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Growth and Yield of Fingermillet [*Eleusine coracana* (L.)] as Influenced by Phosphorus Management Practices

S Kiran Kumar, Ch Pulla Rao , M Sree Rekha and P Ratna Prasad
Department of Agronomy, Agricultural College, Bapatla 522 10, Andhra Pradesh

ABSTRACT

A field experiment conducted during *kharif*, 2015 on sandy soil of Agricultural College Farm, Bapatla. Experiment was laid out in randomized block design with nine treatments (T1: RDP @ 30 kg ha-1; T2: 75% Recommended dose of inorganic phosphorus + FYM @ 3.75 t ha-1; T3: 75% Recommended dose of inorganic phosphorus + Vermicompost @ 0.75 t ha-1; T4: 50% recommended dose of inorganic phosphorus + FYM @ 7.5 t ha^{-1}; T5: 50% Recommended dose of inorganic phosphorus + Vermicompost @ 1.5 t ha-1; T6: T1 + PSB @ 5.0 kg ha^{-1}; T7: T4 + PSB @ 5.0 kg ha-1; T8: T5 + PSB @ 5.0 kg ha-1; T9: No phosphorus.) and replicated thrice. The results indicated that the highest plant height at harvest (100.9 cm), drymatter production (566.0, 3068.0 and 6845.0 kg ha^{-1} at 30,60 DAS and harvest stages), total tillers m-2 (67.0, 72.7 and 74.3 at 30,60 DAS and harvest stages), grain yield (2200 kg ha^{-1}), straw yield (4550 kg ha^{-1}) and highest benefit cost ratio (1.73) was recorded with 50 % recommended dose of phosphorus + FYM @ 7.5 t ha^{-1} + PSB @ 5.0 kg ha^{-1} followed by 50 % recommended dose of phosphorus + Vermicompost @1.5 t ha^{-1} + PSB @ 5.0 kg ha^{-1} and significantly superior to the rest of the treatments.

Key words: *Fingermillet, FYM, Phosphorus management, PSB, Vermicompost.*

India is the largest producer of many kinds of millets, which are often referred to as coarse cereals. Among the rainfed crops, millet group is a prominent one. Different millets grown in India are sorghum (Jowar), pearlmillet (Bajra), fingermillet (Ragi) and other many kinds of small millets like kodo millet, foxtail millet and barnyard millet. Among the millets, fingermillet has a special place in view of its highest water use efficiency and drought resistance character. It is a C_4 plant, and has higher productivity among the small millets.

Fingermillet grain is low in fat (1.3%), crude protein (6-8%), very high in calcium (8.3%), and potassium (0.41%), iron (0.017%) and thiamine (0.42 mg/100g).

Its carbohydrate content ranges from 70-76% with a calorific value of 345 calories/100g. Fingermillet can be considered to have a well-balanced protein for cereal grain with three essential amino acids (lysine being 2.86%, tryptophan 1.39% and methionine 2.86%). The persons who are suffering from diabetes, it is a supplemental food instead of regular food item like rice and it has the capacity to reduce sugar levels in their blood and urine.

It is reputed to tolerate a certain degree of alkalinity in the soil. The protein of fingermillet is considered to be "biologically complete". The protein content of finger millet possess a fairly high biological value, which is needed for the maintenance of nitrogen equilibrium of the body.

In India, it is grown in an area of 1.19 million hectares with an annual production of 1.44 million tonnes and productivity of 1210 kg ha^{-1}. Andhra Pradesh ranks fourth position in area (0.44 lakh ha) and third position in production (0.36 lakh tonnes) of fingermillet in India, with a productivity of 1045 kg ha^{-1}.

Phosphorus plays an important role in the metabolic processes in ragi and activation of number of enzymes participating in the dark reactions in photosynthesis, which inturn, increases the fingermillet yield. It is also associated with increased root growth and early maturity of crop. Phosphorus availability and fertilizer phosphorus use efficiency can be increased with mycorrhiza, phosphate solubilising bacteria (PSB) and fungi which solubilise the soil phosphates. The PSB inoculum is applied to increase the availability of phosphorus to crop.

