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Effect of NPK and Foliar Application of Micronutrients with Growth Regulators on the Yield Performance of Ragi Cv. Co 13

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ABSTRACT

In order to establish the effect of NPK and foliar application of micronutrients with growth regulators on the performance of ragi, a field experiment during January-April 2019. The experimental soil (Typic haplustalf) was clay loam in texture, neutral in reaction (pH 7.4), medium in organic carbon (6.5 g kg^{-1}), low in available N (272 kg ha^{-1}), high in available P (24 kg ha^{-1}) and medium in available K (176 kg ha^{-1}). The DTPA extractable Zn, Fe, Mn, Cu, are 0.7, 11.5, 7.8, 0.6 mg kg^{-1} respectively. The soil analysed the hot water-soluble B of 0.4 mg kg^{-1}, Ammonium oxalate extractable Mo of 0.2 mg kg^{-1} and ammonium acetate buffer extractable Si of 0.4 mg kg^{-1}. The experiment was laid out in a factorial randomized block design with two levels of NPK viz., L_1-100 % (60: 30: 30 kg NPK ha^{-1}) and L_2-150% (90: 45: 45 kg NPK ha^{-1}) and eight treatment combination of micronutrients and growth regulators were applied as foliar spray. The eight treatments are T_1- Water spray, T_2- Micronutrients spray, T_3- Micronutrients + Humic acid (0.3 %), T_4- Micronutrients + Ascorbic acid (200 ppm), T_5- Micronutrients + Salicylic acid (200 ppm), T_6- Micronutrients + Humic acid (0.3 %) + Ascorbic acid (200 ppm), T_7- Micronutrients + Humic acid (0.3 %) + Salicylic acid (200 ppm) and T_8- Micronutrients + Humic acid (0.3 %) + Ascorbic acid (200 ppm) + Salicylic acid (200 ppm) and each treatment was replicated three times. Ragi cv. CO 13 was grown as a test crop. The results of the field experiment revealed that application of 150% NPK and foliar feeding of micronutrients with humic acid, ascorbic acid and salicylic acid (L_2T_8) registered the highest value in respect of growth characters (plant height, leaf area, and number of tillers per plant) and yield parameters (number of ears per plant, ear length, finger numbers ear head and thousand grain weight) of ragi. Foliar application of micronutrients with humic acid, ascorbic acid and salicylic acid to 100% NPK applied plants was identified as the next best treatment in respect of growth and yield of ragi. Application 150% NPK + foliar fertilization of micronutrients enriched with humic acid, ascorbic acid and salicylic acid recorded the highest grain and straw yield of 3051.1 and 5190.6 kg ha^{-1}.

Key words: *Elusine coracana*, Micronutrients, Growth regulators, Yield performance, NPK

Ragi (*Elusine coracana* (L.) Gaertn) is originally native to the Ethiopian highlands and was introduced into India, approximately 4000 year ago. Ragi has high yield potential. It is rich in protein and calories and is a dependable stable food of extremely poor and tribal populations. It is the most important small millet of the tropics (12% of global millet area) cultivated in 25 countries of Asia and Africa predominantly as a staple food grain. The ability of finger millet to tolerate drought and survive in infertile soils coupled with its high nutritional value has made this crop an integral part of farmers risk avoidance strategies as well as various health foods [1]. Ragi flour contains 9 per cent protein and is a good source of dietary calcium (450 mg), Its carbohydrates comprised of free sugars (2%), starch (77.5%) and non-starchy polysaccharides (NSP-20.5%). NSP largely consists of cellulose, hemicelluloses and pectinous material forming a major component of its dietary fiber. Cultivation of ragi in nutrient impoverished soil and inadequate supply of nutrients results in poor harvest. To improve the productivity and to realize maximum profit, application of chemical fertilizers need to be supplemented with micronutrients. Application of micronutrients not only cure the nutritional disorder in plant but are also known to improve the yield and quality [2]. The inherent low availability of micronutrients coupled with fast depletion due to the cultivation of high yielding varieties, results in deficiency of micronutrients. Therefore, supplementation of micronutrient either as foliar spray or soil application with NPK is an imperative need for better growth and yield of the crop.

