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AGRONOMIC BIOFORTIFICATION THROUGH NUTRIENT MANAGEMENT TO ENHANCE YIELD AND QUALITY OF PEARLMILLET

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SUMMARY

An experiment was conducted at Research Farm Area, Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *Kharif* 2022 to study the effect of integrated nutrient management on stover yield quality parameters of pearlmillet. The experiment was conducted in randomized block design with three replications containing 12 treatments. The crop was sown on 12 July, 2022 using pearl millet hybrid 'HHB 67 improved'. Among the treatments, application of RDF (156.25 : 62.50 kg ha^{-1} N : P) + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX (T_{12}) resulted in significantly higher stover yield (70.33 q ha^{-1}), zinc (2.99 ppm), iron (4.13 ppm) content in stover of pearlmillet. It was statistically comparable to RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS (T_{11}) and RDF + 25 kg ha^{-1} $ZnSO_4$ (T_8). The Zn and Fe content in stover was 17.0 & 7.7 % and 5.8 & 2.9 % higher over control and RDF, respectively. Maximum protein and NPK content were recorded in T_{12}.

Key words: Pearlmillet, quality, INM, zinc, iron, stover

Pearlmillet (*Pennisetum glaucum* L.) is one of the most extensively cultivated cereals in the world after rice, wheat and sorghum particularly in arid and semi-arid regions. It is an important dual purpose crop grown for food and fodder. In India, it is one of the important millet crops which flourishes well even under adverse conditions of weather. It provides staple food for the poor people in a short period in the relatively dry tracts of the country. The livestock productivity in India is very less, which can be attributed to poor feed and fodder availability. India needs to feed 512 million livestock population, which is the largest in the world, from its 2.4% geographical area creating pressure on land and water resources. However, only 4.4% of the net cultivated area is under fodder cultivation in the country (Kumar and Chaplot, 2020). There lies a net deficit of green fodder (35.6%), dry fodder (10.95%) and concentrated feeds (44%) (IGFRI- Vision 2050). By 2050 this is expected to increase continuously to the tune of 1012 mt green fodder and 631 mt dry fodder (Ghosh *et al*., 2016). Due to unavailability of adequate amount of green fodder the livestock are feed with straws, husk and stover. Furthermore, increased population growth coupled with rapid urbanization necessitates proper residue management to fulfil livestock demands and increasing their production (Katoch *et al*., 2017). Pearlmilet is locally known as bajra whose fodder is used for livestock feeding, a basis of ration for a large bovine population that is regarded as the most critical component of providing stability in the risk prone crop-livestock farming system in water limited regions. Different AICRP centres and state universities have improved the nutritional quality in high yielding varieties of cereals, pulses, oilseeds, vegetables and fruits. Bio-fortified millets have a great potential to reduce micronutrient deficiency in the developing countries.

There are several approaches adopted to eliminate micronutrient malnutrition. Bio- fortification is a process of increasing the density of vitamins and minerals in a crop through plant breeding, transgenic techniques, agronomic practices. The fortification is a promising and cost effective measure to increase micronutrient concentration (agronomic bio-fortification) in plant to address micronutrient malnutrition. The effectiveness of agronomic bio-fortification largely depends on the bio availability of micronutrients throughout the entire pathway from soil to plant, food and into the animal body. Thus, agronomic bio-fortification is effective in increasing yields in the fastest route to improve the nutritional quality by enhancing micronutrient density in diets.

Increased use of fertilizers without organic recycling has not only aggravated multi-nutrient deficiencies in soil-plant-system but also detrimental to soil health and has created environmental pollution.

Moreover, chemical fertilizers are becoming costlier in agriculture. However, with increasing awareness on soil health and sustainability in agriculture, organic manures and many diverse organic materials have gained importance as components of integrated plant nutrient management. Therefore, it is the right time to evaluate the feasibility and efficiency of organic sources not only for improving and building up of soil fertility but also to increase the fertilizer use efficiency. Hence present investigation was carried out to evaluate the effect of integrated nutrient management on stover yield and quality of pearlmillet.

