

Original Research Article

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Synergetic Interaction of P Solubilizer and P Mobilizer on Yield and Economics of FCV Tobacco in KLS Region of Karnataka

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ABSTRACT

Interests in the use of biological inoculants to increase the mobilization of key nutrients to enhance their availability to crop plants are increasing. Among the key nutrients, Phosphorus (P) is one less subjected to various losses and found in different complex form in the soil. Depleting phosphate rock deposits makes the researchers to emphasize more on the issue. In this line, a study was conducted at ZAHRS, Navile, Shivamogga during *Kharif* 2017 and 2018. The objective of the study was to know the effect of P-solubilizer (*Bacillus megaterium*) and P mobilizer (*Glomus mossae*) and their combination with 100 and 75 per cent recommended dose of P on the yield and economics of FCV tobacco. Results showed that application of 100 per cent RDF with P solubilizer and P mobilizer each @ 6.25 ka ha⁻¹ recorded significantly higher green leaf yield (10795 kg ha⁻¹) and cured leaf yield (1060 kg ha⁻¹). However, application of 75% RDP + 100 % RDNK with P solubilizer and P mobilizer each @ 6.25 kg ha⁻¹ recorded higher cured leaf yield (972 kg ha⁻¹) as compared to 100 % RDF alone (907 kg ha⁻¹). Also higher monetary gains were found with the application of P solubilizer and P mobilizer as compared to 100 % RDF alone. The highest additional benefit cost ratio of 12.24 was recorded with the application of 100 % RDF + P solubilizer and P mobilizer each @ 6.25 kg ha⁻¹. The study encourages use of P solubilizer and P mobilizer bio-fertilizers in FCV tobacco production for higher yield and net returns.

Keywords

P solubilizer, P mobilizer, FCV Tobacco, Yield and B:C ratio

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Introduction

Flue Cured Virginia (FCV) tobacco is a type of tobacco mainly used as filler in cigarettes. It is obtained by flue curing of leaves in special structure called barn. FCV tobacco constitutes 30 per cent of total tobacco

production in India and of which 80 per cent is exported. It has a significant role in Indian economy through foreign exchange and excise duty and thus forms an important commercial crop (Anonymous, 2020). It is cultivated as rainfed crop in KLS region of Karnataka and as irrigated in Andhra Pradesh.

As leaf is the economic product indiscriminate use of fertilizer is quite common among the growers. Disproportionate use of NPK fertilizer not only affects the quality of the final produce and export potential but also environment adversely.

Among the major nutrients phosphate and potassium fertilizers are manufactured from mineral deposits and shrinkage of these deposits has raised the challenge of global food security (Smil, 2000). Phosphorus (P) is an essential plant nutrient and forms several structural units. It acts as energy currency by saving solar energy into ATP and memory unit by forming bonds in DNA and RNA strands. P is essentially required for root growth, photosynthesis, seed formation and early maturity (Shankar *et al.*, 2013).

In soil P is found both mineral and organic forms. Most of the organic P (20 to 80%) has been found to be inert. On an average, soil contains 400–1000 mg kg⁻¹ of total P, of which only 1.00–2.50 per cent is in available form for plant uptake. Plant absorbs P either as HPO₄²⁻ or H₂PO₄⁻ and its concentration in soil solution is low. P availability is highly influenced by soil pH, clay type and content, dominant cation and organic carbon content. Further, mineral P in the soil may become unavailable through fixation or adsorption by clay in soil. It may also become unavailable because of precipitation reactions with cations such as Ca-P in alkaline soil or Fe-P and Al-P in acidic soil. As a result, the concentration of mineral P in the soil solution rarely exceeds 0.1mg kg⁻¹.

Hence P fertilizer are periodically added and approximately 30 million tons of P fertilizers (DAP and TSP) are used globally every year with an actual uptake efficiency of only 20 per cent. The remaining fraction is rapidly converted into insoluble complexes *viz.*, insoluble iron/alluminum/calcium phosphate

depending upon soil pH in the rhizosphere (Fernández *et al.*, 2012). The use of chemical fertilizers can be reduced by exploiting bio-inoculants or biofertilizer which are inexpensive and eco-friendly (Subhashini and Padmaja, 2011).

