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Response of nano fertilizer in relation to nutrient content, nutrient uptake and nitrogen use efficiency in little millet (*Panicum sumatrense* Roth) under rainfed conditions

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Abstract
An experiment was performed in the soil Entisols of New Upland Research cum Instructional Farm, Lamker under S. G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh, India, during the Kharif season of 2021. The experiment was set up in randomized complete block design (RCBD) comprised of 3 replication with 12 treatments. According to the experimental findings, treatment T_{12} (75% RDF + seed treatment with nano fertilizer + Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering) had the maximum dry matter of shoot plant^{-1}, leaf area index, crop growth rate, and yield. However, the relative growth rate and net assimilation rates of various growth indices were significantly impacted by nano fertilizer.

Keywords: Nano fertilizer, little millet, rainfed conditions

Introduction

The nutritional value of food is crucial for maintaining human health. The quality of the diet should be considered in order to sustain human health completely so that complex issues like malnutrition could be quickly identified. Some agricultural foods are not used as human food because of societal illiteracy; millet is one of them. Millet has a variety of health-promoting and therapeutic characteristics that can be used to treat a wide range of illnesses. (Yang X. 2012) [20]. A small amount of little millet (*Panicum sumatrense*) is grown in India up to an altitude of 2100 m, but it is of not much importance elsewhere. It is valued for its nutritional value, resistance to stress and drought, and other qualities. The main benefit of small millet is that it can be kept in storage for up to 10 years or more without getting rotten. As a result, it has long served as a significant reserve food crop. Additionally, it is thought to be free of the main pests and diseases. Despite these benefits, small millet has a low national average grain yield even though it has the capacity to produce up to 3 t ha^{-1}. Its poor production has been attributed to an absence of better varieties, frequent droughts in rainfed conditions, and conventional cultivation methods that have not been upgraded. India produces almost all of the small millet, with a yield of 0.12 Mt on 0.26 mha as of 2018. (Bhat *et al*., 2018) [1]. The reduction is mostly caused by a significant change in food choices from traditional millets and toward other important cereals such as rice (*Oryza sativa*), wheat (*Triticum aestivum*), and maize (*Zea mays*) as well as other commercial crops. (Eliazer Nelson *et al*., 2019; Padulosi *et al*., 2015) [4, 15]. De- hulling, or removing the husk from grains, could be challenging, which is yet another cause for the fall. But currently, there is efficient dehulling and processing machinery that makes processing simple. (Padulosi *et al*., 2015) [15]. Little millet and other small millets are currently in higher demand, highlighting the need for further research and development to be focused on these crops to promote food and nutritional security. Little millet can generate a noticeably higher grain production on marginal soils even with a limited water supply. It possesses a variety of agronomic benefits, including as excellent water use efficiency, salt and water logging tolerance, and resistance to disease and insect pests. (Ganapathy, 2017; Kalaisekar *et al*., 2017; Matsuura *et al*., 2016; Upadhyaya *et al*., 2015) [5, 6, 13, 19].

Material and Methods

An experiment was performed in the soil Entisols of New Upland Research cum Instructional

Farm, Lamker under S. G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh, India, during the Kharif season of 2021. The experiment was consisting of 3 replications with 12 treatments that were carried out in Randomized Block Design (RBD). The treatment details are as follows, T_1: 100% Recommended dose of fertilizer, T_2: 100% RDF without Nitrogen application, T_3: 50% RDF + Seed treatment with nano fertilizer, T_4: 50% RDF+ Foliar spray of nano fertilizer at active tillering stage, T_5: 50% RDF+ Foliar spray of nano fertilizer at 7 to 10 days before flowering, T_6: 50% RDF+ Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering, T_7: 50% RDF + Seed treatment with nano fertilizer + Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering, T_8: 75% RDF+ Seed treatment with nano fertilizer, T_9: 75% RDF + Foliar spray of nano fertilizer at active tillering stage, T_{10}: 75% RDF+ Foliar spray of nano fertilizer at 7 to 10 days before flowering, T_{11}: 75% RDF+ Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering, T_{12}: 75% RDF+ Seed treatment with nano fertilizer + Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering. All plots received the recommended fertilizer dosage of 40:20:10 kg N: P: K ha^{-1} for little millet fields by urea, single super phosphate and muriate of potash respectively. The crop was sown with 50% nitrogen, 100% phosphorus, and 100% potash. The remaining half of the nitrogen dose was given in two split doses during the active tillering stage and at the panicle initiation stage.

