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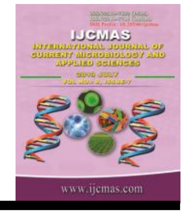

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Effect of Phosphatic Fertilizer and Biofertilizers on Yield and Quality of Finger Millet (*Eleusine coracana* L.)

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A B S T R A C T

A field experiment was conducted to study the response of finger millet to phosphorus fertilizer, PSB and VAM during *kharif*, 2018 on sandy loam soils at Agricultural Research Station, Perumalapalle, Tirupati, Acharya N. G. Ranga Agricultural University, Andhra Pradesh. The experiment was laid out in Randomized Block design with nine treatments and replicated thrice. Among the phosphorus management practices, application of 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) produced higher dry matter production, yield attributes (plant height, number of tillers m^{-2}, number of earheads m^{-2}, number of fingers earhead and length of earhead-1), grain yield and stover yield, grain quality parameters (protein, carbohydrate content) in finger millet. However, it was on par with application of 75% RDF + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). Application of no phosphorus (T_1), registered the lowest values of yield attributes, yield and grain quality parameters.

Introduction

Finger millet (*Eleusine coracana* L.) is an important principal staple food crop grown on marginal and submarginal soils in India.

It is primarily grown in the states of Karnataka, Andhra Pradesh, Odisha and Tamil Nadu in India. It is commonly known as "Nutritious millet" as the grain is nutritionally superior to many cereals providing proteins, minerals, calcium and vitamins in abundance. Straw makes valuable fodder for animals. It contains a low glycemic index and has no gluten, which makes it suitable for diabetes and people with digestive problems, thus considered as a wholesome food for diabetics.

Phosphorus is one of the essential macronutrient for biological growth and proper plant development. Absence of this element in the soil could limit the plant growth and development. A greater part of soil phosphorus is in the form of insoluble phosphates and cannot be utilized by the plants. To increase the availability of phosphorus for plants, large amount of fertilizers are being applied to soil. But a large proportion of applied phosphate fertilizer is quickly transformed to insoluble forms which decrease the efficiency of fertilizers. So, there is a need for microbes which have the capacity to solubilize and mobilise phosphorus. Soil phosphates are rendered available either by plant roots or soil microorganism in the rhizosphere through their secretion of organic acids.

Biofertilizers are products of beneficial microorganisms which increase agricultural production by way of nutrient supply. Phosphorus biofertilizers can mobilize unavailable phosphorus pool which can be used by plants. These biofertilizers are inexpensive and simple to use and have no problem of environmental pollution. Thus, judicious use of biofertilizers along with chemical will help to sustain productivity and soil health apart from meeting a part of fertilizer requirement for different crops. Hence, it is very much essential to develop a workable and compatible nutrient management through biofertilizers including the recommended dose of chemical fertilizers, based on scientific facts, local conditions and economic viability.

Materials and Methods

A field experiment was conducted at of Agricultural Research Station, Perumalapalle, Acharya N. G. Ranga Agricultural University in *kharif*, 2018. Total rainfall received during the crop growth period was 272.7 mm in 19 rainy days. The soil of the experimental field was sandy loam in texture with a pH of 7.6, low in organic carbon (0.23 %), available N (120 kg ha^{-1}) and medium in available phosphorus (43 kg ha^{-1}) and available potassium (218 kg ha^{-1}).

The treatments consisted of nine phosphorus management practices *viz.*, no phosphorus (T_1), 100 % Recommended Dose of Phosphorus (RDP) (T_2), 125% RDP (T_3), 100% RDP + Phosphorus Solubilising Bacteria @ 750 ml ha^{-1} (T_4), 100% RDP + Vesicular Arbuscular Mycorrhizae @ 12.5 kg ha^{-1} (T_5), 100% RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_6), 75% RDP + PSB @ 750 ml ha^{-1} (T_7), 75% RDP + VAM @ 12.5 kg ha^{-1} (T_8) and 75% RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_9).

The Recommended dose of 60-40-30 kg N, P_2O_5 and K_2O ha^{-1} were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. Entire quantity of phosphorus, potassium and half of the dose of nitrogen were applied as basal at the time of transplanting and the remaining half of the nitrogen was top dressed at 30 Days after transplanting. The biofertilizers *i.e*. Liquid Phosphorous Solubilising Bacteria (PSB) @ 750 ml ha^{-1} and Vesicular Arbuscular Mycorrhizae (VAM) @ 12.5 kg ha^{-1} were broadcasted in main field each by mixing it with 100 kg of dried and powdered FYM.

