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EFFECT OF BLENDED NUTRIENT MIXTURES ON GROWTH, YIELD AND QUALITY OF FINGER MILLET (*ELEUSINE CORACANA* (L.) GAERTN.)

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ABSTRACT

A pot culture experiments was conducted during *Kharif* season of 2023-24 at Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru to evaluate the effect of blended nutrient mixtures on growth, yield and quality of finger millet (*Eleusine coracana* (L.) Gaertn.). The experiments were laid out completely randomised design (CRD) with ten treatments. The treatments comprised of NPK (75%), NPK (100%), NPK (125%), NPK (150%), NPKZnB (75%), NPKZnB (100%), NPKZnB (125%) & NPKZnB (150%), absolute control and blanket recommendation. Application of NPKZnB (150%) recorded of higher plant height (101.5 cm), number of leaves (48 plant^{-1}), number of tillers (14 hill^{-1}), leaf area (1193.41 cm^2), chlorophyll content (38.9), dry matter production (19.2 g plant^{-1}), number of ears (14 hill^{-1}), ear length (9.2 cm), number fingers (7 per ear), 1000 grain weight (3.50 g), grain yield (2391.4 kg ha^{-1}), straw yield (4601.05 kg ha^{-1}) and harvest index (34%). With respect to quality parameters higher protein (9.27%), carbohydrate (78.18%), calcium (0.72 mg kg^{-1}) and zinc (38.22 mg kg^{-1}) were recorded in treatment receiving NPKZnB (150%) dose in pot culture experiment at harvest stage.

***Key words*:** Nutrient mixtures, Fertilizers, Dry matter production. Yield, Harvest index.

Introduction

Finger millet (*Eleusine coracana* L.) is a highly nutritious millet crop grown mainly in dry regions, where it serves as an important food source. However, its production often suffers due to poor soil fertility and improper fertilizer use. While farmers typically apply only nitrogen (N), phosphorus (P) and potassium (K), soils in these areas are increasingly deficient in other essential nutrients like calcium, sulphur, zinc and boron. To solve this problem, customized fertilizers, specially blended nutrient mixture have been developed to provide balanced nutrition tailored to the crop's needs and local soil conditions.

These smart fertilizers combine all required nutrients in precise ratios, ensuring better plant uptake and growth. Studies show they improve yields more effectively than traditional NPK fertilizers while also enhancing long-term soil health (Anju *et al.*, 2020; Singh *et al.*, 2014). In India, the government has approved 36 such customized blends under the Fertilizer Control Order (FCO), recognizing their importance for sustainable farming.

This research tested customized fertilizers on finger millet (variety ML-365) in a controlled pot experiment. The goal was to determine their impact on crop growth and yield, compared to conventional methods. Results could help farmers adopt more efficient and eco-friendly fertilization practices, boosting millet production while protecting soil quality for future harvests. By using the

right nutrient mix, finger millet cultivation can become more productive, profitable and sustainable especially in nutrient-poor soils.

Materials and Methods

Experimental soil

The soil sample used for this study was air-dried, crushed using a wooden mallet and sieved through a 2 mm sieve for the pot culture experiment. Particle size distribution was determined using the International Pipette Method (Piper, 1966), while bulk density, particle density and pore space were measured using the cylinder method (Gupta and Dakshinamoorthy, 1980).

Soil pH and electrical conductivity (EC) were determined using a 1:2.5 soil-water extract (Jackson, 1973) and the cation exchange capacity (CEC) was measured using the neutral normal ammonium acetate method (Jackson, 1973).

Organic carbon content was estimated using the chromic acid wet digestion method (Walkley and Black, 1934). Available nitrogen (N) was determined by the alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus (P) using 0.5 *M* NaHCO*f* extraction (Olsen *et al.*, 1954) and available potassium (K) using the neutral normal NH,, OAc method (Stanford and English, 1949), followed by flame photometry. Available calcium (Ca) and magnesium (Mg) were analyzed through EDTA complexometric titration (Jackson, 1973), while available sulphur (S) was measured using the CaCl, extractant method and turbidometry (Black, 1965).

