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Impact of nano fertilizer in relation to growth indices and yield of little millet (*Panicum sumatrense* Roth) under rainfed conditions

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Abstract
An experiment was carried out in the Entisols of the New Upland Research cum Instructional Farm, Lamker, under the S.G. College of Agriculture and Research Station in Jagdalpur, Chhattisgarh, India, during the Kharif season of 2021. 12 treatments were included in the trial which was set up using a randomized complete block design (RCBD) with 3 replications. The results of the experiment showed that, out of all the treatments, treatment T_{12} (75 percent RDF + Seed treatment with nano fertilizer + Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering) recorded significantly higher dry matter of shoot plant^{-1}, leaf area index, crop growth rate and yield. However, Nano fertilizer had significant effect on different growth indices *viz*., relative growth rate and net assimilation rate.

Keywords: Nano fertilizer, little millet, rainfed conditions

Introduction
In past centuries, millets were grown substantially around the world as important grains for provender and human food. It is one of the members of the grain family, which has been grouped into many different varieties throughout history. India produces 38.6% more millet than China does, making it a significant crop in the semi-arid regions of Asia and Africa. 97% of millet is produced in developing countries (Especially India). (McDonough, 2000) [5].

Minor millets were major food crops in the past and are currently promoted as the foods of the future because of the adverse impacts of climate change and global warming that are more pronounced in fragile ecological circumstances. These have a chance to be a source of food and feed for millions of small farmers in dry areas as well as domestic animals as a result of their adaptability to a variety of input conditions, moisture regimes, and temperatures. Millets, which are c4 plants, also hold onto carbon, expanding the choices for reducing CO_2. Through their diversity, they also boost agro-biodiversity and enable mutually advantageous intercropping with other crucial crops. (Brahmachari *et al*., 2018) [2]. The crop is superior to other cereals with respect to of nutrition and medicinal value and has a high tolerance for drought. Patients with diabetes and heart and blood vessel problems are advised to eat grains. Little millet grain has good grain storage qualities and can be kept for a number of years without worrying about store grain insects under normal storage circumstances. Little millet is a crop with a low water requirement and is widely known for its ability to withstand droughts. The crop is suitable for delicate and sensitive agro-ecosystems because it is environmentally friendly. It has a significant function in supplying the diet with considerable levels of phytochemicals and antioxidants. (Ushakumari and Malleshi, 2007) [8]. Little millet provides 65.5 g of carbohydrates, 10.1 g of protein, 3.89 g of fat, 346 Kcal of energy, 7.7 g of dietary fiber, 16.1 milligrams of calcium, 130 milligrams of phosphorus, 91 milligrams of magnesium, 1.8 milligrams of zinc, 1.2 milligrams of iron, 0.26 milligrams of thiamin, 0.05 milligrams of riboflavin (Venkatesh Bhat *et al*., 2018) [9].

Materials that have a single unit between 1 and 100 nm in size in at least one dimension are referred to be nano materials. (Liu and Lal, 2015) [4]. Nano- fertilizer's importance has previously been demonstrated by some studies. Nano fertilizers delay the release of nutrients and lengthen the time that fertilizers are active (Naeem *et al*., 2017) [6]. However, it is important to acknowledge the environmental health and safety risks associated with nano technology and it is crucial to evaluate the toxicity and biocompatibility of nano fertilizers (Bhavani *et al*., 2020) [1].

Material and Methods

During the Kharif season of 2021, the experiment was performed in the Entisols of the New Upland Research and Instructional Farm, Lamker under S.G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh, India. The experiment used a Randomized Block Design (RBD) and had 3 replications with 12 treatments each. The details are as follows T_1: 100 percent RDF, T_2: 100 percent RDF without Nitrogen application, T_3: 50% RDF + Seed treatment with nano fertilizer, T_4: 50 percent RDF + Foliar spray of nano fertilizer at active tillering stage, T_5: 50 percent RDF + Foliar spray of nano fertilizer at 7 to 10 days before flowering, T_6: 50 percent RDF+ Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering, T_7: 50 percent 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 percent RDF+ Seed treatment with nano fertilizer, T_9: 75 percent RDF+ Foliar spray of nano fertilizer at active tillering stage, T_{10}: 75 percent RDF+ Foliar spray of nano fertilizer at 7 to 10 days before flowering, T_{11}: 75 percent RDF+ Foliar spray of nano fertilizer at active tillering stage and 7 to 10 days before flowering, T_{12}: 75 percent 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 required fertilizer dosage of 40:20:10 kg N: P: K ha^{-1} for little millet fields through urea, single super phosphate and muriate of potash respectively. The crop was sown with 50% of the nitrogen, the full dosages of phosphate and potash and the remaining 50% of the nitrogen which was delivered in two split doses at the active tillering stage and the panicle initiation stage.

