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Effect of VAM, Sulphur and Boron on Yield, Nutrient Uptake and Availability of Ragi

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A B S T R A C T

The field experiment was conducted at Achalvadi village, Harur block in Dharmapuri district to study the effect of VAM, Sulphur and boron on yield, nutrient uptake and availability of ragi during October 2019 – February 2020. The experiment consisted of eleven treatments with three replications and the experimental plots were laid out in randomized block design. The results of the present investigation revealed that application of RDF (60:30:30 kgs of NPK ha^{-1}) + Vermicompost @ 3 t ha^{-1} + Seed treatment with *Azospirillum* @ 600 g ha^{-1} + Inoculation of VAM @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum + Foliar spray of Borax 0.5% twice at 30 and 45 DAT (T_{11}) produced the higher grain and straw yield (2963.60 and 5414.43 kg ha^{-1} respectively), nutrient uptake (71.80, 22.53, 51.33 and 18.48 kg ha^{-1} of N, P, K and S respectively) and available soil S (25.33 kg ha^{-1}) while the highest available soil N, P and K (292.72, 19.98 and 273.25 kg ha^{-1} respectively) were recorded under the application of RDF (60:30:30 kgs of NPK ha^{-1}) + Farm yard manure @ 12.5 t ha^{-1} + Seed treatment with *Azospirillum* @ 600 g ha^{-1} + Inoculation of VAM @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum (T_1). The lowest values of yield, nutrient uptake and available soil nutrients were recorded under the control treatment (T_1).

***Key words*:** Ragi, VAM, Sulphur, Boron, yield, Nutrient uptake, Availability

Millets are popularly known as nutri cereals as they are rich in vitamins, minerals and provide most of the nutrients required for the normal functioning of the human body. Besides providing nutritional security, they also help in preventing malnutrition. Considering its value, 2018 has been declared as the "National year of millets" by the Government of India. The UNO accepted India's proposal to adopt 2023 as the "International year of millets" which was unanimously supported by 70 countries. Finger millet (*Eleusine coracana* L. Gaertn.) popularly known as Ragi and African millet is the staple food crop, grown in many hilly regions of Indian sub-continent and world. Finger millet act as a primary source of food for millions of people in tropical dry land regions as it has the ability to withstand adverse weather conditions when grown in the soils with poor water holding capacity [1]. Ragi is nutritionally superior to all other cereals and millets.

Finger millet is known as low fertilizer input crop [2]. Indian soils are generally low in nitrogen, medium in phosphorus and high in potassium. Application of various biofertilizers increase the available nutrient in the soil. The application of Vesicular Arbuscular Mycorrhizal fungi mobilizes the soil unavailable phosphorus and makes it easily available to plants [3]. The various organic manures such as farm yard manure and vermicompost makes the soil more fertile. Sulphur, the secondary macronutrient is necessary for the various enzymatic activities of the plants. The soil application of Sulphur immediately releases the sulphate ions in soil solution which leads to the better availability and absorption of Sulphur resulting in vigorous crop growth and production of higher dry matter by the plant [4]. Boron is essential for the development of reproductive parts and to translocate the photosynthates from source to sink [5]. By considering these facts the field experiment was conducted to study the effect of VAM, Sulphur and boron on yield, nutrient uptake and availability of ragi.

MATERIALS AND METHODS

The field experiment was conducted at Achalvadi village, Harur block in Dharmapuri district to study the effect of VAM, Sulphur and boron on yield, nutrient uptake