MATERIAL AND METHODS

A field experiment was performed in *kharif 2022* at Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar (India). Experiment was laid out in randomized block design with a total number of 12 treatments and replicated thrice. Details of the treatments used in experiment are given in Table 1. Soil of the experimental field was low in organic matter (0.32 %) and available N (119.0 kg ha^{-1}) with medium P_2O_5 (15.8 kg ha^{-1}) and K_2O (232.0 kg ha^{-1}). Weather conditions during the crop growing period is presented in Fig. 1. Pearlmillet variety HHB 67 (Improved) was sown on 12th July 2022 using seed rate of 5 kg ha^{-1} with spacing of 45 cm x 15 cm. Seed was treated with biomix (mixture of *Azotobacter, Azospirillum* and PSB) @ 250 ml ha^{-1} in respective treatment. Two manual weeding and hoeing at 22 and 35 DAS were done to control the weeds. For the maintenance of desirable plant population, thinning and gap filling were done at 20 DAS. One irrigation was given at 55 DAS. Crop was grown in accordance with recommendations of CCS HAU, Hisar. All the procedure as mentioned in package and practices of CCS HAU, Hisar were followed except nutrient management. Different dose of FYM, vermicompost, nitrogen, phosphorus, potassium and micronutrients were applied as per the treatments. The N, P and K nutrients were applied in the form of Urea, Di-ammonium Phosphate (DAP) and Single Super Phosphate (SSP). Soil application of $ZnSO_4$ and foliar spraying of 0.5% $FeSO_4$ and $ZnSO_4$ was done at 25 DAS.

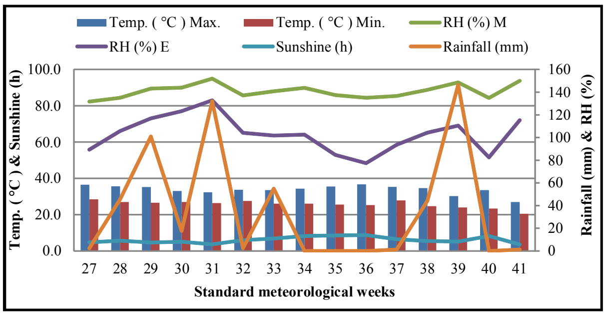

Fig. 1. Weekly meteorological data recorded during crop season.

Each of the plots were harvested and threshed separately. The stover yield for each plot was worked out by subtracting grain weight from total produce of individual plot and it was computed in in q ha^{-1}. Plant samples collected at harvest stage for dry matter

TABLE 1
Effect of different treatments on yield (q/ha), protein (%), zinc content (ppm) and iron content (ppm) of pearlmillet's stover

Treatment	Yield & Quality parameter			
	Stover yield (q/ha)	Protein (%)	Zinc content (ppm)	Iron content (ppm)
T_1: Control	48.92	4.05	2.56	3.90
T_2: RDF (156.25:62.5:0) kg/ha N:P:K through inorganic source	67.01	4.50	2.78	4.01
T_3: RDF + BIOMIX	67.60	4.59	2.78	4.03
T_4: 50% RDN through inorganic source+50% RDN through FYM+BIOMIX	62.55	4.33	2.69	3.93
T_5: 50% RDN through inorganic source+50% RDN through Vermicompost+BIOMIX	63.21	4.34	2.71	3.94
T_6: 75% RDN inorganic source+25% N through FYM+BIOMIX	63.89	4.40	2.76	4.00
T_7: 75% RDN inorganic source+25% N through vermicompost+BIOMIX	64.30	4.46	2.76	4.00
T_8: RDF+25 kg ha-1 $ZnSO_4$ (soil application)	68.97	4.76	2.97	4.02
T_9: RDF+0.5% $ZnSO_4$ (foliar spray) at 25 DAS	68.05	4.65	2.97	4.01
T_{10}: RDF+0.5% $FeSO_4$ (foliar spray) at 25 DAS	68.44	4.66	2.90	4.06
T_{11}: RDF+0.5% $ZnSO_4$+0.5% $FeSO_4$ at 25 DAS	69.76	4.89	2.98	4.10
T_{12}: RDF+0.5% $ZnSO_4$+0.5% $FeSO_4$+BIOMIX	70.33	5.00	2.99	4.13
SEm±	0.58	0.34	0.01	0.23
C.D. 5%	1.72	NS	0.03	0.08