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Humic acid, an important constituent of organic matter has been reported to influence the availability of nutrients in soil and play a vital role on the growth and yield of crops due to its hormone like activity. Moreover, it is also known to promote the yield of the crop by providing an efficient supply of nutrients in the soil through chelation and complex action. Ascorbic acid (vitamin C) is an abundant component of plants. It has proposed functions in photosynthesis as an enzyme cofactor (including synthesis of ethylene, gibberellins and anthocyanins) and in control of cell growth. Exogenous application of ascorbic acid ameliorates adverse effects of drought [3].

Salicylic acid (SA) is a naturally occurring signalling molecule and growth regulator that enhances plant growth particularly in abiotic stress conditions. It reduced the Na uptake of plants and/or increased the uptake of N, P, K, Ca, Mg and the other minerals under salt stress [4]. Therefore, a field experiment was conducted to establish the effect of NPK and foliar application of micronutrients along with humic acid, ascorbic acid and salicylic acid on the yield performance of ragi.

MATERIALS AND METHODS

A field experiment was conducted at Pulikarai village, located at the outskirt of Dharmapuri in Dharmapuri district, Tamil Nadu, India, the experimental site was located between latitudes N 11° 47′ and 12° 33′ longitudes E 77° 02′ and 78° 40′. The weather during the experimental period is generally warm condition, during summer period (March, April, May and June) the temperature reaches maximum of up to 38°C. The average mean annual temperature is 26.8°C with the mean relative humidity of 42 to 45 percent. The mean annual rainfall is 895.56 mm. The experiment was conducted during January-April 2019, using ragi cv. CO 13 as a test crop. The experimental soil (Typic haplustalf) was clay loam in texture, neutral in reaction (pH 7.4), medium in organic carbon (6.5 g kg^{-1}), low in available N (272 kg ha^{-1}), high in available P (24 kg ha^{-1}) and medium in available K (176 kg ha^{-1}). The DTPA extractable Zn, Fe, Mn, Cu, are 0.7, 11.5, 7.8, 0.6 mg kg^{-1} respectively. The soil analysed the hot water-soluble B of 0.4 mg kg^{-1}, Ammonium oxalate extractable Mo of 0.2 mg kg^{-1} and ammonium acetate buffer extractable Si of 0.4 mg kg^{-1}. The experiment was laid out in a factorial randomized block design with two levels of NPK viz., L_1-100% (60: 30: 30 kg NPK ha^{-1}) and L_2- 150% (90: 45: 45 kg NPK ha^{-1}) and eight treatment combination of micronutrients and growth regulators and were applied as foliar spray. The eight treatments are T_1- Water spray, T_2- Micronutrients spray, T_3- Micronutrients + Humic acid (0.3%), T_4- Micronutrients + Ascorbic acid (200 ppm), T_5- Micronutrients + Salicylic acid (200 ppm), T_6- Micronutrients + Humic acid (0.3%) + Ascorbic acid (200 ppm), T_7- Micronutrients + Humic acid (0.3%) + Salicylic acid (200 ppm) and T_8- Micronutrients + Humic acid (0.3%) + Ascorbic acid (200 ppm) + Salicylic acid (200 ppm) and each treatment was replicated three times. Calculated quantity of NPK was applied through urea, single super phosphate and muriate of potash. Half dose of N and full dose of P and K were applied basally and the remaining 50% of N was applied as top dressing on 25 DAT. Ragi cv. CO 13 was grown as a test crop. Ragi seedlings raised in the nursery was transplanted to main field on 21 DAS with 30 cm × 10 cm spacing. Foliar application of micronutrients and growth regulators were done twice, first spray at 25 DAT and second spray at 50 DAT (at flowering stage). The micronutrient mixture used in the study was prepared by mixing micronutrient compounds in water to obtain final concentration of $ZnSO_4$ @ 0.5%, $CuSO_4$ @ 0.1%, H_3BO_3 @ 0.1%, $(NH_4)_6Mo_7O_{24}$ @ 0.01% and Na_2SiO_3 @ 0.05% in spray fluid. Humic acid (HA) used in the study was extracted from lignite using 0.5 N NaOH and applied at 0.3% concentration. The laboratory grade ascorbic acid (AA) and salicylic acid (SA) are applied to the crop @ 200 ppm each. Proper cultural practices were followed and the crop was harvested at maturity. The growth and yield parameters were recorded at appropriate stages crop growth.