Result and Discussion

It was found that various nano fertilizer treatments had significant effects on nutrient content, nutrient uptake, nutrient use efficiency and yield.

NPK content in grain and straw (%)

Table 1 shows that different nano fertilizer treatments had an impact on the NPK content of the grain and straw of little millet. According to the data, treatment T_{12} recorded the highest nitrogen (N) content in straw among each treatment but it was also found to be similar with treatments T_1, T_{11}, T_8, and T_9. The remaining N content in grain and the total N content were found to have no significant effect from the various treatments. Treatment T_1 had a much higher P content than treatments T_{12}, T_{11}, T_{10}, T_9, and T_2 in terms of both grain and total P content. Different treatments used during the trial had no effect on K content.

Table 1: NPK content in grain and straw of little millet at harvest as influenced by different treatments

Treatments	N content (%)			P content (%)			K content (%)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T1	1.55	0.41	1.97	0.18	0.35	0.52	0.46	1.18	1.63
T_2	1.40	0.31	1.71	0.16	0.34	0.50	0.45	1.12	1.57
T_3	1.43	0.35	1.78	0.12	0.29	0.41	0.40	1.15	1.55
T_4	1.45	0.35	1.81	0.12	0.30	0.41	0.41	1.14	1.55
T_5	1.42	0.35	1.78	0.12	0.30	0.42	0.41	1.13	1.54
T_6	1.46	0.36	1.82	0.12	0.30	0.41	0.42	1.14	1.56
T_7	1.47	0.36	1.83	0.14	0.31	0.44	0.42	1.16	1.58
T_8	1.49	0.37	1.85	0.13	0.33	0.46	0.44	1.16	1.61
T_9	1.44	0.37	1.80	0.15	0.32	0.47	0.43	1.18	1.61
T_{10}	1.41	0.39	1.79	0.16	0.33	0.49	0.43	1.19	1.63
T_{11}	1.50	0.40	1.90	0.16	0.33	0.49	0.44	1.20	1.64
T_{12}	1.59	0.42	2.01	0.16	0.33	0.49	0.44	1.21	1.65
SEm±	0.08	0.02	0.08	0.01	0.02	0.02	0.02	0.05	0.05
CD @ 5%	NS	0.05	NS	0.03	NS	0.06	NS	NS	NS
CV%	9.15	8.39	7.17	14.00	9.05	7.34	6.76	7.28	5.88

NPK uptake by plant (Kg ha^{-1})

The information in Table 2 demonstrates that various nano fertilizer treatments had a significant effect on the ability of plant to absorb NPK. The data reveals that treatment T_{12} considerably had the highest overall nitrogen uptake by plants including grain and straw and treatment T_{11} had the similar result of uptake in straw. Treatment T_{12}, which was determined to be on par with treatments T_1 and T_{11}, had the highest levels of total phosphorus uptake by plants, including grain and straw. However, treatment T_{12} considerably had the highest total potassium uptake by grain and straw and had similar results with treatment T_{11} and T_1 in the grain. The high nutrient uptake using nano fertilizer has been attributed to the nutrients being more readily available in the soil for rapid crop absorption. (Mehta and Bharat, 2019) [14]. To improve their uptake, fertilizers are enclosed in nano particles and made readily available to plants. (Chhipa, 2017) [2]. The slow-release element may also contribute to an increase in nutrient absorption. (Manikandan and Subramanian, 2016) [12]. Application of nanomaterials resulted in increased water intake, which in turn increased nutrient uptake and increased biomass output. (Liu and Liao, 2008) [11]. Plants receive nutrients through nano structured formulations which are designed to provide regulated or gradual release of active components for effective uptake. (Raliya *et al.*, 2017) [17].