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and availability of ragi during October 2019 – February 2020. The experimental field is located at 11°59'56'' N latitude, 78° 29'15'' E longitude with altitude of 392 m above mean sea level in the North Western Agro-climatic zone of Tamil Nadu. The experiment consisted of eleven treatments with three replications and the experimental plots were laid out in randomized block design. The cultivar Paiyur 2 was chosen for the study. The experimental plots were laid out in randomized block design and the treatments were allotted randomly in each replication. The treatments consisted of T_1 - RDF alone (60:30:30 Kg of NPK ha^{-1}) / control, T_2 - T_1 + Farm yard manure @ 12.5 t ha^{-1}, T_3 - T_1 + Vermicompost @ 3 t ha^{-1}, T_4 - T_2 + Seed treatment with *Azospirillum* @ 600 g ha^{-1}, T_5 - T_3 + Seed treatment with *Azospirillum* @ 600 g ha^{-1}, T_6 - T_4 + Inoculation of VAM @ 12 kg ha^{-1}, T_7 - T_5 + Inoculation of VAM @ 12 kg ha^{-1}, T_8 - T_6 + Sulphur @ 40 kg ha^{-1} through gypsum, T_9 - T_7 + Sulphur @ 40 kg ha^{-1} through gypsum, T_{10} - T_8 + Foliar spray of Borax 0.5% twice at 30 and 45 DAT and T_{11} - T_9 + Foliar spray of Borax 0.5% twice at 30 and 45 DAT. The texture of experimental field soil was sandy loam which was low in available nitrogen, medium in available phosphorus and potassium and low in available Sulphur. VAM was applied to the soil before transplanting by mixing with soil and sand. 40 kg ha^{-1} Sulphur was applied basally and 0.5% borax was foliar sprayed on 30 and 45 DAT.

RESULTS AND DISCUSSION

Yield

The application of VAM, Sulphur and boron achieved a spectacular effect on the yield of ragi. Among the various treatments imposed in the study, maximum grain and straw yield of 2963.60 and 5414.43 kg ha^{-1} were achieved through the application of RDF (60:30:30 kgs of NPK ha^{-1}) + vermicompost @ 3 t ha^{-1} + seed treatment with *Azospirillum* @ 600 g ha^{-1} + inoculation of VAM @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum + foliar spray of borax @ 0.5% twice at 30 and 45 DAT (T_{11}). The application of farm yard manure @ 12.5 t ha^{-1} + seed treatment with *Azospirillum* @ 600 g ha^{-1} + inoculation of VAM @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum + foliar spray of borax @ 0.5% twice at 30 and 45 DAT (T_{10}) ranks next and both are on par with each other. The lowest grain yield of 1301.51 kg ha^{-1} was recorded under the control (T_1). The higher yield attributes and yield from the treatment T_{11} might be due to the combined application of various sources of nutrients. The application of vermicompost have provided the essential nutrients required for the growth and development of crop. Phosphorus is necessary for the development of grains. The soil application of mycorrhizal fungi have mobilized the soil unavailable phosphorus and make it available for the plants. Sulphur plays an important role in carbohydrate metabolism, energy transformation and activation of carbon fixing enzymes. These enzymatic activities have led to increased transformation of photosynthates towards sink and resulted in the formation of bold grain and increased the yield [6]. Boron application significantly increased the dry matter accumulation of plants which have promoted the transport of photosynthates from vegetative organs to the reproductive organs, thus resulting in significant improvement of yield. Foliar application of boron increased the grain yield of rice due to the substantial decrease in panicle sterility and increase in grain size [7-9].

Table 1 Effect of VAM, sulphur and boron on nutrient uptake and post-harvest soil available nutrient of transplanted ragi (kg ha^{-1})

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Nutrient uptake (kg ha^{-1})				Post-harvest soil available nutrient (kg ha^{-1})			
			N	P	K	S	N	P	K	S
T_1	1301.51	3109.98	42.10	16.26	37.66	9.28	233.41	14.03	221.58	12.57
T_2	2009.19	3910.15	57.66	17.13	48.10	12.11	267.28	17.12	262.01	14.73
T_3	2044.31	3947.19	60.66	17.46	45.40	12.59	268.68	16.84	255.65	15.06
T_4	2049.70	4210.87	63.73	18.20	46.43	13.30	280.34	16.70	264.07	14.93
T_5	2075.21	4188.94	66.60	18.06	49.50	13.46	285.32	17.74	262.37	15.46
T_6	2245.95	4679.31	67.50	19.40	48.40	13.32	286.65	19.06	258.66	15.63
T_7	2306.23	4724.94	66.40	19.23	48.23	13.42	284.34	19.60	263.20	15.83
T_8	2517.82	4957.39	71.33	21.13	47.43	17.35	292.72	19.98	273.25	24.06
T_9	2540.10	4902.34	70.80	21.63	48.40	18.28	288.09	19.80	267.36	24.03
T_{10}	2873.77	5324.41	71.66	22.30	49.76	18.37	277.36	18.32	263.12	24.56
T_{11}	2963.60	5414.43	71.80	22.53	51.33	18.48	278.09	18.02	266.65	25.33
SEd	52.70	67.10	3.13	0.90	1.22	0.45	8.50	0.97	5.37	0.80
CD (p=0.05)	109.93	139.98	6.55	1.89	2.56	0.94	17.73	2.04	11.21	1.69