RESULTS AND DISCUSSION

The results of the field experiment revealed that among the treatments L_2T_8 recorded the tallest plant with the height of 73.8 cm on 60 DAT. This was followed by the treatments L_1T_8, L_2T_7 and L_1T_7. The treatments L_1T_7 and L_2T_6 as well as L_1T_5 and L_2T_4 were found to be on par with each other in respect of plant height. The improvement in plant height due to foliar application of micronutrients with growth regulators to both 100% NPK and 150% NPK applied plants might be attributed to proper nourishment of crop for optimum growth. Application of micronutrients along with NPK increased cell division and cell elongation [5]. The humic acid extracted from different lignite act as growth regulators in the plant system by retarding the activity of IAA oxidase enzyme. Therefore, the persistence of IAA in the plant system increased the cell division and cell enlargement which led to increased plant height [6]. The activity of ascorbic acid in cell division and cell elongation [7] also has contributed to the increased plant height. Similarly salicylic acid also plays an important role in improving mitosis and cell elongation [8].

Among the treatments L_2T_8 recorded the highest leaf area of 1057.0 cm^2 on 60 DAT. This was followed by the treatments L_1T_8, L_2T_7 and L_1T_7. The treatment L_1T_7 and L_2T_6 were found to be on par with each other with regard to leaf area.

Balanced supply of both macro and micronutrients could have increased the cell division and cell enlargement and produced broader leaves. Production of higher leaf area enhances the harvesting of solar radiation which results in higher photosynthesis and effective utilization of applied resources.

Among the treatments L_2T_8 recorded the highest tiller numbers of 6.4 on 60 DAT. Based on number of tillers $plant^{-1}$ the treatments are arranged in descending order as L_1T_8> L_2T7> L_1T_7> L_2T_6> L_1T_6> L_2T_3> L_1T_3> L_2T_5> L_1T_5> L_2T_4> $L_1T_4L_2$>L_1T_2 >L_2T_1. The treatments pair L_1T_7 and L_2T_6 as well as $L_1T_5$and L_2T_4were found to be on par with each other on 60 DAT in respect of tiller numbers $plant^{-1}$. The increased tiller production with increased fertilizer may be related to the extra nutrients provided by increased dose of NPK for the growth of tiller primordia. Higher uptake and recovery of nutrients from the applied nutrients resulted in higher tillering ability of the crop plants [9].

Yield parameters

The main yield attributes in finger millet are number of fingers ear $head^{-1}$, number of ears $plant^{-1}$, ear head length and 1000-grain weight. The difference in the performance of yield attributes in various treatments could be due to variation in translocation of photosynthates from vegetative to reproductive parts. Higher production of photosynthates due to sufficient assimilatory area of vigorous plants would have synthesized more carbohydrates and translocated to the reproductive parts such as developing ears, which resulted in better filling and more grain weight and increased yield components [10]. In the present study, significantly higher number of fingers ear head^{-1} (8.6), 1000 grain weight (3.72 g), number of ears (5.9) and ear head length (10.9 cm) was registered with application of 150% recommended dose of NPK fertilizers + foliar application micronutrients along with humic acid, ascorbic acid and salicylic acid (L_2T_8). This was closely followed by application of 100% recommended dose of NPK fertilizers + foliar application of micronutrients with humic acid, ascorbic acid and salicylic acid (L_1T_8), which recorded finger numbers ear head^{-1} of 8.1, 1000 grain weight of 3.56 g, number of ears of 5.6 plant^{-1} and ear head length of 10.2 cm. Application of increased dose of NPK and foliar fertilization of micronutrients with growth regulators could have helped for the production of more number of productive tillers plant^{-1} and number of fingers ear head^{-1} and ear head length [11-13].