Result and Discussion

In Table 1, it was noted that various nano fertilizer treatments had significant effects on dry matter of shoot $plant^{-1}$, leaf area index, crop growth rate, relative growth rate, net assimilation rate and yield.

Dry matter of shoot $plant^{-1}$ (g)

Dry matter accumulation is an important measure of a crop's photosynthetic effectiveness, which consequently affects its yield. Among the all treatments, treatment T_{12} results showed significantly highest dry matter accumulation at harvest. Nano-fertilizers are associated with enhanced height of plant, number of tillers and area of leaf which could be attributed to significance increase in dry matter accumulation. Nano-fertilizers have been associated to increased plant height, tiller number and leaf area, which may be explained by a substantial increase in the accumulation of dry matter. Nano particles improve plant growth parameters including height of plant, leaf area, and the overall number of leaves, as well as dry matter accumulation, content of chlorophyll and photosynthesis rate as well as plant production and photosynthesis translocation to various areas of the plant in comparison to traditional fertilizers. (Ali and Al-Juthery, 2017; Singh *et al*., 2017) [10, 7].

Leaf area index

The capacity of plants to capture solar energy for photosynthesis is determined by the leaf area index, a key measure of plant growth. Table 1 shows the considerable impact of several treatments on the LAI of little millet at each stage of crop growth till harvest. Treatment T_{12} had the significantly highest leaf area index of all the treatments. The growing leaf area index could be attributed to the greater responsiveness of nano fertilizers as a result of their more concentrated surface area, higher density of areas, or improved reactivity of these areas on particle surfaces. Because of these characteristics plants can more easily absorb nano-scale nutrients. (Dhoke *et al*., 2013) [3].

Crop growth rate (g/m^2/day)

Table 1 presents the data on crop growth rate (CGR) for the little millet crop at various growth stages. The data shows that treatment T_{12} produced the highest CGR among all of the treatments. When compared to conventional fertilizers, nanoparticle fertilizers increase height of plant, leaf area, and overall number of leaves as well as dry matter of shoot plant-1, content of chlorophyll and rate of photosynthesis which increases translocation of photosynthetic materials to various parts of the plant. (Ali and Al-Juthery, 2017; Singh *et al*., 2017) [10, 7].

Table 1: Effect of nano fertilizer on dry matter of shoot plant-1, LAI, CGR, RGR and NAR

Treatments	Dry matter of shoot/plant (g)	Leaf area index	Crop growth rate (g/m2/day)	Relative growth rate (g/g/day)	Net assimilation rate (g/m^2/day)
T_1	13.66	3.16	0.27	0.024	0.012
T_2	7.80	1.35	0.14	0.024	0.011
T_3	9.00	1.51	0.19	0.024	0.014
T_4	11.29	2.21	0.23	0.024	0.013
T_5	9.59	1.63	0.21	0.027	0.016
T_6	12.20	2.38	0.25	0.025	0.014
T_7	12.00	2.82	0.18	0.017	0.009
T_8	10.20	1.89	0.21	0.024	0.014
T_9	12.13	2.58	0.18	0.017	0.009
T_{10}	10.93	2.07	0.22	0.024	0.013
T_{11}	14.54	3.39	0.30	0.025	0.012
T_{12}	16.12	3.85	0.29	0.021	0.011
SEm±	0.58	0.18	0.01	0.001	0.001
CD @ 5%	1.71	0.54	0.04	0.004	0.002
CV%	8.63	13.13	9.22	10.226	9.690

Relative growth rate (g/g/day)

The data represented in Table 1 shows that treatment T_5 recorded significantly maximum relative growth rate among the all treatments.

Net assimilation rate (g/m^2/day)

The data given in Table 1that treatment T_5 recorded greater net assimilation rate at 75 Days after showing at harvest which had similar result to the treatment T_3, T_6 and T_8.

Yield

According to the data in Table 2, treatment T_{12} significantly improved both grain and straw yield. To maximize growth and productivity, foliar fertilization has the potential to improve the efficiency and frequency with which a nutrient is absorbed by the plant (Kandil and Eman, 2017) [11].

Table 2: Response of nano fertilizer on yield of grain and straw and harvest index of little millet

Treatments	Grains yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Harvest Index (%)
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

Ultimately, the use of nanotechnology in agriculture is still in its nascent stages. But it could influence agricultural systems, especially when it involves issues related to the application of fertilizer. In comparison to conventional sources of fertilizers, Nano fertilizer application encouraged growth, development, and has the ability to boost crop yield and plant nutrition with improved effectiveness and agronomic efficiency. Although it was found that treatment T_{12} recorded maximum dry matter of shoot / plant, LAI, CGR and yield whereas treatment T_5 recorded higher RGR and net assimilation rate.

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