Nutrient uptake

Application of VAM, Sulphur and boron had a remarkable effect on the uptake of N, P, K and S on the transplanted ragi. Among the various treatments imposed on study, application of RDF (60:30:30 kgs of NPK ha^{-1}) + vermicompost @ 3 t ha^{-1} + seed treatment with *Azospirillum* @ 600 g ha^{-1} + inoculation of VAM @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum + foliar spray of borax @ 0.5% twice at 30 and 45 DAT (T_{11}) registered the maximum values for N (71.80 kg ha^{-1}), P (22.53 kg ha^{-1}), K (51.33kg ha^{-1}) and S (18.48kg ha^{-1}) uptake of ragi. The association of mycorrhizal fungal with the roots of crops explores the extracellular hyphae beyond the root hairs, thereby increases the nutrient uptake of crops by increasing the nutrient absorptive system surface area of roots [10-11]. Higher root colonization of mycorrhizal fungi might have increased the phosphatase activity of soil. These phosphatase enzymes mineralize the soil bound P into soluble form and make it easily available to the plants [12]. Application of Sulphur to the crop has resulted in the profuse vegetative and root growth, that might have increased the absorption of Sulphur and other nutrients from the soil, which further have led to the increased dry matter production due to its direct involvement in cell division, cell elongation and cell enlargement [13-14]. The minimum N, P, K and S uptake were recorded under the control treatment (T_1). This might be due to the lack of soil organic matter as it received only the recommended dose of chemical fertilizer [15-16].

Post-harvest soil available nutrient

Post-harvest available soil N, P, K and S were greatly influenced by the application of VAM, Sulphur and boron to the transplanted ragi. Among the various treatments tried, application of farm yard manure @ 12.5 t ha^{-1} + seed treatment with *Azospirillum* @ 600 g ha^{-1} + inoculation of VAM @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum (T_8) registered the maximum available soil N (292.72 kg ha^{-1}), P (19.98 kg ha^{-1}) and K (273.25kg ha^{-1}), while the available soil S (24.06kg ha^{-1}) was highest in application of vermicompost @ 3 t ha^{-1} + seed treatment with *Azospirillum* @ 600 g ha^{-1} + inoculation of VAM @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum + foliar spray of borax @ 0.5% twice at 30 and 45 DAT (T_{11}). This might be due to the improved physiochemical properties of soil due to the amelioration and synergistic effect of Sulphur with other nutrients in the soil [17]. The higher amount of available Sulphur in the treatment T_{11} might be due the application of Sulphur to the soil through gypsum which are not taken up by plants. It was followed by application RDF (60:30:30 kgs of NPK ha^{-1}) + vermicompost @ 3 t ha^{-1} + seed treatment with Azospirillum @ 600 g ha^{-1} + Sulphur @ 40kg ha^{-1} through gypsum (T_9). The post-harvest available soil N, P, K and S were minimum under the control treatment (T_1) [18].

CONCLUSION

From the findings of the present study, it can be concluded that application of vermicompost @ 3 t ha^{-1} + seed treatment with *Azospirillum* @ 600 g ha^{-1} + inoculation of Vesicular Arbuscular Mycorrhizae (VAM) @ 12 kg ha^{-1} + Sulphur @ 40 kg ha^{-1} through gypsum + foliar spray of borax @ 0.5% twice at 30 and 45 DAT is an efficient technology to increase the yield and nutrient uptake of the ragi.