*BIOMIX: Azotobacter + Azospirillum + PSB.

estimation were utilised for nutrient analysis. Samples were dried in hot air oven at 60^0C for 48 hours till a constant weight was obtained. Dried plant samples were powdered in a willey mill using 0.5 mm sieve and stored in butter paper covers for further chemical analysis. The nitrogen content in digested plant samples was estimated by modified Micro Kjeldahl method by using KEL PLUS instrument, after digesting the powdered plant samples by using H_2SO_4 and H_2O_2 (Piper, 1966). The Phosphorus content was determined by Vanadomolybdo phosphoric acid yellow colour method (Koening and Johnson, 1942). The potassium content in the digested plant samples was determined by flame photometer after making proper dilution (Jackson, 1973). Protein content of stover was calculated by multiplying % nitrogen in stover with a conversion factor of 6.25. The zinc and iron content of stover after proper digestion was estimated by Atomic Absorption Spectrophotometer (AAS) method as outlined by Lindsay and Norvell (1978). Uptake of each nutrient (N, P and K) (kg ha^{-1}) in stover was computed as follows:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Per cent nutrient content in stover} \times \text{yield kg/ha}}{100}$$

Data was subjected to statistical analysis using OP STAT software developed by CCS HAU, Hisar.

RESULTS AND DISCUSSION

Yield

Among the nutrient management treatments significantly higher stover yield (70.33 q ha^{-1}) was recorded with treatment T_{12} (recommended dose of fertilizer + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX) and it was statistically at par with T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS) and T_8 (RDF + 25 kg ha^{-1} $ZnSO_4$ (soil application) at 25 DAS). The stover yield of pearlmillet with treatment T_{12} was 43.7 & 4.9 % higher over control and RDF, respectively. Crop production is a function of the environment and the genetic potential of the crop variety. As genetic potential of specific crop cultivar remains constant, interaction of crops and environment affects yield of various components. Increase in stover yield may be ascribed to better root growth and development, nutrient uptake and elevated dry matter accumulation plant^{-1}. These results were in conformity with Reddy *et al.* (2016) and Prashantha *et al.* (2019) in finger millet.

Quality Parameters

Protein content (%) in stover

Maximum protein content (5.00%) in stover was found in treatment T_{12} (application of recommended dose of fertilizer + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX) followed by treatment T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS) while lowest protein content (4.05 %) was found in T_1 control. In relation to protein content in stover, Treatment T_{12} demonstrated an increase of 23.25 and 11.1 percent over control and RDF respectively (Table 1). Increasing availability of nitrogen in the soil, to the plants might have resulted higher N content in stover. It is well known fact that nitrogen in stover is directly responsible for higher protein content because it is a primary component of amino acid which constitutes the basis of protein. The findings of present investigation were in agreement with Yadav *et al.* (2014b) and Togas *et al.* (2017).

Zinc content (ppm) in stover

Application of recommended dose of fertilizer + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX (T_{12}) in which iron and zinc both were sprayed at 25 DAS of pearlmillet significantly increased the Zn concentration in the stover of pearlmillet as compared to control (Table 1). Foliar spray of either Zn or combination of both Fe and Zn with different nutrition levels gives significantly higher Zn content in stover of pearlmillet over rest of the treatments. Treatment T_{12} had significant higher zinc content and it was statistically at par with T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS), T_9 (RDF + 0.5% $ZnSO_4$ (foliar spray) at 25 DAS) and T_8 (RDF + 25 kg ha^{-1} $ZnSO_4$ (soil application). Treatment T_{12} resulted in a higher zinc content in stover which was 17.0 and 7.7% higher compared to the control and RDF, respectively. The increased concentration of Zn in stover of pearlmillet might be due to the improvement in Zn uptake by plants as the foliar applied Zn is phloem mobile and can be easily translocated in to developing plant. The foliar applied $ZnSO_4$ is highly water soluble which allows for its greater and immediate uptake by plant leaves. The increased micronutrient concentration in stover of pearlmillet with foliar application of Zn had

