Report, 1995-96) and (iv) drip irrigation improved fertiliser use efficiency and thereby reduced requirement of fertilisers to the extent of 478 kg of urea equivalent, 313 kg of SSP equivalent and 367 kg of MOP equivalent (Shinde *et al*., [19]) provided a clue that with the inoculation of consortium of biofertilisers, we could reduce dose of chemical fertilisers by almost 50 %. Besides, incorporation of fly ash was purposefully made to serve as a partial source of both Ca and P (@ 40 kg/5MT/ha P added; Page *et al*., [10]) as well as micro-nutrients for healthy growth.

To reduce water consumption, electricity, cost of manual labour and increase fertiliser use efficiency, we resorted to two stage application of SSP at the time of plantation @ 550 kg/ha and the same amount after two months; a similar pattern, was followed for MOP i.e. 367 kg/ha at the time of plantation and the same amount after two months, by necessity of their limited solubility. However, urea was applied through drip from the beginning of 3rd month to completion of 6th month at the rate of 8 kg/ha per day, thereby totalling to 960 kg. The

financial implications of reduction in fertiliser dose are summarised in Table 3.

From Table 3, it is obvious that Rs. 9,714 have been saved per hectare of banana plantation and thereby we have come close to our first objective of devising a strategy which is farmer-friendly. Incidentally, this strategy has also proved to be eco-friendly by virtue of a fact that it has used only 50 % of the recommended dose of chemical fertilisers and has far surpassed the doses found optimal by other researchers. This should be an eye opener that scope exists for optimisation of fertiliser supplements; the dose found optimal for our research farm may be slightly higher for high fertility lands where the quantum of unutilised fertiliser is already in the soil. This reduction in usage of fertilisers was possible in the present studies due to (i) supplementation of nutrients through SC, (ii) sustained release of nutrients by the application of a consortium of biofertilisers and (iii) increased efficiency of use of fertilisers through drip irrigation, thereby localising input fertilisers in rhizosphere only. This strategy has simultaneously served as an anti-pollution plank, in the larger interest of farmers, eco-system and government. In achieving these objectives for farmers and eco-system, interests of consumers were not side-tracked. This will become obvious from the quality and quantity of banana produced (Table 4).

From Table 4, it is quite clear that while achieving larger objectives of farmers and ecosystem, customers' objectives were not compromised. In fact, they are also achieved simultaneously in producing better quality banana and higher quantum which has indirect effect of stabilising the price in an affordable/moderate range for the customers.

Major adverse effect of intensive banana cultivation during the last three decades has been manifested by reduction in soil fertility, increased salinity, minimal organic matter in soil and reduced/ineffective microbial population. Uninterrupted cultivation of banana has also induced emergence of host-specific fungal infestation, locally known as *Karpa*. These manifestations have been detrimental to everybody's interest and needed to be addressed. Long term (during 1965-85) fertility experiments conducted all over the country have unequivocally shown that neither organic manure alone, nor chemical fertilisers alone can achieve sustained yields of any produce under modern intensive farming. However, an integrated approach of soil conditioner (organic matter), biofertilisers and supplementary chemical fertilisers has been found to be promising for sustained higher productivity [9]. The present studies on banana support these findings unambiguously. In fact, Sankaram [15] philosophised that crop nutrition must respect prescriptions of Integrated Nutrient Management (INM). Our approach meets justly the same by a judicious combination of chemical fertilisers:biological fertilisers (including soil conditioner) in the ratio of 50:50. That soil conditioners meet 15-20 % nutrition directly and provide matrix for biofertilisers to thrive, for giving additional nutrition has been borne out from studies by Sharma *et al*. (In press). More than 30 % nutritional requirements are met by PSMs and *Azotobacter* has also come out in a conclusive manner from several studies (Gaur, [5]; Gaur *et al*., [6]; Barber, [1]; Stevenson, [21]; Venkataraman and Tilak, [24]; Varma and Bhattacharya, [23]; DARE/ICAR Annual Report [3]). Finally, an observation that application of 100 gm N through drip gives an effect equivalent to about 200 gm N substantiates higher efficiency of fertilisers utilisation, regardless of chemical or biological origin.

In conclusion, the present study has successfully attempted to devise a cost-effective and eco-friendly strategy in the interest of farmers, government and consumers through the judicious application of SC, PGR, biofertilisers, fly ash, besides using only 50 % dose of chemical fertilisers.