Micronutrients were extracted using the DTPA method and analyzed via atomic absorption spectrometry (AAS) (Lindsay and Norvell, 1978), while available boron (B) was determined using the Azomethane-H method (Berger and Truog, 1939). Statistical analysis of the data was performed using Microsoft Excel (Microsoft Corporation, USA) and the AGRES statistical software package, version 7.0.

Pot culture Experiment, Design and Methodology

Two blended nutrient mixtures i.e. N P K (without micronutrients) and N P K Zn B (with micronutrients) were prepared by following fertilizer compatible chart. Individual fertilizers were bulk blended of and pulverised, finally the mixtures are adjusted to 50:40:37.5:12.5:10 N: P_2O_5:K_2O: Zn: Borax kg ha^{-1} (RDF for Finger millet). Later 4 different levels (75%, 100%, 125% & 150%) are made for both blended nutrient mixtures (N P K & N P K Zn B).

The pot culture experiment was conducted during the *Kharif* (Rainy) season of 2023-24 at the All India Coordinated Research Project for Dryland Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India. The experimental site is located in the Eastern Dry Zone (Zone 5) of Karnataka, at 12° 51'N latitude, 77° 35'E longitude, and an altitude of 930 m above mean sea level (MSL).

The experiment comprised ten treatments and was laid out in a completely randomized design (CRD) with three replications. The study was conducted in plastic pots with a 15 kg capacity volume and a height of 55 cm. The same treatment combinations used in the experiment were follows: T_1: Absolute control ($N_0P_0K_0$), T_2: 100% NPK (RDF), T_3: NPK (75%), T_4: NPK (100%), T_5: NPK (125%), T_6: NPK (150%), T_7: NPKZnB (75%), $T_{8:}$ NPKZnB (100%), $T_{9:}$ NPKZnB (125%) and T_{10}: NPKZnB (150%). A total of 10 kg of experimental soil was thoroughly mixed with farmyard manure (FYM) before being filled into pots up to three-fourths (¾) of their capacity. A uniform dose of 50:40:37.5:12.5:10 kg ha^{-1} (N: P, O… : K, O: Zn: Borax) was applied through blended nutrient mixtures as a fertilizer solution while sowing, following the treatment schedule. Seeds of finger millet variety ML-365 were treated with *Trichoderma viride* at 4 g kg^{-1} to control seed-borne diseases. After 24 hours, the seeds were further treated with *Pseudomonas* at 10 g kg^{-1} and subsequently shade-dried. In each pot, five seeds were sown, followed by irrigation as per crop requirements. Weeding and plant protection measures were undertaken as needed to manage pests and diseases.

In each pot, growth attributes *viz.*, plant height, number of leaves, number of tillers, leaf area, chlorophyll content and dry matter production, were recorded. For dry matter production, plants were uprooted, air dried and then oven dried at 60°C till a constant weight is obtained. The weight was recorded using an electrical top pan balance and dry matter was expressed in grams per plant. Yield attributes *viz,* number of ears, ear length, number fingers and 1000 grain weight. Seed yield and straw yield were recorded at harvest stage and expressed in kg ha^{-1}. Harvest index was calculated by using the following formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Grain quality

Crude protein content (g $100g^{-1}$) was derived by multiplying the nitrogen percentage (obtained via standard methods) by the conversion factor 6.25 (A.O.A.C., 1965). These standardized analytical methods ensured precise assessment of grain quality parameters in the study.

Table 1: Initial characters of experimental soil.