Phosphate solubilizing microbes (PSMs) are group of beneficial microorganisms capable of hydrolyzing organic and inorganic phosphorus compounds from insoluble compounds. The P solubilising ability of several strains of bacterial (*Bacillus Pseudomonas* and *Azotobacter*) and fungal (*Penicillium* and *Aspergillus*) species have been described in detail (He *et al.*, 1997). These form integral part natural phosphorus cycle. Soil and seed inoculation with Phosphate Solubilizing Bacteria (PSB) improves solubilization of fixed soil phosphorus and of applied phosphates, resulting in higher crop yields (Bhattacharya and Jain, 2000).

Vesicular arbuscular mycorrhiza (VAM) - a root colonizing fungi stimulates plant growth and accelerates root development (Raminder *et al.*, 2014). It forms association with more than 90 per cent of plant species and helps in mobilizing the available P by increasing root surface area and greater exploration of soil volume by its hyphal network (Suri *et al.*, 2011). The synergic effect of P solubilisation by PSB and P mobilization by VAM on crop productivity is often reported in literature (Zaidi and Khan, 2005; Patra *et al.*, 2013). Even though these microbes are ubiquitous the phosphate solubilising ability varies from soil to soil or from one production system to another. Hence a study was taken with a objective to know the effect of P-solubilizer (*Bacillus megaterium*) and P mobilizer (*Glomus mossae*) and their combination with 100 and 75 per cent recommended phosphorus on the yield of Tobios-6 variety of FCV Tobacco.

Materials and Methods

The experiment was conducted at ZAHRS, Navile, Shivamogga during *Kharif* 2017 and 2018 with Randomized Complete Block Design. The soil of the experimental site (Table 1) was sandy loam with shallow depth, neutral in reaction (pH 6.70) with normal electrical conductivity (0.136 dSm^{-1}) and low in organic carbon (4.90 g kg^{-1}). The soil was low in available nitrogen ($253.86 \text{ kg ha}^{-1}$), high in available phosphorus ($154.72 \text{ kg ha}^{-1}$), medium in available potassium ($220.14 \text{ kg ha}^{-1}$). The total rainfall received during the crop growth period was lower than normal rainfall (Table 2) and per cent deviation of -3.97 (2017) and -6.74 (2018) was recorded.

Bacillus megaterium as P- solubilizer and *Glomus mossae* as P- mobilizer was used in the study. Both biofertilizers were procured from Organic Farming Research Center, UAHS, Shivamogga. Standard *Bacillus megaterium* culture was obtained from UAS, GKVK, Bengaluru and mass production was carried out by following standard protocol. For VAM production, sterilized mixture of soil, sand and compost (2:2:1 ratio) was filled in pot. VAM culture (10 % solution) was inoculated and finger millet seeds were sown. The finger millet crop was maintained for 45 days. Latter VAM was isolated from rhizosphere of finger millet and used in the current study as VAM is not host specific but always host preference is there.

The experiment was replicated thrice with seven treatments viz., **T₁**: 100 % RDF; **T₂**: 100 % RDF + P mobilizer @ 12.5 kg ha^{-1} ; **T₃**: 100 % RDF + P solubilizer @ 12.5 kg ha^{-1} ; **T₄**: 100 % RDF + P mobilizer @ 6.25 kg ha^{-1} + P solubilizer @ 6.25 kg ha^{-1} ; **T₅**: 75% RDP + 100 % RDNK + P mobilizer @ 12.5 kg ha^{-1} ; **T₆**: 75% RDP + 100 % RDNK + P solubilizer @ 12.5 kg ha^{-1} and **T₇**: 75% RDP + 100 % RDNK + P mobilizer @ 6.25 kg ha^{-1} .

¹+ P solubilizer @ 6.25 kg ha^{-1} . Main field was thoroughly prepared by ploughing and FYM at the rate of 12.5 t ha^{-1} was applied 20 days before transplanting. Ridges were raised at 90 cm apart and planting point was marked at 60 cm distance.

