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Performance of little millet (*Panicum sumatrence* L.) to nano fertilizer and nitrogen levels on yield, economics and soil parameters

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Abstract
Experiment was carried out at the farm of Zonal Agriculture Research Station, Shendapark, Kolhapur (M.S.), India during *kharif*, 2021. The experiment was laid out in randomized block design with three replication and consisted of twelve treatments. The treatment consists of different levels of RDN along with seed treatment and foliar sprays of nano nitrogen fertilizer. Variety *Phule Ekadashi* was used for experiment. Though the effect of nano fertilizer and different nitrogen levels on soil parameters were found non-significant still the highest values of soil pH (6.87), EC (0.26 dSm^{-1}) and OC (0.53%) was recorded by the treatment T_{12} (75% RDN+ Seed treatment with 1% nano fertilizer + Foliar spray of nano fertilizer @ 0.4% at active tillering stage and 7-10 days before flowering) over initial observations. In case of nutrient availability in soil after harvest the maximum nutrient was recorded in treatment T_{12} these are as follows N (278.67 kg ha^{-1}), P (48.85 kg ha^{-1}) and K (245.81 kg ha^{-1}). However, lowest nutrient availability was shown by treatment T_2. The higher cost of cultivation was recorded in treatment T_{12} which was Rs. 26655 ha^{-1} and treatment T_{11} [75% RDN + Foliar spray of nano fertilizer @ 0.4% at active tillering stage and 7-10 days before flowering] which was Rs. 26655 ha^{-1}. The lowest cost of cultivation was recorded by treatment T_2 [T_1 without Nitrogen application] which was Rs. 22896 ha^{-1}. The T_{12} recorded maximum values for both gross monetary returns (Rs. 53316 ha^{-1}) and net monetary returns (Rs. 26661ha^{-1}). However, treatment T_2 observed the lower figures in case of both gross monetary returns (Rs. 35784 ha^{-1}) and net monetary returns (Rs. 12888 ha^{-1}). The higher benefit: cost ratio was recorded by the treatment T_{12} which was 2.00 and the lowest benefit: cost ratio was recorded by treatment T_2 which was 1.56.The treatment T_{12}performed good in obtaining higher grain yield of 1466kgha^{-1} and straw yield of 2458 kgha^{-1}.

Keywords: Little millet**,** nano fertilizer**,** nitrogen levels, nutrient availability, soil parameters

Introduction
One of the earliest foods consumed by humans is millets, which may have been the first cereal grain used in residential settings. Small- seeded millets are resilient, rain-fed crops that thrive well in dry region and also grow well in low soil fertility and moisture. Millets are incredibly nutrient rich, non-glutenous and acid-free meals. They are regarded as the least allergic and most easily digestible grains available in the market. Millets are referred as "nutria-cereals" due to their higher nutritional content. They are also known as "famine reserves" due to their prolonged storability under circumstances. (Michaelraj and Shanmugam, 2013) [6].

By taking into consideration importance of millets Government of India had proposed to united nations for declaring 2023 as International Year of Millets. The proposal of India was supported by 72 countries and declared 2023 as International Year of Millets (IYOM) on 5th March, 2021. Now, Government of India is celebrating 2023 as a IYOM with purpose of making peoples' movement towards Indian millets, recipes and value-added products which are helpful to accept at global level.

Little millet (*Panicum sumetranse* L.) is one of the minor millets, which belongs to family *Poaceae.* It is important catch crop as it withstands both drought and water logging conditions. It contains 67.0 g of carbohydrates, 7.7 g of proteins, 4.7 g of fats, 12.2 g of dietary fibers, 1.5 g of mineral matter, 17.0 g of calcium, 220.0 mg of phosphorous and 6.0 mg of iron. (Divyashree *et al*., 2018). Even though it is nutritionally rich crop it got neglection because of lack of adoption of improved package of practices. And it is one of the reasons of less production and productivity of little millet.

Nutrient management is an approach for maintaining and enhancing soil fertility and improving productivity of the crop.

Among all primary macronutrients, nitrogen is most important nutrient required by the plant. In all vegetative growth stages of plant nitrogen plays an important role as it is major constitute of chlorophyll which imparts green color to the plant and helps for the production of proteins (Iqbal, 2019) [3]. Nitrogen use efficiency (NUE) by crops is very low when comparison is done with the quantity of nitrogen applied to soil. Whatever amount of nitrogen as a conventional fertilizer applied out of this only 30-50 percent get utilized by plant, while remaining nitrogen lost by leaching and volatilization. Now it's time to solve this problem by adopting nanotechnology (Maria *et al.*, 2010) [5]. The phrase 'Nanotechnology' comes from the Greek word 'nanos', which means dwarf having size of particles about 1-100 nm. Nanotechnology will be the blessing for contemporary agricultural farming as it enhances the efficiency of nutrient uptake by using nano-fertilizers. (Manikandan *et al.*, 2018) [4]. Before being approved as a nano fertilizer, a substance or set of particles must pass tests to determine their size, stability, form and characterisation **(**Misra *et al.*, 2014) [7]. Several studies shows that nano fertilizers profoundly increase the crop yield over control which are without application of nano fertilizer, when applied as foliar spray. This because of nano fertilizer gets direct entry into leaves of plant through stomata and other openings. As they are utilized according to need of plant that encourages the growth of plant and increases the rate of metabolic processes like, photosynthesis which leads to higher accumulation of photosynthates and its translocation towards the economic parts of the plant. This foliar application of nano particles increases crop yield significantly. Nano fertilizer provide more surface area and more availability of nutrients to the crop. (Singh *et al.*, 2017) [13]. Hence, through this trial major emphasis was given on nutrient management particularly nitrogen by making eminent use of nano fertilizers over conventional fertilizers.