TABLE 2
Effect of different treatment on NPK content (%) and uptake (kg/ha) in stover of pearlmillet

Treatment	Nitrogen		Phosphorus		Potassium	
	Content	Uptake	Content	Uptake	Content	Uptake
T_1: Control	0.65	31.67	0.08	3.80	2.40	117.41
T_2: RDF (156.25:62.5:0) kg/ha N:P:K through inorganic source	0.72	48.25	0.11	7.33	2.54	172.31
T_3: RDF+BIOMIX	0.73	49.66	0.11	7.58	2.54	171.53
T_4: 50% RDN through inorganic source+50% RDN through FYM+BIOMIX	0.69	43.31	0.09	5.51	2.44	152.62
T_5: 50% RDN through inorganic source+50% RDN through Vermicompost+BIOMIX	0.69	43.91	0.09	5.89	2.46	154.57
T_6: 75% RDN inorganic source+25% N through FYM+BIOMIX	0.70	45.02	0.10	6.30	2.48	158.45
T_7: 75% RDN inorganic source+25% N through vermicompost+BIOMIX	0.71	45.93	0.10	6.68	2.50	160.75
T_8: RDF + 25 kg/ha $ZnSO_4$ (soil application)	0.76	52.53	0.12	8.62	2.58	177.94
T_9: RDF+0.5% $ZnSO_4$ (foliar spray) at 25 DAS	0.74	50.58	0.11	7.79	2.54	172.68
T_{10}: RDF+0.5% $FeSO_4$ (foliar spray) at 25 DAS	0.75	51.00	0.12	8.18	2.56	174.77
T_{11}: RDF+0.5% $ZnSO_4$+0.5% $FeSO_4$ at 25 DAS	0.78	54.53	0.13	9.08	2.60	181.38
T_{12}: RDF+0.5% $ZnSO_4$+0.5% $FeSO_4$+BIOMIX	0.80	56.27	0.15	10.40	2.61	184.63
SEm±	0.006	1.54	NS	0.67	0.017	2.85
C.D. 5%	0.017	4.01	NS	1.92	0.050	8.43

been reported by Jain *et al.* (2018) and Durgude *et al.* (2019).

Iron content (ppm) in stover

Significantly higher iron content (4.13 ppm) in stover was recorded in T_{12} (application of recommended dose of fertilizer + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX) in which iron and zinc both were sprayed at 25 DAS of pearlmillet over control (3.90 ppm) in stover, which were statistically similar to treatment T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS) and treatment T_{10} (RDF + 0.5% $FeSO_4$ (foliar spray) at 25 DAS). The implementation of T_{12} led to an increase in the iron content in stover, with an elevation of 5.7 & 2.9% compared to the control and RDF (Table 1). The increased concentration of Fe in stover might be due to the improvement Fe uptake by plants as the foliar applied Fe is phloem mobile and can be easily translocated in to developing plant. The foliar applied $FeSO_4$ is highly water soluble which allows for its greater and immediate uptake by plant leaves. The increased micronutrient concentration in stover of pearlmillet with foliar application of Fe have been reported by Srivastav *et al.* (2020).

Chemical studies

NPK content (%) in stover

The maximum content of nitrogen, phosphorus and potassium in stover was recorded in treatment T_{12} (recommended dose of fertilizer + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX) followed by treatment T_{11} (RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS) and T_8 (RDF + 25 kg ha^{-1} $ZnSO_4$ (soil application). Non-significant variations among treatments was recorded regarding P content in stover (Table 2).