Seedlings of 55 to 65 days were transplanted during July month. P- solubilizer and mobilizers were applied at the rate of 12.5 kg ha^{-1} and each at 6.25 kg ha^{-1} in combination as per treatment requirement. P- solubilizer and mobilizer were mixed with FYM and applied around the seedling a day after planting. Basal dose of 50 per cent of N and K was applied through ammonium sulphate and SOP fertilizer. Entire dose of P was applied as basal through DAP as per treatment requirement. Except for the treatment crop was managed according to package of practices of the University. Green leaf and cured leaf yield from net plot were recorded at each picking for both the years and converted to kg ha^{-1} . Top grade equivalent was worked out after grading of conditioned leaves based on leaf position and colour. The economics was worked out for pooled yield data. Additional benefit cost ratio was worked out by considering additional expenditure made and additional returns obtained.

The experimental design was a randomized complete block design (RCBD), and the statistical analysis was done by the standard procedures suggested by Gomez and Gomez (1984).

Results and Discussion

Green leaf yield, cured leaf yield and top grade equivalent

The rate of P application and inoculation of P solubilizer and P mobilize either alone or in combination significantly influenced the green leaf yield, cured leaf yield and top

grade equivalent (Table 3) during both the years as well as in pooled analysis. Treatment receiving 100 per cent RDF with application of P solubilizer and P mobilizer each @ 6.25 kg ha⁻¹ produced consistently and the highest green leaf yield (10795 kg ha⁻¹) and cured leaf yield (1060 kg ha⁻¹). In pooled analysis application of P solubilizer and P mobilizer each @ 6.25 kg ha⁻¹ along with 100 per cent RDF gave 9.12 per cent higher green leaf yield and 16.86 per cent higher cured leaf yield as compared to the 100 per cent RDF alone. When phosphate fertilizer is applied to soil all its water soluble P enters soil solution and readily forms sparingly soluble compound with aluminium, iron, calcium, etc. It is well recognized that the value of phosphate fertilizer depends primarily upon the release of P from these sparingly compounds. Application of P solubilizer and P mobilizer enhances the P availability to

plants by solubilizing precipitated phosphates and mineralizing organic P in soil (Chen *et al*, 2006; Kang *et al*, 2002 and Pradhan and Sukla, 2005). Microbes influences soil fertility through different soil processes like assimilation, decomposition, mineralization and storage/release of nutrients.

Although the most prevalent reported benefit of biofertilizer is improved availability of nutrients, but there are increasing number of studies which describes other benefits. Increased level of phytohormones and other compounds *viz.*, auxins, cytokinins, gibberellins, abscisic acid, ethylene and salicylic acid are commonly reported as result of biofertilizer application. Thus increased availability of these phytohormones greatly affects root growth, resulting in improvements in uptake of moisture and nutrients (Ardakani and Mafakheri, 2011).

Table.1 Initial soil properties of experimental site

Parameters	Values
pH (1:2.5)	6.70
Electrical conductivity (dS m ⁻¹ at 25 ⁰ C)	0.136
Organic carbon (g kg ⁻¹)	4.90
Available Nitrogen (kg ha ⁻¹)	253.86
Available Phosphorus (kg ha ⁻¹)	154.72
Available Potassium (kg ha ⁻¹)	220.14

Table.2 Year-wise normal and actual rainfall received (mm) during crop period

Month	2017			2018		
	Normal rainfall (mm)	Actual rainfall (mm)	Deviation	Normal rainfall (mm)	Actual rainfall (mm)	Deviation
July	201.9 (14)	136.4 (11)	-32.44	199.8 (14)	154.2 (21)	-22.82
August	139.2 (14)	156 (11)	12.07	139.7 (14)	174.2 (19)	24.70
September	102.7 (7)	186.6 (14)	81.69	105.4 (7)	82.4 (5)	-21.82
October	142 (7)	84.6 (7)	-40.42	140.1 (7)	134.8 (5)	-3.78
Total	585.8 (42)	563.6 (43)	-3.79	585 (42)	545.6 (50)	-6.74

Table.3 Effect of application of different rates of P, P-mobilizer and P-solubilizer on yield and top grade equivalent of FCV tobacco