Results and Discussion

Dry matter production

Dry matter production of finger millet recorded at flowering and harvest differed significantly with phosphatic fertilizer and biofertilizers. At flowering, significantly the highest dry matter production was recorded with application of 100 % RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) followed by 75 % RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). At harvest, the highest dry matter production was obtained with 75 % RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) which was at par with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6). The treatment no phosphorus (T_1) was received significantly lowest dry matter production.

Yield attributes

Application of phosphorus fertilizer, PSB and VAM exerted significant influence on number of number of tillers m-2 and number of earheads m-2 at harvest. Among the nine phosphorus management practices, application of 100 % RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} ($T_{6)}$ registered higher number of number of tillers m-2 and number of earheads m^{-2} followed by 75 % RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_9). The yield attributes *viz*., plant height, number of fingers $earhead^{-1}$ and length of earhead-1 was non-significant effected by treatments. However, taller plant and length of earhead-1 was produced with application of 100 % RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} ($T_{6)}$ while, higher number of fingers $earhead^{-1}$ which was on par with that due to 75 % RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_9). The yield attributes were at their lowest with no phosphorus (T_1) (Table 1).

Grain yield

The highest grain yield (Table 2 and Fig. 1.) of finger millet was produced with 100 % RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_6) followed by 75% RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_9). The lowest grain yield was recorded with no phosphorus (T_1).

Straw yield

The highest straw yield (Table 2 and Fig. 2.) of finger millet was recorded with application of 100 % RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_6) which was on par with 125% RDP (T_3). The lowest stover yield was recorded with no phosphorus (T_1).

Grain quality parameters

Protein content

All the treatments showed non-significant affect on Protein content in grain (Table 2). Maximum protein content was observed with 75 % RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) while the lowest was noticed with no phosphorus (T_1).

Carbohydrate content

Carbohydrate content of grain was significantly influenced by treatments. The highest carbohydrate content of finger millet grain (Table 2) was recorded with 75 % RDF + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) which was at par with 75 % RDF + PSB @ 750 ml ha^{-1} (T_7). The lowest carbohydrate content was recorded with no phosphorus (T_1). Higher dry matter production recorded might be due to application of inorganic phosphorus play an important role in metabolic processes and activation of number of enzymes participating in the dark reaction in photosynthesis which in turn increased plant growth and root development. Application of PSB resulted in production of growth promoting substances and there by enhanced the availability of phosphorus and other nutrients in soil. VAM also enhanced the activity of phytohormones like cytokinin and indole acetic acid in plants resulting in better growth and development of plants and Kumar *et al.*, (2017) and Mahdi *et al.*, (2010),

Application of phosphatic biofertilizers along with inorganic phosphorus might have synergistic and additive effect on attributing characters. Phosphorus management had continuous favourable effect on yield attributes, enhanced and steady nutrient release with the application of 100 % RDP + PSB @ 750 ml ha^{-1}+ VAM @ 12.5 kg ha^{-1} (T_6).

Table.1 Dry matter production and yield attributes of finger millet as influenced by phosphorus management practices

Treatments	Dry matter production kg ha^{-1}		Plant height (cm)	Number of tillers m^{-2}	Number of earheads m^{-2}	Number of fingers $earhead^{-1}$	Length of earhead (cm)
	F	H					
T_1 : No Phosphorus	5333^{c}	7522^{c}	85.65	90^{c}	65^{c}	8	**9.06**
T_2 : 100 % Recommended dose of Phosphorus (RDP)	5728^{bc}	8112^{bc}	87.20	100^{ab}	67^{bc}	10	**9.20**
T_3 : 125 % RDP	5583^{bc}	7868^{bc}	85.86	96^{bc}	69^{bc}	9	**9.40**
T_4 : 100 % RDP + Phosphorus Solubilizing Bacteria (PSB)	5661^{bc}	8556^{b}	87.86	93^{bc}	68^{bc}	9	**9.76**
T_5 : 100 % RDP + Vesicular Arbuscular Mycorrhizae (VAM)	5728^{bc}	8000^{bc}	85.66	96^{bc}	68^{bc}	9	**9.55**
T_6 : 100 % RDP + PSB + VAM	6616^{a}	9473^{a}	90.60	104^{a}	85^{a}	10	**10.13**
T_7 : 75 % RDP + PSB	6124^{abc}	8692^{b}	87.53	94^{bc}	70^{bc}	10	**9.73**
T_8 : 75 % RDP + VAM	5825^{abc}	8395^{b}	85.86	101^{a}	67^{bc}	9	**10.06**
T_9 : 75 % RDP + PSB + VAM	6450^{ab}	9545^{a}	89.83	103^{a}	74^{b}	11	**10.07**
F value	2.71*	7.35**	0.71	5.59**	35.0**	1.10	**1.19**
p-value	0.042	0.000	0.677	0.002	0.000	0.411	**0.360**