MATERIAL AND METHODS

A field trial was carried out on sandy soil of Agricultural College Farm, Bapatla during *kharif,* 2015. The soil was slightly acidic and low in organic carbon (0.09%), low in available nitrogen (130 kg ha^{-1}) and medium in available phosphorus (24 kg ha^{-1}) and potassium (240 kg ha^{-1}). The experiment was laid out in randomized block design with nine treatments and replicated thrice. The treatments consisted of T_1 : Recommended dose of phosphorus (RDP) @ 30 kg P_2O_5 ha^{-1}, T_2 : 75% Recommended dose of inorganic phosphorus + FYM 3.75 t ha^{-1}, T_3 : 75 % Recommended dose of inorganic phosphorus + Vermicompost @ 0.75 t ha^{-1}, T_4 : 50 % Recommended dose of inorganic phosphorus + FYM 7.5 t ha^{-1}, T_5 : 50 % Recommended dose of inorganic phosphorus + Vermicompost @ 1.5 t ha^{-1}, T_6 : T_1 + PSB @ 5.0 kg ha^{-1}, T_7 : T_4 + PSB @ 5.0 kg ha^{-1}, T_8 : T_5 + PSB @ 5.0 kg ha^{-1} and T_9 : No phosphorus. The fingermillet variety (Sri Chaitanya) was sown on 21st August 2015. A total of 504.9 mm rainfall received during crop growth period. Seed was sown by increasing bulk with mixing sand to seed and sown in lines by manually. Thinning and gap filling was done at 15 DAS. Entire dose of nitrogen and potassium were applied as basal in the form of urea and muriate of potash and nitrogen was applied in three equal splits through urea at basal, tillering stage (30DAS) and at earhead emergence stage (60 DAS). The phosphorus was applied as per the treatments. The data on plant height, drymatter production, yield attributes, yield and net returns were recorded as per standard statistical procedures. The observation on growth parameters *viz.,* plant height, drymatter production, days to flowering and maturity and yield parameters *viz.,* number of earheads m^{-2}, earhead length, number of fingers $earhead^{-1}$, number of filled grains $finger^{-1}$, test weight, grain yield and straw yield were analysed by adopting Panse and Sukhatme (1978) standard procedures.

RESULTS AND DISCUSSION

Growth parameters

The results (Table 1) revealed that the plant height was significantly affected by phosphorus management practices. Significantly taller plants (53, 94.5 and 100.9 cm at 30, 60 DAS and at harvest respectively) was recorded with T_7 treatment (50% Recommended dose of inorganic phosphorus + FYM @ 7.5 t ha^{-1} + PSB @ 5.0 kg ha^{-1}) followed by T_8 treatment (50 % Recommended dose of inorganic phosphorus + Vermicompost @ 1.5 t ha^{-1} + PSB @ 5 kg ha^{-1}) 51.2, 90.3, 99.7 cm at 30, 60 DAS and at harvest stages. These two treatments were found to be significantly superior to the rest of the treatments, but remained at par with the T_4 treatment (50% recommended dose of inorganic phosphorus + FYM @ 7.5 t ha^{-1}). Similar trend was noticed in respect of plant height recorded at 60 DAS and at harvest stage as that was observed with 30 DAS. This might be due to enhanced availability of nutrients, production of growth promoting substances and reduced phosphorus fixation by PSB chelating effects and also solubilization of unavailable forms of phosphorus. These results are in accordance with the findings of Apoorva *et al* (2010), Gavde (2010), Vandana and Thakarl and kumar (2012), Kadalli *et al.* (2006), Umesh *et al.* (2006) and Anilkumar *et al.* (2003).

Significant drymatter production (Table 1) was recorded by T_7 at all the stages of crop growth. Application of T_7 (50 % recommended dose of phosphorus + FYM @ 7.5 t ha^{-1} + PSB @ 5.0 kg ha^{-1}) treatment was recorded higher drymatter production (566, 3068 and 6845 kg ha^{-1} at 30, 60 DAS and at harvest stages respectively) over the rest of the treatments but it was statistically at par with the T_8 treatment *i.e.* 50 % Recommended dose of inorganic phosphorus + Vermicompost @ 1.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (511, 2526 and 6271 kg ha^{-1} respectively). This might be due to the biofertilizer (phosphorus solubilizing) component in the treatment in combination with inorganic sources which might have synergistic and additive effect on drymatter production. However, they increase the fertilizer use efficiency of the crop as well as soil fertility by promoting soil microbial activities and narrow down C : N ratio which in turn might have resulted in longer availability of the nutrients throughout the crop growth period. These results are in agreement with the findings of Anilkumar *et al.* (2003).