Treatment	Green leaf yield (kg ha ⁻¹)			Cured leaf yield (kg ha ⁻¹)			Top grade equivalent (kg ha ⁻¹)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T₁: 100 % RDF	10080	9708	9894	875	938	907	570	493	532
T₂: 100 % RDF + P mobilizer @ 12.5 kg ha⁻¹	10544	10018	10281	1000	924	962	549	481	515
T₃: 100 % RDF + P solubilizer @ 12.5 kg ha⁻¹	10523	10082	10303	971	933	952	454	488	471
T₄: 100 % RDF + P mobilizer @ 6.25 kg ha⁻¹+ P solubilizer @ 6.25 kg ha⁻¹	10594	10995	10795	1078	1041	1060	485	574	529
T₅: 75 % RDP + 100 % RDNK + P mobilizer @ 12.5 kg ha⁻¹	9659	9286	9472	990	857	924	558	535	546
T₆: 75 % RDP + 100 % RDNK + P solubilizer @ 12.5 kg ha⁻¹	8417	8928	8672	862	947	904	392	369	380
T₇: 75 % RDP + 100 % RDNK + P mobilizer @ 6.25 kg ha⁻¹+ P solubilizer @ 6.25 kg ha⁻¹	9779	10012	9896	956	989	972	555	573	564
SEm_±	343.65	342.88	283.75	39.86	32.76	29.13	31.08	31.26	28.65
CD at 5%	1058.89	1056.51	874.33	122.82	100.96	89.77	95.77	96.32	88.28

Note: P Mobilizer – *Glomus mossae* P Solubilizer- *Bacillus megaterium*

Table.4 Effect P mobilizer and P solubilizer on benefit cost ratio of FCV Tobacco

Treatment	Cured leaf yield (kg ha ⁻¹)	Cost of cultivation (Rs ha ⁻¹)	Gross return (Rs ha-1)	Net return (Rs ha-1)	B:C
T₁: 100 % RDF	907	115320	126980	11660	1.10
T₂: 100 % RDF + P mobilizer @ 12.5 kg ha⁻¹	962	117070	134680	17610	1.15
T₃: 100 % RDF + P solubilizer @ 12.5 kg ha⁻¹	952	117070	133280	16210	1.14
T₄: 100 % RDF + P mobilizer @ 6.25 kg ha⁻¹+ P solubilizer @ 6.25 kg ha⁻¹	1060	117070	148400	31330	1.27
T₅: 75 % RDP + 100 % RDNK + P mobilizer @ 12.5 kg ha⁻¹	924	116820	129360	12540	1.11
T₆: 75 % RDP + 100 % RDNK + P solubilizer @ 12.5 kg ha⁻¹	904	116820	126560	9740	1.08
T₇: 75 % RDP + 100 % RDNK + P mobilizer @ 6.25 kg ha⁻¹+ P solubilizer @ 6.25 kg ha⁻¹	972	116820	136080	19260	1.16

Note: P Mobilizer – *Glomus mossae* P Solubilizer- *Bacillus megaterium*

Market value: Rs.140 kg⁻¹

Cost of P-solubilizer: Rs.100 kg⁻¹

Cost of P-mobilizer: Rs.100 kg⁻¹

Table.5 Effect P mobilizer and P solubilizer on additional benefit cost ratio of FCV Tobacco

Treatments	Cured leaf yield (kg ha ⁻¹)	Additional yield over check (kg)	Additional income (Rs ha ⁻¹)	Additional expenditure (Rs)	Additional benefit cost ratio
T₁: 100 % RDF	907	-	-	-	-
T₂: 100 % RDF + P mobilizer @ 12.5 kg ha⁻¹	962	55	7700	1750	4.4
T₃: 100 % RDF + P solubilizer @ 12.5 kg ha⁻¹	952	45	6300	1750	3.6
T₄: 100 % RDF + P mobilizer @ 6.25 kg ha⁻¹+ P solubilizer @ 6.25 kg ha⁻¹	1060	153	21420	1750	12.24
T₅: 75 % RDP + 100 % RDNK + P mobilizer @ 12.5 kg ha⁻¹	924	17	2380	1500	1.59
T₆: 75 % RDP + 100 % RDNK + P solubilizer @ 12.5 kg ha⁻¹	904	-	-	-	-
T₇: 75 % RDP + 100 % RDNK + P mobilizer @ 6.25 kg ha⁻¹+ P solubilizer @ 6.25 kg ha⁻¹	972	65	9100	1500	6.07