*** Significant at p=0.05 level ** Significant at p=0.01 level**
Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT)

F: Flowering, H: Harvest

Table.2 Yield and quality parameters of finger millet as influenced by Phosphorus management practices

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Protein Content (%)	Carbohydrate content (%)
T_1 : No Phosphorus	3692^{d}	7966^{b}	7.31	**52.56^{d}**
T_2 : 100 % Recommended dose of Phosphorus (RDP)	3846^{bc}	8382^{a}	7.44	**64.80^{ab}**
T_3 : 125 % RDP	4083^{abc}	8545^{a}	7.54	**65.76^{a}**
T_4 : 100 % RDP + Phosphorus Solubilizing Bacteria (PSB)	3946^{bc}	8421^{a}	7.47	**59.30^{c}**
T_5 : 100 % RDP + Vesicular Arbuscular Mycorrhizae (VAM)	3858^{bc}	8459^{a}	7.36	**60.80^{bc}**
T_6 : 100 % RDP + PSB + VAM	4328^{a}	8614^{a}	7.59	**65.56^{a}**
T_7 : 75 % RDP + PSB	3783^{cd}	8521^{a}	7.54	**68.83^{a}**
T_8 : 75 % RDP + VAM	3942^{bc}	8514^{a}	7.45	**66.90^{a}**
T_9 : 75 % RDP + PSB + VAM	4157^{ab}	8387^{a}	7.62	**68.90^{a}**
F value	3.54*	3.20*	0.76	**13.86****
p-value	0.015	0.023	0.636	**0.000**

*** Significant at p=0.05 level ** Significant at p=0.01 level**
Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT)

PSB: liquid PSB 750 ml ha^{-1}, VAM: 12.5 kg ha^{-1}

Fig.1 Grain yield (kg ha^{-1}) of finger millet as influenced by phosphorus management practices