Materials and Methods

Experiment was carried out at the farm of Zonal Agriculture Research Station, Shendapark, Kolhapur (M.S.), India during *kharif*, 2021. The variety Phule Ekadashi was used for research trial. The gross plot size was 3.80 m × 3.60 m and net plot size was 3.20 m × 2.70 m. The experiment was consisting of three replications with twelve treatments that were laid out in Randomized Block Design (RBD). The treatment details are as follows, T_1:RDF (60:30:30 NPK kg ha^{-1}), T_2: T_1 without nitrogen application, T_3: 50% RDN + Seed treatment with 1% nano fertilizer, T_4: 50% RDN + Foliar spray of nano fertilizer @ 0.4% at active tillering stage, T_5: 50% RDN + Foliar spray of nano fertilizer @ 0.4% at 7-10 days before flowering, T_6: 50% RDN +Foliar spray of nano fertilizer @ 0.4% at active tillering stage and at 7-10 days before flowering, T_7: T_3+ Foliar spray of nano fertilizer @ 0.4% at active tillering stage and at 7-10 days before flowering, T_8: 75% RDN + Seed treatment with 1% nano fertilizer, T_9: 75% RDN + Foliar spray of nano fertilizer @ 0.4% at active tillering stage, T_{10}: 75% RDN + Foliar spray of nano fertilizer @ 0.4% at 7-10 days before flowering, T_{11}: 75% RDN + Foliar spray of nano fertilizer @ 0.4% at active tillering stage and at 7-10 days before flowering, T_{12}: T_8 + Foliar spray of nano fertilizer @ 0.4% at active tillering stage and at 7-10 days before flowering. The recommended dose of fertilizer 60:30:30 kg N: P: K Kg ha^{-1} for little millet. The source used to supply are urea, single super phosphate and muriate of potash and they are applied as per the treatment. Nitrogen was applied in two split doses at active tillering stage and at panicle initiation stage. Total phosphorous and potash were applied at the time of sowing. IFFCO nano urea is used for seed treatment and foliar spraying in little millet and applied as per treatment. All observations are recorded by following standard methodology of research. Data is statistically analysed as per the method given by Panse and Sukhatme (1967) [9].

Result and Discussion

Yield of little millet: Table 1 is showing the results of experiment regarding the grain yield, straw yield and harvest index of little millet crop as influenced by the effect of nano fertilizer and nitrogen levels. Treatment T_{12} recorded the highest values for grain yield kg ha^{-1}. This treatment numerically at par with treatments T_{11}, T_7, T_6 and T_9, however treatment T_{12} significantly found superior over rest treatments T_4, T_{10}, T_5, T_1, T_8, T_3 and T_2 with highest grain yield of 1466kgha^{-1}. The reason behind it is the foliar application of nano nitrogen on leaves. As nano urea is in liquid form it easily gets entry into leaves infrastructure through stomata which is assimilated by plants and easily distributed through phloem from source to sink and utilized according to need of plant. Indicating that nano nitrogen fertilizer increases area for different metabolic processes such as photosynthesis. Its application leads to increase grain yield of little millet. Lowest grain yield was recorded by treatment T_2 with grain yield of 969kg ha^{-1}. (Rajput *et al.*, 2022 and Samanta *et al.*, 2022) [10, 11]. The maximum straw yield was noted under treatment T_{12} (2458 kg ha^{-1}) which was significantly at par with treatment T_{11}, T_7, T_6, T_9, T_4 and T_{10}. However, treatment T_{12} significantly superior over rest of the treatments T_5, T_1, T_8, T_3 and T_2. Lowest straw yield was noted in treatment T_2 (1892kg ha^{-1}) (Imam Sarvar MD 2021) [2]. Numerically, highest harvest index (37%) was noticed under treatment T_{12}. The treatment T_2 resulted in lowest harvest index (34%) of little millet. (Rajput *et al.*, 2022 and Samanta *et al.*, 2022) [10, 11].