At all the growth stages, highest number of tillers m^{-2} was recorded (Table 1) with T_7 treatment (67, 72.7 and 74.3 at 30, 60 DAS and at harvest stages respectively) which was at par with

Table 1. Plant height, drymatter production and total tillers at different stages of fingermillet as influenced by phosphorus management practices.

Treatment	Plant height (cm)			Drymatter production (kg ha^{-1})			Total tillers (No. m^{-2})		
	30 DAS	60DAS	Harvest	30DAS	60DAS	Harvest	30DAS	60DAS	Harvest
T_1 : Recommended dose of phosphorus (RDP) @ 30 kg P_2O_5 ha^{-1}	43.5	72.6	80.9	304	1545	3956	59.0	66.1	69.3
T_2 :75% Recommended dose of inorganic phosphorus + FYM 3.75 t ha^{-1}	44.8	76.5	84.3	312	1776	5503	59.0	66.0	66.6
T_3 :75 % Recommended dose of inorganic phosphorus + Vermicompost @ 0.75 t ha^{-1}	43.3	75.1	82.0	307	1860	5339	59.0	67.0	65.2
T_4:50 % Recommended dose of inorganic phosphorus + FYM 7.5 t ha^{-1}	50.7	81.7	91.1	320	2206	5720	61.6	67.0	68.0
T_5: 50 % Recommended dose of inorganic phosphorus Vermicompost @ 1.5 t ha^{-1}	47.7	72.0	87.5	318	1961	5669	60.1	66.7	67.6
T_6: T_1 + PSB @ 5.0 kg ha^{-1}	44.2	79.4	84.5	317	1838	4097	61.5	67.0	69.3
T_7: T_4 + PSB @ 5.0 kg ha^{-1}	53.0	94.5	100.9	566	3068	6845	67.0	72.7	74.3
T_8: T_5 + PSB @ 5.0 kg ha^{-1}	51.2	90.3	99.7	511	2526	6271	64.6	70.2	72.6
T_9: No phosphorus	42.6	69.0	77.6	250	1341	3535	57.7	65.4	66.6
S.Em ±	1.58	3.59	3.55	22.0	179.6	255.5	1.82	1.35	1.26
CD (P=0.05)	4.7	10.8	10.7	66	538	766	5.4	4.0	3.8
CV (%)	5.8	7.9	7.0	10.7	15.5	8.4	5.1	3.4	3.1

Table 2. Days to 50% flowering and maturity of fingermillet as influenced by phosphorus management practices.

Treatment	Days to 50% flowering	Days to maturity
T_1 : Recommended dose of phosphorus (RDP) @ 30 kg P_2O_5 ha^{-1}	71	104
T_2 :75% Recommended dose of inorganic phosphorus + FYM 3.75 t ha^{-1}	70	103
T_3 :75 % Recommended dose of inorganic phosphorus + Vermicompost @ 0.75 t ha^{-1}	70	103
T_4:50 % Recommended dose of inorganic phosphorus + FYM 7.5 t ha^{-1}	73	103
T_5: 50 % Recommended dose of inorganic phosphorus + Vermicompost @ 1.5 t ha^{-1}	70	104
T_6: T_1 + PSB @ 5.0 kg ha^{-1}	73	104
T_7: T_4 + PSB @ 5.0 kg ha^{-1}	68	103
T_8: T_5 + PSB @ 5.0 kg ha^{-1}	68	103
T_9: No phosphorus	75	104
S.Em ±	1.09	0.49
CD (P=0.05)	1.5	NS
CV (%)	2.6	0.8

T_8 treatment (64.6, 70.2 and 72.6 at 30, 60 DAS and at harvest stages respectively). This might be due to the adequate availability of plant nutrients and favourable nutritional environment prevailed near the vicinity of plant roots of through the biofertilizer application. These findings corroborate the results of Gavade (2010) and Anilkumar *et al.,*(2003).