Particulars	Value Obtained	Method	References
Mechanical analysis			
Coarse sand (%)	36.35	International Pipette Method	Piper (1966)
Fine sand (%)	26.80		
Silt (%)	5.60		
Clay (%)	31.25		
Texture	Sandy clay loam		
Bulk density (Mg m^{-3})	1.42	Cylinder method	Gupta and Dakshinamoorthy, (1980)
Particle density (Mg m^{-3})cv	2.56		
Pore space (%)	44.53		
OC (%)	0.43	Chromic acid we digestion method	Walkey and Black (1934)
pH	6.64	Potentiometry	Jackson (1973)
EC (dS m^{-1})	0.09	Conductometry	Jackson (1973)
Available N (kg ha^{-1})	216.04	Alkaline permanganate method	Subbiah and Asija (1956)
Available P, O… (kg ha^{-1})	21.39	Olsen extractant method, Spectrophotometry	Jackson (1973)
Available K, O (kg ha^{-1})	115.38	NH_4 OAC extractant method, Flame photometry	Jackson (1973)
Exch. Ca (cmol (pz) kg^{-1})	1.2	NH_4 OAC extractant method, Versenate titrimetry	Jackson (1973)
Exch. Mg (cmol (pz) kg^{-1})	0.8	NH_4 OAC extractant method, Versenate titrimetry	Jackson (1973)
Available S (mg kg^{-1})	14	$CaCl_2$ extractant method, Turbidimetry	Black (1965)
DTPA Fe (mg kg^{-1})	4.97	Atomic absorption spectrophotometry	Lindsay and Norwell (1978)
DTPA Mn (mg kg^{-1})	5.16	Atomic absorption spectrophotometry	Lindsay and Norwell (1978)
DTPA Cu (mg kg^{-1})	0.40	Atomic absorption spectrophotometry	Lindsay and Norwell (1978)
DTPA Zn (mg kg^{-1})	0.39	Atomic absorption spectrophotometry	Lindsay and Norwell (1978)
Hot water soluble B (mg kg^{-1})	0.37	Azomethane-H method	Berger and Truog (1939)

Carbohydrate (CHO) content was calculated by using the following formula and expressed in percentage (Igbabul *et al.*, 2014) *i.e.* CHO (g $100g^{-1}$) = 100 - [Crud protein + Crude fat + Crude fibre + Ash + moisture]. Calcium and Zinc in grain were estimated by Diacid - digestion followed by EDTA - complexometric titration and DAPA – Atomic absorption spectrophotometer methods respectively.

Result and Discussion

Initial characteristics of the experimental soil

Mechanical composition of experimental soil indicated in Table 1. Soil contained 36.35 percent coarse sand, 26.80 percent fine sand, 5.60 percent silt and 31.25 percent clay and it belonged to Sandy clay loam texture. The pore space percentage was found to be 44.53. Bulk density and particle density of the soil were 1.42 Mg m^{-3} and 2.56 Mg m^{-3} respectively.

The soil was slightly acidic in reaction with pH of 6.64 and electrical conductivity of 0.09 (dS m^{-1}). The organic carbon content of the soil was 0.43 percent and the CEC was found to be 22.50 c mol (p^+) kg^{-1} of soil. The soil was low in alkaline $KMnO_4$- N (216.04 kg ha^{-1}), medium in Olsen- P (21.39 kg ha^{-1}) and medium in NH_4OAC extractable potassium (115.38 kg ha^{-1}). The available S in soil was medium (14 mg kg^{-1}). The micro nutrient contents were as follows: Fe - 4.97 mg kg^{-1}, Zn - 0.39 mg kg^{-1}, Cu - 0.40 mg kg^{-1}, Mn - 5.16 mg kg^{-1} and B - 0.37 mg. kg^{-1}.

Effect of blended nutrient mixtures on growth attributes of finger millet

The application of blended nutrient mixtures significantly affected various growth parameters of finger millet crop (Table 2). Higher plant height (101.5 cm),

Plate 1: Pot culture Experiment

Table 2: Effect of blended nutrient mixtures on growth attributes of finger millet at harvest stage.

Treatments	Plant height (cm)	Number of leaves	Number of tillers (per hill)	Leaf area (cm^2)	Chlorophyll content	Dry matter production (g/plant)
T_1: Absolute control ($N_0P_0K_0$)	55.8	18	3	439.14	18.4	3.7
T_2: 100% NPK (RDF)	87.2	43	10	976.80	29.9	15.0
T_3: NPK (75%)	70.0	40	7	557.03	24.6	10.1
T_4: NPK (100%)	76.4	26	10	689.19	26.9	13.0
T_5: NPK (125%)	87.9	32	11	844.83	32.1	14.7
T_6: NPK (150%)	93.1	41	12	999.22	35.8	16.2
T_7: NPKZnB (75%)	77.5	34	10	727.84	25.4	14.0
T_8: NPKZnB (100%)	89.9	38	11	888.17	29.5	15.7
T_9: NPKZnB (125%)	92.3	42	12	1026.30	36.9	16.5
T_{10}: NPKZnB (150%)	101.5	48	14	1193.41	38.9	19.2
F test	S	S	S	S	S	S
S. Em±	0.96	0.64	0.22	16.68	0.46	0.31
CD at 5 %	2.86	1.91	0.65	49.57	1.35	0.91

