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Effect of nitrogen management on productivity of kodo millet (*Paspalum scrobiculatum* L.)

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Abstract
The research aimed to study effect of nitrogen management on productivity of kodo millet (*Paspalum scrobiculatum* L.). The field experiment was carried out at instructional farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (Chhattisgarh) during *kharif* 2023. The experiment was laid out in randomized block design with three replication and consisted of seven treatments. The treatment consists of different levels of RDN along with basal and top dressing of conventional urea and foliar sprays of nano urea. Variety Indira kodo^{-1} was used for experiment. The results indicated that 75% RDN + 1 spray of nano urea @ 4 ml litre^{-1} water at tillering stage + 100% PK (T_4), recorded higher plant height (117.16 cm), number of tillers m^{-1} row length (140.41), number of effective tillers m^{-1} row length (136.80), number of racemes plant^{-1} (6.80), panicle length (8.94 cm), which was statistically on par with the T_3 and T_2.

Keywords: Kodo millet, nano fertilizer, nitrogen level, growth and yield attributes

Introduction
Small millets are traditional cereal crops, agronomically more adopted to impoverished soil, which originated either Asia or Africa, gaining significance in recent years under the changed climatic scenario, they are considered as grains for future, as they are known for their climate resilient features including adaptation to a wide range of ecological conditions, less irrigation requirement, better growth and productivity in low nutrient input conditions, less reliance on synthetic fertilizers and minimum vulnerability to environmental stress (Kole *et al*., 2015) [7].
Among the small millet crops, kodo millet (*Paspalum scrobiculatum* L.) is an important millet crop, grown in India, which is self-pollinating belongs to the family poaceae and having longest duration crop among other minor millet. It is known as harka, rice grass, ditch millet, native paspalum and Indian crown grass etc. grown as minor crop in many Asian countries, with the exception of Decan plateau in India where it is grown as a food source. Kodo millet contains 8.3 g protein, 1.4 g fat, 2.6 g minerals, 65.9 g carbohydrate and 309 kcal energy (Banerjee and Maitra, 2020) [1]. 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 kodo millet. 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) [5]. 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 and Rajput *et al.*, 2023) [8, 10]. 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 (Chavan *et al.*, 2023) [4]. 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) [11]. In view to above, present study is undertaken to study effect of nitrogen management in productivity of kodo millet (*Paspalum scrobiculatum* L.).

Materials and Methods

The experiment was carried out at instructional farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur (Chhattisgarh) during *kharif* 2023. Variety Indira kodo-1 was used for experiment. The gross plot size m x m and net plot was m x m. Row to row spacing was 30 cm. The experiment was laid out in randomized block design with three replication and consisted of seven treatments. The treatments comprised of T_1 [100% RDF (N 50% basal dose + N 50% at tillering stage)], T_2 [100% RDF (N 25% basal dose + N 50% at tillering stage + N 25% at PI stage)], T_3 (75% RDN + 1 spray of nano urea @ 2 ml litre^{-1} water at tillering stage + 100% PK), T_4 (75% RDN + 1 spray of nano urea @ 4 ml litre^{-1} water at tillering stage + 100% PK), T_5 (50% RDN + 1 spray of nano urea @ 2 ml litre^{-1} water at tillering stage + 100% PK), T_6 (50% RDN + 1 spray of nano urea @ 4 ml litre^{-1} water at tillering stage + 100% PK), T_7 [Control (100% PK only)]. The recommended dose of phosphorus (30 kg ha^{-1}) and potassium (20 kg ha^{-1}) were applied as basal through SSP and MOP, respectively. Nitrogen (40 kg ha^{-1}), applied as urea was split into doses according to treatments. Foliar spray of nano urea was applied at tillering stage of crop. Observations were recorded from random plants per treatment, focusing on various aspect of the crop, including growth and yield.

Results and Discussion

It was observed that growth and yield attributing characters like plant height, number of tillers m^{-1} row length, panicle length, number of racemes plant^{-1} were significantly influenced by different treatments, presented in Table 1.