Table 2: NPK uptake in grain and straw of little millet at harvest as influenced by different treatments

Treatments	N uptake (%)			P uptake (%)			K uptake (%)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T1	20.67	9.35	30.03	2.34	7.81	10.15	6.02	26.51	32.54
T2	9.81	4.25	14.06	1.13	4.58	5.71	3.20	15.16	18.36
T_3	12.98	5.38	18.36	1.08	4.43	5.51	3.59	17.57	21.16
T_4	17.08	7.03	24.10	1.38	5.89	7.27	4.80	22.68	27.48
T_5	14.76	6.70	21.46	1.21	5.81	7.01	4.23	21.34	25.57
T_6	18.37	7.84	26.22	1.48	6.54	8.02	5.22	25.17	30.39
T_7	18.74	8.42	27.18	1.73	7.21	8.93	5.35	27.31	32.65
T_8	15.69	7.14	22.82	1.40	6.35	7.75	4.69	22.65	27.34
T_9	18.12	8.16	26.28	1.84	7.22	9.05	5.44	26.29	31.73
T_{10}	15.66	7.05	22.71	1.82	6.02	7.84	4.83	21.78	26.61
T_{11}	20.88	9.20	30.07	2.17	7.68	9.85	6.14	27.79	33.93
T_{12}	24.32	11.15	35.46	2.38	8.87	11.24	6.70	32.13	38.84
SEm±	0.76	0.49	1.76	0.11	0.44	0.50	0.29	1.15	1.35
CD @ 5%	2.25	1.45	5.19	0.32	1.31	1.48	0.86	3.41	3.98
CV%	7.66	11.10	12.22	11.42	11.77	10.59	10.05	8.38	8.08

Nutrient use efficiency

With the aid of information on grain production and the amount of nutrient used in each treatment, the agronomic nutrient use efficiency of N was estimated for each treatment. The data obtained has been presented in Table 3. Treatment T_7 recorded the highest nitrogen use efficiency of all the fertilizer-applied treatments, found at par with treatments T_6 and T_{12}. Nano fertilizers can penetrate into plants from the treated surface and increase absorption and usage efficiency because they have a bigger surface area and particles that are smaller than the pore size of the plant's root and leaves. (Dimkpa *et al*., 2015, Qureshi *et al*., 2018; Kumar *et al*., 2020) [3, 16, 9]. Reduced particle size increases a specific surface area of fertilizer and particle count per unit area which increases the potential of nano- fertilizer interaction and boosts nutrient uptake and penetration, resulting in high nutrient use efficiency. (Liscano *et al*., 2000) [10]. According to reports, using nano fertilizers reduces the possibility of adverse effects while increasing the effectiveness of fertilizer use. (Kottegoda *et al*., 2011) [8].

Table 3: Effect of nano fertilizer on agronomic nutrient use efficiency

Treatments	Agronomic nutrient use efficiency
	Nitrogen use efficiency
T1	20.52
T2	0.00
T_3	13.51
T_4	31.17
T_5	22.26
T_6	36.63
T_7	38.01
T_8	15.64
T_9	24.58
T_{10}	18.21
T_{11}	30.52
T_{12}	36.27
SEm±	1.07
CD @ 5%	3.16
CV%	7.73

Yield

According to the data in Table 4, treatment T_{12} was recorded greatly increased grain and straw yield. In order to improve growth and productivity, foliar fertilization has the potential to boost the effectiveness and frequency with which a nutrient is utilized by the plant. (Kandil and Eman, 2017) [17]. The crop output is greatly increased by foliar application of nano fertilizers. (Tarafdar *et al*., 2012) [18].

Table 4: Effect of nano fertilizer on grain yield, straw yield, and harvest index of little millet

Treatments	Grains yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	HI (%)
T_1	1319.77	2261.20	36.88
T_2	704.30	1350.61	34.24
T_3	906.95	1527.29	37.23
T_4	1171.84	1985.76	37.07
T_5	1038.27	1896.48	35.40
T_6	1253.68	2203.02	36.28
T_7	1274.40	2357.99	35.05
T_8	1056.29	1944.31	35.14
T_9	1257.34	2233.54	35.89
T_{10}	1113.88	1818.02	38.06
T_{11}	1390.98	2322.20	37.43
T_{12}	1520.30	2668.46	36.30
SEm±	56.36	84.66	1.74
CD @ 5%	166.36	249.89	NS
CV%	8.36	7.16	8.33

Conclusion

Based on the previous findings, it can be determined that the application of 75% RDF + Seed treatment with nano fertilizer + Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering (T_{12}) produced better results in terms of yield as well as nitrogen and potassium uptake whereas phosphorus uptake was found to be at its highest in the treatment T1 using 100% of the recommended dose of fertilizer. For a greater nitrogen use efficiency, the application of 50% RDF + Seed treatment with nano fertilizer + Foliar spray of nano fertilizer during the active tillering stage and 7 to 10 days prior to blooming T_7 showed better results.

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