number of leaves (48 plant^{-1}), number of tillers (14 hill^{-1}), leaf area (1193.41 cm^2) chlorophyll content (38.9), and dry matter production (19.2 g plant^{-1}) observed by application of NPKZnB (150%) followed by NPKZnB (125%) (T_9) and NPKZnB (100%) (T_8) which were statistically *on par*.

This is due to balanced fertilization which improved the nutrient availability resulting in greater nutrient uptake and also might have increased the higher photosynthesis and better translocation of photosynthates to different parts (Guo *et al.,* 2019). This would have improved significantly the growth attributing parameters. This would have improved significantly higher plant height and higher number of tillers. The product of number of tillers and plant height is taken as an indication of the total dry matter production of plant. This is in accordance with Tekulu, 2019 and Mengistu, 2022 research reports on Maize.

Effect of blended nutrient mixtures on yield attributes of finger millet

Application of NPKZnB (150%) significantly increased both yield attributes, seed yield and straw yield (Table 3). More number of ears (14 hill^{-1}), ear length (9.2 cm), number fingers (7 per ear) and 1000 grain weight (3.50 g). Maximum seed yield (2391.40 kg ha^{-1}), straw yield (4601.05 kg ha^{-1}) and harvest index ((34 %) were recorded by application of NPKZnB (150%) followed NPKZnB (125%) (T_9) and NPKZnB (100%) (T_8) which were statistically *on par* in pot culture experiment at harvest stage.

This could be attributed to the fact that added blended nutrient mixtures contained nutrients *viz.*, N, P, K, Ca, S, Zn and B and these nutrients enhanced the availability of nutrients to plants. This leads to enhanced photosynthetic activity, profuse shoot and root growth, thereby activating

Table 3: Effect of blended nutrient mixtures on yield attributes of finger millet at harvest stage.

Treatments	Number of ears	Ear length (cm)	Number fingers	1000 grain weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1: Absolute control ($N_0P_0K_0$)	3	5.1	5	2.14	615.28	1230.82	0.33
T_2: 100% NPK (RDF)	10	8.2	5	3.03	1968.10	4109.36	0.32
T_3: NPK (75%)	7	7.0	5	2.64	1319.50	3010.01	0.30
T_4: NPK (100%)	10	7.6	5	2.66	2133.60	4211.56	0.34
T_5: NPK (125%)	11	8.2	6	3.11	2199.40	4280.45	0.34
T_6: NPK (150%)	12	8.6	7	3.18	2211.02	4301.94	0.34
T_7: NPKZnB (75%)	10	7.2	6	2.37	1497.30	3610.76	0.29
T_8: NPKZnB (100%)	11	8.0	6	2.50	2361.13	4570.51	0.34
T_9: NPKZnB (125%)	12	8.4	7	3.14	2388.84	4588.78	0.34
T_{10}: NPKZnB (150%)	14	9.2	7	3.50	2391.40	4601.05	0.34
F test	S	S	S	S	42.24	75.40	-
S. Em±	0.22	0.08	0.06	0.03	125.49	224.02	-
CD at 5 %	0.65	0.24	0.19	0.09	615.28	1230.82	-

Table 4: Effect of blended nutrient mixtures on grain quality of finger millet at harvest stage.