Table 1 Effect of NPK and foliar application of micronutrients with growth regulators on plant height (cm), leaf area (cm^2) and number of tillers hill^{-1} of ragi

Levels of NPK / Treatments	Plant height (cm)			leaf area (cm^2)			No of tillers hill^{-1}		
	L_1-100% NPK	L_2-150% NPK	Mean	L_1-100% NPK	L_2-150% NPK	Mean	L_1-100% NPK	L_2-150% NPK	Mean
T_1	29.6	30.5	30.0	672.2	704.3	688.2	1.9	2.0	1.9
T_2	33.9	37.3	35.6	732.6	758.9	745.7	2.2	2.3	2.2
T_3	52.4	55.8	54.1	882.5	907.7	895.1	3.8	4.2	4.0
T_4	40.8	44.2	42.5	785.3	808.6	796.9	2.4	2.8	2.6
T_5	45.3	48.9	47.1	831.4	856.8	844.1	3.0	3.4	3.2
T_6	59.2	62.6	60.9	931.1	959.4	945.2	4.7	5.1	4.9
T_7	63.7	67.1	65.4	979.6	1009.5	994.5	5.3	5.7	5.5
T_8	70.5	73.8	72.1	1032.7	1057.0	1044.8	6.1	6.4	6.2
Mean	49.4	52.5	50.9	855.9	882.7	869.3	3.6	3.9	3.8
	SEd	CD(p=0.05)		SEd	CD(p=0.05)		SEd	CD(p=0.05)	
For NPK	0.55	1.13		3.95	8.08		0.05	0.10	
For Treatment	1.10	2.27		7.91	16.16		0.10	0.21	
NPK × Treatment	1.16	3.21		11.19	22.86		0.14	0.30	

Table 2 Effect of NPK and foliar application of micronutrients with growth regulators on the number of ear head per hill, Ear head length and number of fingers per ear head of ragi

Levels of NPK / Treatments	No. of ear head per hill			Ear head length(cm)			No. of fingers per ear head		
	L_1-100% NPK	L_2-150% NPK	Mean	L_1-100% NPK	L_2-150% NPK	Mean	L_1-100% NPK	L_2-150% NPK	Mean
T_1	2.0	2.2	2.1	4.1	4.7	4.4	4.2	4.3	4.2
T_2	2.3	2.5	2.4	5.2	5.6	5.4	4.4	4.5	4.4
T_3	3.8	4.1	3.9	7.8	8.0	7.9	5.4	5.9	5.6
T_4	2.6	2.9	2.7	6.1	6.6	6.3	4.7	4.9	4.8
T_5	3.0	3.4	3.2	6.8	7.3	7.0	5.1	5.2	5.1
T_6	4.5	4.9	4.7	8.5	9.0	8.7	6.4	6.9	6.6
T_7	5.0	5.3	5.1	9.2	9.7	9.4	7.1	7.6	7.3
T_8	5.6	5.9	5.7	10.2	10.9	10.5	8.1	8.6	8.3
Mean	3.6	3.9	3.7	7.2	7.7	7.4	5.6	5.9	5.8
	SEd	CD(p=0.05)		SEd	CD(p=0.05)		SEd	CD(p=0.05)	
For NPK	0.48	0.98		0.07	0.15		0.07	0.14	
For Treatment	0.96	1.97		0.15	0.31		0.14	0.29	
NPK × Treatment	0.13	0.28		0.20	0.45		0.19	0.41	

Adequate supply of macro and micronutrients to the crop from applied NPK fertilizers + foliar fertilization with micronutrients along with humic acid, ascorbic acid and salicylic acid could have increased the photosynthetic activity of plant and helped to develop extensive root system. This would have helped the plant to extract more nutrients from soil resulting in better development of yield components [14].