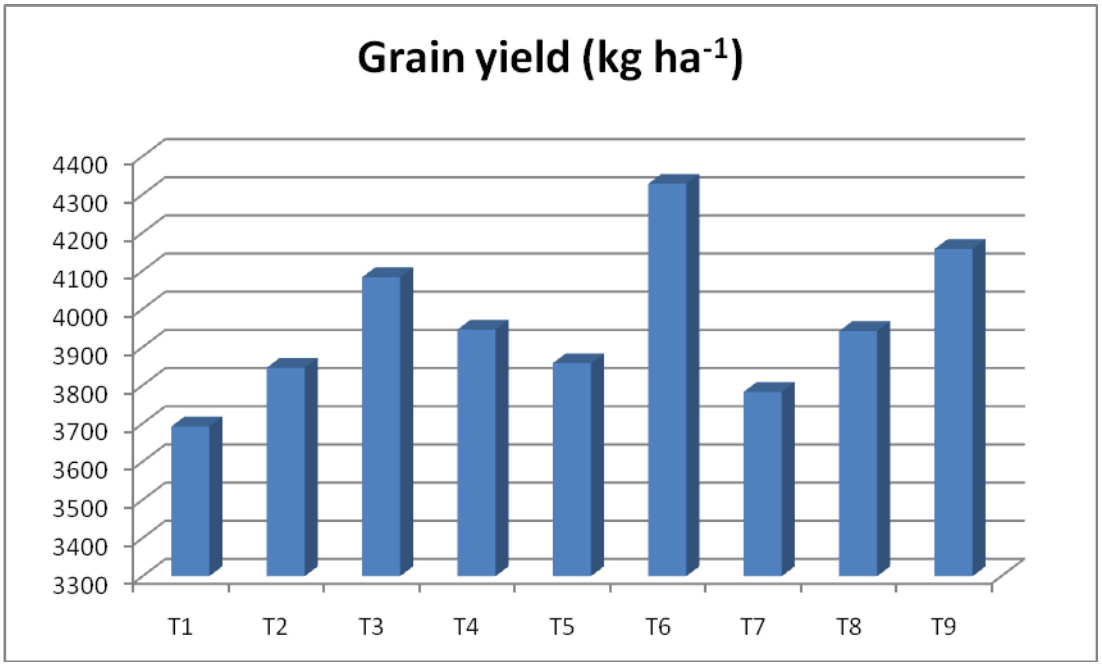
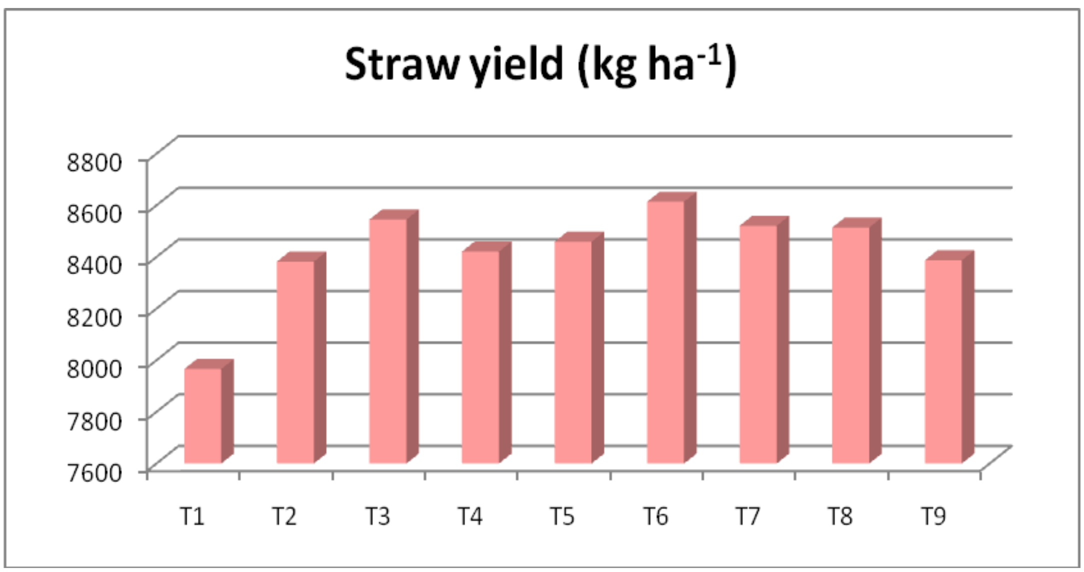


Fig.2 Straw yield (kg ha^{-1}) of finger millet as influenced by phosphorus management practices



The results are in conformity with that of yield Meena and Gautam (2005) and Divya *et al.,* (2017)

The increase in grain yield of finger millet with might be attributed to better supply of nutrients along with conducive physical environment leading to better root activity and higher nutrient absorption, which resulted in more plant growth and superior yield attributes responsible for higher yield. The application of biofertilizers (PSB and VAM) increased the efficiency of chemical fertilizers due to control release of nutrients in the soil through microbial activity which might have facilitates better crop growth (Acharya *et al.*, 2012).

The increased straw yield might be due to addition of inorganic phosphorus and phosphorus solubilizers and mobilizers which may increase the uptake of plant nutrients to manufacture more quality of photosynthates resulting higher straw yield. Furthermore, VAM not only supplies essential nutrients but also water to plants resulting in better growth that led to increasing straw yield. The present findings are in accordance with findings of Pramanik and Bera (2012).

Increased availability of nitrogen in the soil to the plant (through inorganic fertilizers and biofertilizers) might have resulted in increased nitrogen content in seed. It is a well-known fact that nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acid which constitutes the basis of protein.

The present investigations were in agreement with those Meena and Gautam (2005). The lowest grain protein content of finger millet was recorded with no phosphorus (T_1).

Maximum carbohydrates content was recorded due to combined application of inorganic phosphorus, PSB and VAM helps in increases microbial load in soil which secrete many growth promoting substances which accelerates the physiological processes like synthesis of carbohydrates. The similar results are obtained by Patil *et al.*, (2018). The lowest carbohydrate content of finger millet grain was recorded with no phosphorus (T_1).

Combined application of 100 % RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} is the most efficient phosphorus management practice for the better growth, yield and quality of finger millet.

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