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Table 1. Randomised block design for banana plantation

Sr. No	Treatments	Coding	Description
1.	T_1	$S_0F_0M_0$	No inputs
2.	T_2	$S_0F_0M_1$	Only microbes
3.	T_3	$S_0F_1M_0$	Only fly ash 2.5 t/ha
4.	T_4	$S_0F_1M_1$	Fly ash 2.5 t/ha + Microbes
5.	T_5	$S_0F_2M_0$	Only fly ash 5 t/ha
6.	T_6	$S_0F_2M_1$	Fly ash 5 t/ha + Microbes
7.	T_7	$S_1F_0M_0$	Only soil conditioner 5 t/ha
8.	T_8	$S_1F_0M_1$	Soil conditioner 5 t/ha + Microbes
9.	T_9	$S_1F_1M_0$	Soil conditioner 5 t/ha + Fly ash 2.5 t/ha
10.	T_{10}	$S_1F_1M_1$	Soil conditioner 5 t/ha + Fly ash 2.5 t/ha + Microbes
11.	T_{11}	$S_1F_2M_0$	Soil conditioner 5 t/ha + Fly ash 5 t/ha
12.	T_{12}	$S_1F_2M_1$	Soil conditioner 5 t/ha + Fly ash 5 t/ha + Microbes
13.	T_{13}	$S_2F_0M_0$	Only soil conditioner 10 t/ha
14.	T_{14}	$S_2F_0M_1$	Soil conditioner 10 t/ha + Microbes
15.	T_{15}	$S_2F_1M_0$	Soil conditioner 10 t/ha + Fly ash 2.5 t/ha
16.	T_{16}	$S_2F_1M_1$	Soil conditioner 10 t/ha + Fly ash 2.5 t/ha + Microbes
17.	T_{17}	$S_2F_2M_0$	Soil conditioner 10 t/ha + Fly ash 5 t/ha
18.	T_{18}	$S_2F_2M_1$	Soil conditioner 10 t/ha + Fly ash 5 t/ha + Microbes

Table 2. Recommended and actually applied fertiliser doses

Sr. No	Fertilisers used	Urea (Kg/ha)	SSP (Kg/ha)	MOP (Kg/ha)	Reference
1.	Recommended dose *	1,913	2,200	1,467	Pawar et al., [11]; Souvenir, [20],
2.	For 50 MT banana/ha	891	938	2,697	Tandon, [22]
3.	Consumption in fruits ** (50 MT banana/ha)	301	75	600	Marchal & Mallesard, [8]
4.	Consumption by 2000 plants/ha ***	696	210	2,007	Marchal & Mallesard, [8]
5.	General recommendation	1,052	880	2,425	Shanmugam and Velayutham, [16]
6.	Another recommendation @	217-434	625-1,250	334-668	Randhawa, [14]
7.	Recommendation for Robusta variety	1,722	2,970	1,653	Randhawa, [14]
8.	Recommended dose for *Basarai*, *Sindurni* and *Shrimanti* varieties	1,913	2,750	1,467	Horticultural Directorate, MP Govt., Khandwa
9.	Recommendation by Bharat Agro-Services Kolhapur @@	1,196	1,650	1,470	E-619, Shahupuri, Kolhapur-416 001
10.	Recommended dose	957	1,100	735	Dagade, [2]
11.	Recommended dose #	2,609	3,300	2,204	Pawar et al., [11]

* Derived from 880 kg N, 352 kg P_2O_5 and 880 kg K_2O by multiplication with 2.174 for urea, 6.25 for SSP and 1.67 for MOP.
** Approximate uptake in the fruits (Grand Nain), by recycling peduncle waste.
*** Besides above, 184 kg Ca and 70 kg Mg were consumed.
@ Besides the above dose, 20-25 kg FYM and 5 kg wood ash recommended per plant.
@@ Besides the above dose, its product, ORMICHEM and cattle dung/nutritious cake were recommended.
# Application of urea in 2nd, 4th and 6th month, while 50 % dose of SSP and MOP at the time of plantation and in 2nd month gave better yield of banana.

Table 3. Financial savings through biotech approach

Sr. No	Particulars	Urea (Kg/ha)	SSP (Kg/ha)	MOP (Kg/ha)	Remark(s)
1.	Recommended dose	1,913	2,200	1,467	Pawar et al., [11]; Souvenir, [20]
2.	Actually used dose	960	1,100	734	Through DBRM grant
3.	Saving of fertilisers/ha	953	1,100	733	(Sr. 1) - (Sr. 2)
4.	Financial saving/ha on chemical fertilisers	3,812	3,190	2,712	Rs. 9,714 saving/ha
Prices: Urea Rs. 4,000/MT; SSP Rs. 2,900/MT; MOP Rs. 3,700/MT					

Table 4. Qualitative and quantitative profiles of banana

Sr. No	Parameter under study	Banana produced by farmers	Banana produced through biotech inputs
1.	Size	Small, medium and large	Medium and large
2.	Appearance	Good-best	Best
3.	Dark spots	Frequent	Rare
4.	Preservability	Moderate (3-4 days)	Upto 2 weeks
5.	Potential for export	Moderate	More
6.	Taste	Sweet	Sweeter and appealing
7.	Average weight per bunch	12-14 Kg *	17 -18 Kg **
8.	Productivity per hectare	50-59 MT	75-79 MT
9.	Financial gain	Rs. 1,50,000	Rs. 2,25,000

* In many cases, due to either fungal infestation or high soil salinity, average weight has been 8-10 Kg.
** About 25-50 % bunches weighed between 21-23 Kg.