NPK uptake (kg/ha) in stover

Macronutrients *viz.,* N, P, and K uptake in stover of pearlmillet were recorded higher in treatment T_{12} with application of recommended dose of fertilizer + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX (Table 2). NPK content and uptake stover of pearlmillet increased with every incremental dose of nitrogen and phosphorus and it seems to be due to increased NPK in the soil solution from added nitrogen and phosphorus which is utilized by the plants. The findings of present investigation were in agreement with Yadav *et al.* (2014b) and Togas *et al.* (2017).

CONCLUSION

Based on the experiment it may be concluded that application of recommended dose of fertilizer + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + BIOMIX closely followed by RDF + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at 25 DAS and RDF + 25 kg ha^{-1} $ZnSO_4$ (soil application) resulted in better stover yield and enhanced the NPK, Zn, Fe and protein content of pearlmillet stover. Hence, agronomic biofortification through integrated nutrient management is a good option to improve yield and quality of pearlmillet stover.

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REFERENCES

Durgude, A. G., S. R. Kadam, I. R. Bagwan, A. D. Kadlag, and A. L. Pharande, 2019: Response of zinc and iron to *Rabi* sorghum grown on an Inceptisol. *International journal of chemical studies*. **7**(3): 90-94.

Ghosh, P. K., D. R. Palsaniya, and S. Ramakrishna, 2016: Forage research in India: Issues and strategies. *Agriculture Research journal.* **53**: 1-12.

IGFRI Vision, 2050: Indian Grassland and Fodder Research Institute, Jhansi (UP), India.

Jackson, M. L. 1973: *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Jain, A. K., S. Shrivastava, and V. Arya, 2018: Response of organic manure, zinc and iron on soil properties, yield and nutrient uptake by pearlmillet crop grown in Inceptisol. *International journal of pure and applied bioscience*. **6**(1): 426-435.

Katoch, R., Apoorva, A. Tripathi, and S. Sood, 2017: Improving nutritive value and digestibility of maize stover- A review. *Forage Research* **43**: 174-180.

Koenig, R. and C. Johnson, 1942: Colorimetric determination of phosphorus in biological materials. *Industrial and Engineering Chemistry Analytical Edition*. **14**(2): 155-156.

Kumar, D., and P. C. Chaplot, 2020: Effect of fertility levels on growth and yield of multi-cut forage sorghum genotypes. *Forage Research*. **46**(1): 92-94.

Lindsay, W. L. and W. A. Norvell, 1978: Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal.* **42**: 421-428.

Piper, C. S. 1966: Soil and Plant Analysis. Hans Publisher, Bombay.

Prashantha, G. M., S. S. Prakash, S. Umesha, T. Chikkaramappa, C. T. Subbarayappa, and V. Ramamurthy, 2019: Direct and residual effect of zinc and boron on yield and yield attributes of finger millet–groundnut cropping system. *International Journal of Pure and Applied Bioscience*. **7**(1): 124-134.

Reddy, S. B. P., K. V. N. Madhuri, K. Venkaiah, and T. Prathima, 2016: Effect of nitrogen and potassium on yield and quality of pearlmillet (*Pennisetum glaucum* L.). *International Journal of Agriculture Innovations and Research*, **4**(4): 2319-1473.

Srivastav, P., C. H. Rao, T. R. Prakash, and S. A. Hussain, 2020: Effect of agronomic biofortification of pearlmillet (*Pennisetum glaucum L.*) cultivars with iron on growth parameters and quality. *Journal of Pharmacognosy and Phytochemistry.* **9**(5): 395-397.

Togas, R., L. R. Yadav, S. L. Choudhary, and G. V. Shisuvinahalli, 2017: Effect of integrated use of fertilizer and manures on growth, yield and quality of pearlmillet. *International Journal of Current Microbiology and Applied Sciences*. **6**(8): 2510- 2516.

Yadav, R., R. K. Nanwal, and A. Kumar, 2014b: Effect of potash, zinc and biofertilizer application on yield and nutrient uptake in pearlmillet. *Annals of Biology*. **34**(4): 645-648.