Lowest number of days (Table 2) to 50 per cent flowering (68 days) was recorded by both the treatments viz., T_7 (50% Recommended dose of inorganic phosphorus + FYM 7.5 t ha^{-1}+PSB @5 kg ha^{-1}) and T_8 (50 % Recommended dose of inorganic phosphorus + Vermicompost @ 1.5 t ha^{-1} + PSB @ 5 kg ha^{-1}) treatments (68 days). Number of days taken to reach maturity(Table 2) was not influenced by the phosphorus management, due to the fact that these were mostly controlled by genetic characters. This might be due to better nutrient uptake and enhanced photosynthetic rate, drymatter accumulation and rapid growth rate because of increased nutrient availability with the increasing fertility level in combination with biofertilizer application. These results are in agreement with the findings of Kumar and Gautam (2004).

Yield attributes

Highest number of ear heads m^{-2} (62.0) was (Table 3) recorded with T_7 treatment (T_4 + PSB @ 5 kg ha^{-1}), T_8 treatment (T_5 + PSB @ 5 kg ha^{-1}) and T_6 treatment (T_1 + PSB @ 5 kg ha^{-1}) and lowest number was recorded by control (55.0). This increase in number of earheads m^{-2} may be ascribed to better nutrition as a result of application of fertilizers and biofertilizer and along with organics which might have aided in higher root growth and development and enhanced the uptake and translocation of nutrients. The present findings are in complete agreement with the finding of Ahiwale *et al.* (2013) and Pradeep kumar *et al.* (2014),

Highest number of fingers per earhead (Table 3) was observed by application of 50% RDP + FYM @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (T_7) 8.3 which was at a par with T_8 50 % RDP + vermicompost @ 1.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (8.1) and T_4 i.e. 50 % RDP + FYM @7.5 t ha^{-1} (8.0).

Highest number of filled grains (Table 3) per finger (161.0) was observed by application of 50% RDP + FYM @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (T_7) which was at par with T_8 i.e. 50% RDP + Vermicompost @ 1.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (151.0) and T_4 i.e. 50 % RDP + FYM @ 7.5 t ha^{-1} and 50% RDP + Vermicompost @ 1.5 t ha^{-1} (150.0).

In this trial, 50 % Recommended dose of inorganic phosphorus + FYM 7.5 t ha^{-1} + PSB @ 5.0 kg ha^{-1} (T_7) recorded significantly higher test weight (3.0 g) (Table 3) followed by T_8 i.e. 50 % Recommended dose of inorganic phosphorus +Vermicompost 1.5 t ha^{-1} + PSB @ 5.0 kg ha^{-1} (2.8 g). Rest of the treatments were statistically at par with each other.

This might be due to better nutrition due to application of chemical fertilizers along with organic manures and biofertilizer might have resulted into better root growth and development and enhanced nutrient availability, uptake & translocation. Due to the organic manure addition, nutrient status of soil was improved and availability of nutrients for longer period throughout the crop growth was enhanced and this might be the reason to increase the No. of fingers per earhead. Enhanced availability of phosphorus by PSB might have supported photosynthesis long enough during grain-filling for increased number of filled grains and test weight. The present results are in agreement with the findings of Nigade and More (2013) and Apoorva *et al.* (2010).

Grain yield and straw yield

The maximum grain yield (2200 kg ha^{-1}) and straw yield (4550 kg ha^{-1}) were recorded (Table 3) with the combined application of inorganic, organic and biofertilizer (PSB) (50% RDP + FYM @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}) but it remained at par with 50 % RDP + Vermicompost @ 1.5 t ha^{-1} + PSB @ 5 kg ha^{-1}, followed by 50% RDP + FYM 7.5 t ha^{-1} (1951 and 4250 kg ha^{-1} grain and straw yields, respectively). This might be due to Phosphorus is important in plant bioenergetics. As a component of ATP, phosphorus is needed for the conversion of light energy to chemical energy (ATP) during photosynthesis. Phosphorus is also involved in better root growth enhanced nutrient uptake and translocation of photosynthates from source to sink. Application of P fertilizers might have synergistic effect on increasing grain yield of fingermillet.