Yield

The grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depends upon the efficient photosynthetic structure as well as the extent of translocation into sink (grains) and also on plant growth and development during early stages of crop growth. The production and translocation of synthesized photosynthates depends upon mineral nutrition supplied either by soil or through foliar application. Most of the photosynthetic pathways are dependent on enzymes and coenzymes which are synthesized with adequate supply of mineral elements such as nitrogen, phosphorus, potassium and trace elements.

Application of 150% recommended dose of NPK fertilizers and foliar spray of micronutrients along with humic acid, ascorbic acid and salicylic acid (L_2T_8) recorded the highest grain yield of 3051.8 kg ha^{-1}as compared to other treatments. Increased grain yield in treatment L_2T_8 might be due to the fact that the crop has not experienced any nutrient stress at any growth stage because of micronutrient foliar spray. The improved vegetative growth and growth parameters such as number of productive tillers and number of fingers open head resulted in good grain yield [15]. Further, foliar fertilization of Zn, B, Cu, Mo and Si to plants might have stimulated metabolic and enzymatic activities which resulted in improved growth and more grain yield.

Table 3 Effect of NPK and foliar application of micronutrients with growth regulators on grain yield, straw yield and 1000 grain weight of ragi

Treatments \ Levels of NPK	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			1000 grain weight		
	L_1-100% NPK	L_2-150% NPK	Mean	L_1-100% NPK	L_2-150% NPK	Mean	L_1-100% NPK	L_2-150% NPK	Mean
T_1	2180.7	2208.5	2194.6	2825.1	2987.0	2906.0	2.40	2.44	2.42
T_2	2305.2	2317.9	2311.5	3158.7	3337.9	3248.3	2.46	2.49	2.47
T_3	2421.7	2435.3	2428.5	3998.2	4153.7	4075.9	2.68	2.75	2.71
T_4	2338.0	2376.2	2357.1	3471.2	3651.2	3561.2	2.50	2.53	2.51
T_5	2408.1	2415.7	2411.9	3777.9	3817.5	3797.7	2.55	2.58	2.56
T_6	2458.9	2607.3	2533.1	4251.5	4413.9	4332.7	2.81	2.93	2.87
T_7	2674.8	2745.1	2709.9	4442.2	4691.6	4566.9	3.05	3.31	3.18
T_8	2898.3	3051.8	2975.0	4940.8	5190.6	5065.7	3.56	3.72	3.64
Mean	2460.7	2519.7	2490.2	3858.2	4030.4	3944.3	2.75	2.84	2.79
	SEd	CD(p=0.05)		SEd	CD(p=0.05)		SEd	CD(p=0.05)	
For NPK	23.8	49.0		43.13	88.85		0.03	0.06	
For Treatment	47.6	97.4		86.2	177.7		0.06	0.13	
NPK × Treatment	66.8	137.3		120.8	248.9		0.09	NS	

Straw yield of ragi was also significantly influenced by different treatments as that of grain yield. Among the different treatments, L_2T_8 produced the highest straw yield of 5190.6 kg ha^{-1}. The increase in straw yield of ragi might be due to application of increased levels of NPK from 100% to 150% as well as foliar application of micronutrients along with growth regulators. The increase in straw yield may be due to increase in vegetative growth as evident from higher plant height, leaf area and increased number of tillers. The higher straw yield under these treatments was mainly as a result of higher nutrient supply, and foliar application of micronutrients with growth regulators helped the crop to use optimum level of nutrients.

CONCLUSION

The increased dose of NPK to tune of 50% along with foliar application of micronutrients, humic acid and ascorbic acid could be recommended to realize the higher yield in ragi in nutrient impoverished soil.

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