LITERATURE CITED

1. Anonymous. 2009. Results of front-line demonstrations (2000-2007) and technologies for increasing small millet production in India, Project coordinating unit (small millets), ICAR, Bangalore.
2. Johansson J, Paul L, Finlay RD. 2004. Microbial interactions in the mycorhizosphere and their significance for sustainable agriculture. *Microbial. Ecology* 18: 1-13.
3. Aggarwal A, Kadian N, Tanwar A, Yadav A, Gupta KK. 2011. Role of Arbuscular Mycorrhizal Fungi (AMF) in global sustainable development. *Journal of Applied and Natural Science* 3(2): 340-351.
4. Vishwanath H, Pujari BT, Prakash SS, Babu R, Deshmanya JB. 2006. Growth attributes, dry matter production and its portioning and nutrient uptake studies in spineless safflower (*Carthamus tinctorius* L.) var, NARI-6 as influenced by nitrogen and sulphur levels. *Karnataka Jr. Agric. Sciences* 19(4): 913-917.
5. Bolanos L, Lukaszewski K, Bonilla I, Blevins D. 2004. Why boron? *Plant Physiology and Biochemistry* 42(11): 907-912.
6. Rahman MN, Islam MB, Sayem SM, Rahman MA, Masud MM. 2007. Effect of different rates of Sulphur on the yield and yield attributes of rice in old Brahmaputra floodplain soil. *Jr. Soil Nature* 1(1): 22-26.
7. Rehman A, Farooq M, Ata Cheema Z, Nawaz A, Wahid A. 2014. Foliage applied boron improves the panicle fertility, yield and biofortification of fine grain aromatic rice. *Journal of Soil Science and Plant Nutrition* 14(3): 723-733.
8. Shankar MA, Thimmegowda MN, Bhavitha NC, Manjunatha BN. 2018. Yield and economics of finger millet and redgram rotation as influenced by zinc, boron and biofertilizer nutrition. *Mysore Jr. Agric. Sciences* 52(1): 43-48.
9. Prashantha GM, Prakash S, Umesha S, Chikkaramappa T, Subbarayappa CT, Ramamurthy V. 2019. Direct and residual effect of zinc and boron on yield and yield attributes of finger millet–groundnut cropping system. *Int. Jr. Pure Applied Biosciences* 7(1): 124-134.
10. Marulanda A, Barea JM, Azcon R. 2006. An indigenous drought tolerant strain of *Glomus intraradices* associated with a native bacterium improves water transport and root development in Retama sphaerocarpa. *Microb. Ecology* 52: 670-678.
11. Fahramand M, Adibian M, Sobhkhizi A, Noori M, Moradi H, Rigi K. 2014. Effect of arbuscular mycorrhiza fungi in agronomy. *Jr. Nov. Appl. Science* 3(4): 400-404.
12. Banerjee P, Sagar Maitra S. 2020. The role of small millets as functional food to combat malnutrition in developing countries. *Indian Journal of Natural Sciences* 10(60): 20412-20417.
13. Patel GN, Patel PH, Patel RM. 2009. Irrigation and sulphur management in summer groundnut (*Arachis hypogaea* L.) under North Gujarat conditions. *Jr. Oil Seeds Research* 25(1): 35-37.
14. Rajput RK, Singh S, Varma J, Rajput P, Singh M, Nath S. 2018. Effect of different levels of nitrogen and Sulphur on growth and yield of Indian mustard (*Brassica juncea* (L.) *Czern and Coss.*) in salt affected soil. *Journal of Pharmacognosy and Phytochemitry* 7(1): 1053-1055.
15. Sandhya Rani Y, Triveni U, Patro TS, Patro SK, Anuradha N. 2017. Revisiting of fertilizer doses in finger millet [*Eleusine coracana* (L.) *Garten*.] through targeted yield and soil test crop response (STCR) approach. *Int. Jr. Curr. Microbiol. App. Science* 6(7): 2211-2221.
16. Harika JV, Maitra S, Shankar T, Bera M, Manasa P. 2019. Effect of integrated nutrient management on productivity, nutrient uptake and economics of Finger millet (*Eleusine coracana* L. *Gaertn*). *International Journal of Agriculture, Environment and Biotechnology* 12(3): 273-279.
17. Sahoo I, Satish P, Hussain SA, Kumar SH. 2020. Growth, yield attributes and yield of foxtail millet as influenced by varieties and integrated nutrient management. *Journal of Pharmacognosy and Phytochemistry* 9(4): 3426-3429.
18. Roy AK, Ali N, Lakra RK, Alam P, Mahapatra P, Narayan R. 2018. Effect of integrated nutrient management practices on nutrient uptake, yield of finger millet (*Eleusine coracana* L. *Gaertn*) and post-harvest nutrient availability under rainfed condition of Jharkhand. *International Journal of Current Microbiology and Applied Sciences* 7(8): 339-347.