Growth attributes

Plant height (cm): Crop growth in terms of plant height varied significantly due to the application of different level of nitrogen at all stages of crop growth. Significantly highest plant height (117. 16 cm) observed under treatment T_4 (75% RDN + 1 spray of nano urea @ 4 ml litre^{-1} water at tillering stage + 100% PK) However, it was found at par with treatment T_3 (75% RDN + 1 spray of nano urea @ 2 ml litre^{-1} water at tillering stage + 100% PK) and T_2 [100% RDF (N 25% basal dose + N 50% at tillering stage + N 25% at PI stage)]. significantly lowest plant height (64.12 cm) was observed in treatment with T_7 (Control 100% PK only). Effect of nano fertilizer on plant height of kodo millet observed significant increase due to use of nano urea with chemical fertilizers. Application of nano urea at different growth stages (foliar spray at active tillering stage) promoted growth of the plants. Nano fertilizer provides nutrients for the plant or aid in the transport or absorption of available nutrients resulting in better crop growth (Benzon *et al*., 2015; Jyothi and Hebsur, 2017) [2, 6].

Number of tillers (m^{-1} row length)

The maximum number of tillers (140.411 m^{-1} row length) was recorded in treatment of T_4 (75% RDN + 1 spray of nano urea @ 4 ml litre^{-1} water at tillering stage + 100% PK), but at par with T_3 (75% RDN + 1 spray of nano urea @ 2 ml litre^{-1} water at tillering stage + 100% PK) and T_2 [100% RDF (N 25% basal dose + N 50% at tillering stage + N 25% at PI stage)]. However, significantly lowest number of tillers (92.38 m^{-1} row length) was observed in treatment T_7 (Control 100% PK only). At tillering stage foliar spray of nano urea increases the number of tillers in treatment T_4 and T_3 as application of nano urea encourages the plant to absorb and utilize the nitrogen efficiently, which stimulate crop growth metabolism, resulted higher number of tillers. The similar finding resulted by Pal *et al.,* (2023) [9] and Chandan *et al.,* (2023) [3].

Yield attributes

Among different treatments maximum number of effective tillers (136.8 m^{-1} row length), highest number of racemes plant^{-1} (6.807), highest panicle length (8.940) was recorded under T_4 (75% RDN + 1 spray of nano urea @ 4 ml litre^{-1} water at tillering stage + 100% PK), which was close to treatment T_3 (75% RDN + 1 spray of nano urea @ 2 ml litre^{-1} water at tillering stage + 100% PK) and T_2 [100% RDF (N 25% basal dose + N 50% at tillering stage + N 25% at PI stage)]. Higher values associate with yield contributing characters *viz.*; number of effective tillers m^{-1} row length, length of panicle, number of racemes plant^{-1} under treatment T_4, T_3 and T_2 may be due to adequate supply of nitrogen through either by foliar application of nano urea combined with moderate dose of nitrogen by conventional once or split application of higher dose of nitrogen. The nano-fertilizers enhances the efficacy of conventional fertilizers, leading to optimal nutrient absorption by plant cells, thereby promoting optimal growth and metabolic processes like photosynthesis resulted maximum values for yield attributing characters. A similar result was observed by Singh *et.al.*, (2023) [12] and Pal *et.al.*, (2023) [9].

Table 1: Effect of nitrogen management on growth and yield attributes of kodo Millet

Treat.	Plant height (cm)	Number tillers (m^{-1} row length)	Number of effective tillers (m^{-1} row length)	Panicle length (cm)	Number of racemes (plant^{-1})
T_1	101.093	124.71	121.53	8.080	6.423
T_2	106.310	129.03	125.40	8.420	6.500
T_3	115.007	138.10	135.60	8.730	6.610
T_4	117.160	140.41	136.80	8.940	6.807
T_5	84.597	110.93	106.82	6.210	5.300
T_6	87.667	113.07	108.40	6.520	5.420
T_7	64.120	92.38	84.80	4.953	4.410
S.Em	3.756	3.736	3.691	0.367	0.278
CD (%)	11.701	11.639	11.499	1.144	0.868

Conclusion

On the basis of results of present investigation, the following conclusions can be drawn; 75% RDN + 1 spray of nano urea @ 4 ml litre^{-1} water at tillering stage + 100% PK gave the maximum vegetative growth parameters and yield attributes of kodo millet.

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