Economics of little millet

Economics of little millet as influenced by different nano nitrogen fertilizer and nitrogen levels treatments represented in Table 2 as in respect of the cost of cultivation, gross monetary returns, net monitory returns and B:C ratio. The higher cost of cultivation was recorded in treatment T_{12} which was Rs. 26655 ha^{-1} and treatment T_{11} which was Rs. 26655 ha^{-1}. However, the lowest cost of cultivation was recorded by treatment T_2 which was Rs. 22896 ha^{-1} (Soutade 2017) [14]. The higher gross return was recorded in treatment T_{12} which was Rs.53316 ha^{-1} which was numerically at par with treatment T_{11}, T_7, T_6, and T_9. The lowest gross monetary return was recorded by treatment T_2 which was Rs. 35784 ha^{-1} (Sankar *et al.*, 2020) [12]. The higher net return was recorded in treatment T_{12} which was Rs. 26661ha^{-1} which was significantly superior over treatments T_5, T_1, T_8, T_3 and T_2 except treatments T_{11}, T_7, T_6, T_9, T_4 and T_{10} which was numerically at par with treatment T_{12}. However, the lowest net monetary return was recorded by treatment T_2 which was Rs. 12888 ha^{-1}(Rajput *et al.*, 2022) [10]. The higher benefit: cost ratio was recorded by the treatment T_{12} which was 2.00 and the lowest benefit: cost ratio was recorded by treatment T_2 which was 1.56 (Rajput *et al.*, 2022 and, Sankar *et al.*,

2020) [10, 12].

Soil parameters

The effect of nano fertilizer and different nitrogen levels on soil parameters like pH, EC (dSm^{-1}) and OC (%) and the available nutrient content (N, P and K) in soil after harvest of little millet as influenced by nano fertilizer and nitrogen levels was found non-significant one and it is pertained in Table 3. Though the recorded mean values of soil parameters are like soil pH (6.86), EC (0.26 dSm^{-1}) and OC (0.50%) (Nigade *et al.*, 2011) [8] and the recorded mean values of available soil nitrogen, phosphorus and potassium are as follows (277.33 kg ha^{-1}), (48.47 kg ha^{-1}) and (244.33 kg ha^{-1}) respectively (Nigade *et al.*, 2011) [8].

Table 1: Effect of nano fertilizer and nitrogen levels on grain yield, straw yield and harvest index of little millet

Treatments	Grain Yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Harvest Index (%)
T_1	1178	2192	35
T_2	969	1892	34
T_3	1169	2178	35
T_4	1262	2243	36
T_5	1227	2214	36
T_6	1299	2250	36
T_7	1333	2267	37
T_8	1177	2197	35
T_9	1292	2247	37
T_{10}	1248	2228	36
T_{11}	1337	2274	37
T_{12}	1466	2458	37
S. Em±	63.55	81.69	1.42
C. D. at 5%	186.41	239.61	NS

Table 2: Economics of little millet as influenced by nano fertilizer and different nitrogen levels.

Sr. No	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit: Cost ratio
T_1	24665	43258	18593	1.75
T_2	22896	35784	12888	1.56
T_3	24252	42944	18692	1.77
T_4	25395	46132	20737	1.82
T_5	24982	44931	19949	1.80
T_6	26242	47389	21147	1.81
T_7	26242	48523	22281	1.85
T_8	24548	43246	18698	1.76
T_9	25395	47153	21758	1.86
T_{10}	24982	45662	20680	1.83
T_{11}	26655	48692	22037	1.83
T_{12}	26655	53316	26661	2.00
S. Em±	-	2113.19	2113.19	0.083
C. D. at 5%	-	6197.79	6197.79	NS
General mean	25242	45586	20344	1.80

Table 3: Mean soil parameters in soil after harvest of little millet as influenced by nano fertilizer and nitrogen levels.

Treatments	pH	EC (dSm^{-1})	OC (%)	Nitrogen (Kg ha^{-1})	Phosphorous (Kg ha^{-1})	Potassium (Kg ha^{-1})
T_1	6.90	0.27	0.50	277.00	51.59	244.20
T_2	6.87	0.27	0.48	276.33	49.16	248.48
T_3	6.87	0.27	0.49	276.33	49.50	249.71
T_4	6.87	0.26	0.52	277.00	46.76	246.94
T_5	6.87	0.26	0.50	277.00	50.53	249.46
T_6	6.83	0.26	0.52	278.00	45.44	242.54
T_7	6.87	0.26	0.52	278.00	47.86	244.77
T_8	6.90	0.28	0.49	276.67	48.98	241.14
T_9	6.90	0.27	0.52	277.33	48.95	245.00
T_{10}	6.83	0.26	0.51	277.00	45.55	245.81
T_{11}	6.80	0.26	0.51	278.67	48.51	241.50
T_{12}	6.87	0.26	0.53	278.67	48.85	245.81
S. Em±	0.05	0.005	0.01	2.46	1.25	4.97
C. D. at 5%	NS	NS	NS	NS	NS	NS
Mean	6.86	0.26	0.50	277.33	48.47	244.33
Initial Status	6.85	0.26	0.50	270.00	47.98	245.00

Conclusion

Based on investigation, it can be concluded that treatment T_{12} (75% RDN+ Seed treatment with 1% nano fertilizer + Foliar spray of nano fertilizer @ 0.4% at active tillering stage and 7-10 days before flowering) is best suitable treatment for the sub-montane zone of Kolhapur as it achieves higher yield, higher benefit: cost ration along with high gross and high net returns and also performs well in relation to all soil parameters.

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