Treatments details	Protein (%)	Carbohydrate (%)	Ca (mg kg^{-1})	Zn (mg kg^{-1})
T_1: Absolute control ($N_0P_0K_0$)	3.41	50.01	0.27	6.27
T_2: 100% NPK (RDF)	8.46	72.41	0.63	32.25
T_3: NPK (75%)	8.30	60.07	0.58	17.37
T_4: NPK (100%)	8.51	65.44	0.60	12.29
T_5: NPK (125%)	9.08	71.46	0.62	11.28
T_6: NPK (150%)	9.12	74.04	0.68	13.65
T_7: NPKZnB (75%)	8.88	68.39	0.53	31.81
T_8: NPKZnB (100%)	8.75	71.57	0.60	32.48
T_9: NPKZnB (125%)	9.11	75.02	0.64	34.54
T_{10}: NPKZnB (150%)	9.27	78.18	0.72	38.22
F test	S	S	S	S
S. Em±	0.13	0.60	0.01	0.86
CD at 5 %	0.37	1.78	0.03	2.54

greater absorption of these nutrients from soil, followed by efficient transfer of these metabolites in the seed with the resultant increase in number of ears, ear length, number fingers, 1000 grain weight, grain yield, straw yield and harvest index. Similar results were reported by Goud. 2013 who conducted research on influence of doses of customized fertilizer on nutrient uptake and yield of finger millet.

Effect of blended nutrient mixtures on grain qualities of finger millet

Seed quality parameters are presented in Table 4. There was significant increase in the protein content of grain with the increase in the dose of the blended nutrient mixtures. Highest protein content was recorded in T_{10}: NPKZnB (150%) dose (9.27%) followed by T_6: NPK (150%) dose (9.12%), dose NPKZnB (125%) and NPK (125%) are on par with each other and lowest protein content (3.41) was noticed in absolute control. This might be due to increased availability of nitrogen which is a main constituent of protein with increase in the dose of customized fertilizer. Further, balanced nutrition may also contributed to increased uptake of nutrients thereby increasing protein content of grain. Several workers have observed that nitrogen application to crops tended to increase protein content in grains. Yadav *et al.*, (2017) reported that the pearl millet grain protein content increased from 9.85 to 11.29% at 90 kg N ha^{-1}, and from 10.01 to 11.51% at 120 kg N ha^{-1} with the increase in K level from 0 to 60 kg K_2O ha^{-1}. Protein yield of grains was significantly increased as a result of K application regardless of the N level.

Higher calcium content of grain (0.72 mg kg^{-1}) was noticed in NPKZnB (150%) dose, followed by NPK (150%) (0.68 mg kg^{-1}), T_9: NPKZnB (125%) (0.64 mg kg^{-1}) and T_5: NPK (125%) (0.62 mg kg^{-1}) treatments are on par with each other. This may be attributed to balanced nutrition which increased the growth parameters that in turn resulted in increased nutrient uptake. This could be due to the synergistic effect of P on the uptake and concentration of exchangeable Ca.

Higher concentration of zinc about 38.22 mg kg^{-1} was registered in T_{10}: NPKZnB (150%), followed by T_9: NPKZnB (125%) (34.22 mg kg^{-1}). Treatments T_8 (32.48 mg kg^{-1}) and T_7 (31.81 mg kg^{-1}) are on par with each other. The increase in seed quality traits can also be ascribed to better seed size besides, zinc might have helped in synthesis of carbohydrates and protein in plants, resulting in increased TSS and reducing sugars. Further, the increased zinc nutrition seemed to improve the metabolic activities of plant resulting in a significant increase in the zinc uptake. The results are in line with the findings of Yadav *et al.*, (1989) and Indulkar and Malewar (1994).

Carbohydrates shows significant result with different treatments. 78.18% was recorded by application of T_{10}: NPKZnB (150%) dose, followed by T_9: NPKZnB (125%) (75.02%) and (74.04%) in the treatment T_6: NPK (150%).

Conclusion

From the study, it was concluded that among different macronutrient fertilizer mixtures, application of T_{10}: NPKZnB (150%) (T_{10}) showed improvement in growth, yield and quality of finger millet. The mixture, T_{10}: NPKZnB (150%) contains appreciable quantity of N, P, K, Ca, S, Zn and B. Hence, T_{10}: NPKZnB (150%) can be effectively utilized in the place of conventionally used Urea + DAP +MOP to obtain maximum seed yield in finger millet.

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Competing Interests

Authors have declared that no competing interest exists.

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