Note: P Mobilizer – *Glomus mossae* P Solubilizer- *Bacillus megaterium*

The beneficial effect of bio-agent inoculation on plant growth through root development, solubilisation minerals and plant water relationship were also reported by Poonia and Dhaka (2012). Further, in the present study application of 75 % RDP + 100 % RDNK along with application of P solubilizer and P mobilizer each @ 6.25 kg ha⁻¹ recorded on par cured leaf yield and TGA with the treatment receiving 100 % RDF+ P solubilizer + P mobilize each @ 6.25 kg ha⁻¹. Thus 25 per cent of fertilizer could be saved without yield reduction. This infers the balanced P nutrition through efficient solubilisation and mobilization of fixed P by microbes. Also pooled data showed that 75 % RDP + 100 % RDNK along with dual application of P solubilizer and P mobilizer each @ 6.25 kg ha⁻¹ recorded highest TGE (564 kg ha⁻¹). Mehrvarz *et al.*, (2008) observed that sole application of PSB increased the biological yield, while the application of the same bacteria along with mycorrhiza achieved the maximum grain weight.

Application of bio-agents alone or in combination with P fertilizer was 30-40 per cent better in improving grain yield of wheat than P fertilizer alone and inoculation of bioagents in combination without P fertilizer improved grain yield up to 20 per cent as against sole P fertilization. The application of PSB and plant growth promoting rhizobacteria together could reduce 50 per cent of P fertilizer application without any significant decrease of crop yield (Sharma *et al.*, 2013). The low yield of plants grown on the control treatments in the current study could be attributed to the disappearance of indigenous microbes, which are essential to improve nutrient bioavailability and uptake in the rhizosphere soil.

Economics of PSB and VAM inoculation

Perusal of data in the Table 4 indicate that the highest net returns (Rs. 31330 ha⁻¹) was

observed with application of 100 % RDF+ P solubilizer @ 6.25 kg ha⁻¹ + P mobilizer @6.25 kg ha⁻¹ followed by 75% RDP + 100 % RDNK + P mobilizer @ 6.25 kg ha⁻¹+ P solubilizer @ 6.25 kg ha⁻¹ (Rs. 19260 ha⁻¹). The B:C ratio ranged from 1.08 (75 % RDP + 100 % RDNK + P solubilizer @ 12.5 kg ha⁻¹) to 1.27 (100 % RDF+ P solubilizer @ 6.25 kg ha⁻¹ + P mobilizer @6.25 kg ha⁻¹). The treatment receiving 100 % RDF+ P solubilizer @ 6.25 kg ha⁻¹ + P mobilizer @ 6.25 kg ha⁻¹ has recorded additional benefit cost ratio of 12.24 with an additional cost of Rs. 1750 ha⁻¹ (Table 5). The increases in monetary benefits and higher B:C ratio with the application of P solubilizer and P mobilizer are purely due to increase in the yield. Use of bio-agents reduce the cost of cultivation by reducing fertilizer demand without comprising yield and hence gave higher B:C ratio. Similar observations were also reported in by Dadhich and Gupta (2001), Premsekhar and Rajashree (2009) and Singh *et al.*, (2009).

The present study confirms the beneficial effect of P solubilizer and P mobilizer application in improving the yield of FCV tobacco. Application of 75 % RDP +100 % RDNK + P solubilizer and P mobilizer each at 6.25 kg ha⁻¹ recorded on par yield with 100 % RDF alone and 100 % RDF + P solubilizer and P mobilizer each at 6.25 kg ha⁻¹. Bio-agents present in bio-fertilizer supports plant growth and help in realization of yield advantages. These are low cost natural inputs and can effectively reduce the synthetic fertilizer requirement. Thus efforts are needed to popularize P solubilizer and P mobilizer among farming community.

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