Table 3. Number of earheads, No. of fingers per earhead, No.of filled grains per finger, test weight, grain yield and straw yield of fingermillet as influenced by phosphorus management practices.

Treatment	Earheads (No.m^{-2})	No. of fingers $earhead^{-1}$	No. of filled grains $finger^{-1}$	Test weight (g/1000 grains)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 : Recommended dose of phosphorus (RDP) @ 30 kg P_2O_5 ha^{-1}	56	7.2	130	2.67	900	2800
T_2 :75% Recommended dose of inorganic phosphorus + FYM 3.75 t ha^{-1}	60	7.8	144	2.67	1448	3850
T_3 :75 % Recommended dose of inorganic phosphorus + Vermicompost @ 0.75 t ha^{-1}	58	7.4	141	2.67	1508	3750
T_4:50 % Recommended dose of inorganic phosphorus + FYM 7.5 t ha^{-1}	62	8.0	150	2.73	1678	3954
T_5: 50 % Recommended dose of inorganic phosphorus Vermicompost @ 1.5 t ha^{-1}	59	7.8	150	2.70	1602	3850
T_6: T_1 + PSB @ 5.0 kg ha^{-1}	59	7.4	147	2.67	980	2950
T_7: T_4 + PSB @ 5.0 kg ha^{-1}	62	8.3	161	3.00	2200	4550
T_8: T_5 + PSB @ 5.0 kg ha^{-1}	62	8.1	151	2.87	1951	4250
T_9: No phosphorus	55	6.4	128	2.67	800	2650
S.Em ±	1.65	0.19	4.50	0.04	94.7	198.8
CD (P=0.05)	5.0	0.5	13.5	0.1	284.0	596.2
CV (%)	4.8	4.3	5.3	3.0	11.2	9.5

Table 4. Economics of different treatments of fingermillet as influenced by phosphorus management practices.

Treatment	Total cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Returns per rupee invested
T_1 : Recommended dose of phosphorus (RDP) @ 30 kg P_2O_5 ha^{-1}	6594	12200	5606	0.85
T_2 :75% Recommended dose of inorganic phosphorus + FYM 3.75 t ha^{-1}	8940	19301	10361	1.15
T_3 :75 % Recommended dose of inorganic phosphorus + Vermicompost @ 0.75 t ha^{-1}	9540	19971	10431	1.09
T_4:50 % Recommended dose of inorganic phosphorus + FYM 7.5 t ha^{-1}	10286	22113	11827	1.15
T_5: 50 % Recommended dose of inorganic phosphorus Vermicompost @ 1.5 t ha^{-1}	10536	21149	10613	1.00
T_6: T_1 + PSB @ 5.0 kg ha^{-1}	6774	13235	6461	0.95
T_7: T_4 + PSB @ 5.0 kg ha^{-1}	10466	28675	18209	1.73
T_8: T_5 + PSB @ 5.0 kg ha^{-1}	10716	25537	14821	1.38
T_9: No phosphorus	6178	10925	4747	0.76

Similar results have also been reported by researchers like Ahiwale *et al.*(2013) and Arulmozhiselvan *et al.* (2013).

Economics

Gross returns and net returns were increased (Table 4) with the increase in levels of organic manure and phosphorus applied along with biofertilizer. The highest gross returns (₹ 28675ha^{-1}) and net returns (18209 ha^{-1}) were recorded by the application of 50 % RDP + FYM @7.5 kg ha^{-1} + PSB @ 5 kg ha^{-1} (T_7) which was closely followed by 50% RDP + Vermicompost @ 1.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (T_8) Rs. 25537 and Rs. 14821 gross and net returns.

Highest returns per rupee investment (1.73) was obtained with the application of 50%Recommended dose of phosphorus + FYM @ 7.5 t ha^{-1} + PSB @ 5.0kg ha^{-1} (T_7 treatment) followed by T_8 treatment (1.38). These results are in accordance with Basavaraju and Purushotham (2009) and Singh (2002),

Conclusion

Based on the above results and discussion, it can be concluded that application of 50 % RDP + FYM @7.5 kg ha^{-1} + PSB @ 5 kg ha^{-1} gave higher growth, yield parameters, grain & straw yield, gross returns and net returns of fingermillet and highest returns per rupee investment.

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