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Effect of Silicon nutrition on growth, yield and economics of Kodomillet

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Abstract

A field experiment was conducted at Ambagarathur Village, Thirunallar Taluk of Karaikal District during *Kharif* season (June - October, 2021) to study the effect of silicon nutrition on growth, yield and economics of kodomillet. The experiment consisted of ten treatments and were laid out in randomized block design and replicated thrice. The treatments comprised of T_1 - RDF (44:22:0 kg NPK ha^{-1}), T_2 - RDF + 25 kg Si ha^{-1} through fly ash, T_3 - RDF + 50 kg Si ha^{-1} through fly ash, T_4 - RDF + 75 kg Si ha^{-1} through fly ash, T_5 - RDF + 25 kg Si ha^{-1} through fly ash + Silicate Solubilizing Bacteria (SSB), T_6 - RDF + 50 kg Si ha^{-1} through fly ash + Silicate Solubilizing Bacteria (SSB), T_7 - RDF + 75 kg Si ha^{-1} through fly ash + Silicate Solubilizing Bacteria (SSB), T_8 - RDF + 25 kg Si ha^{-1} through Silicon Enriched Farmyard Manure (SiEFYM), T_9 - RDF + 50 kg Si ha^{-1} through Silicon Enriched Farmyard Manure (SiEFYM), T_{10} - RDF + 75 kg Si ha^{-1} through Silicon Enriched Farmyard Manure (SiEFYM). Among the different treatments tried in this study, application of 75 kg Si ha^{-1} through SiEFYM along with RDF (T_{10}) recorded higher growth attributes (plant height, number of tillers hill^{-1}, leaf area index, dry matter production), yield attributes (number of panicles hill^{-1}, filled grains panicle^{-1} and test weight) and yields (grain – 2502 kg ha^{-1} and straw- 3996 kg ha^{-1}) of kodomillet. Regarding economics, the highest gross income (₹ 79056), net income (₹ 43998) and BCR (₹ 2.25) were also recorded under application of 75 kg Si ha^{-1} through SiEFYM along with RDF (T_{10}). Therefore, it can be concluded that application of 75 kg Si ha^{-1} through SiEFYM along with RDF (44:22:0 NPK kg ha^{-1}) holds immense potentiality to uplift the productivity and profitability of kodomillet.

Kodomillet (*Paspalum scrobiculatum* L.) is one of the major food crops being cultivated in tribal areas of the country. The crop was first domesticated in southern part of Rajasthan and Maharashtra some 3,000 years ago[15]. This crop is a critical component of the dry farming ecosystem due to its wide range of adaptability, ease of cultivation and ability to tolerate biotic and abiotic stresses. In India, kodomillet is grown mostly in Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Kerala, Karnataka and Tamil Nadu. This minor cereal is locally known as varagu, kodo, haraka and arakalu. It has superior nutritional properties including high micronutrients and low glycemic index (GI). Grain contains protein: 11%, fiber: 9%, carbohydrates: 66.6g, vitamin- Band effective iron content (39.60ppm)[8]. It is used as Herbpathy for heart disease, strangury and prevention of insulin resistance, diabetes, obesity, *etc.*,[4].

Kodomillet is grown in India on marginal lands and produces high grain yield over under limited water. Currently, it is being cultivated only in India on limited acre (0.20 million ha^{-1})[6]. It is grown in area of about 9 lakh ha with annual production of about 3.1 lakh tonnes[32]. Madhya Pradesh and Tamil Nadu have maximum share in production and promotion of kodomillet. In Tamil Nadu, it occupies over an area of 70.60 thousand hectares with an annual production of 77.72 tonnes and average productivity of 538 kg ha^{-1} . Now a day's kodomillet is recommended as a substitute for rice next to finger millet to the patients who are suffering from diabetes diseases[30]. Further, the burgeoning population of our country may stabilize around 1.4 and 1.6 billion by 2025 and 2050, requiring annually 380 and 450 million tonnes of food grains, respectively[28]. To satisfy future food requirements, it is necessary to enhance the kodomillet production and productivity.

Kodomillet production is highly variable and the area is declining. The major constraints are (i). Kodomillet is grown on poor, shallow and marginal soils under rainfed conditions, which is still grown in the hilly areas under shifting cultivation (ii). The soils on which this crop is cultivated have low moisture retention capacity and (iii). Seeds are often broadcasted under unfertilized and un-weeded conditions. Among them, inadequate nutrient supply greatly affected the productivity of kodomillet. Therefore, balance supply of nutrients is essential for obtaining higher yield. In a more specific study of nutrients, an element called silicon has been found equally important as macronutrients and is gaining attention of scientist for enhancing the yield and quality of crops[17].

Silicon (Si) is the second most abundant element of the earth's surface and plays a significant role imparting biotic, abiotic stress resistance and enhancing crop productivity[3]. Silicon promotes upright growth, prevents lodging, encourages positive leaf exposure to light, provides resistance to bacterial and fungal diseases and insect pests, and also lessens some abiotic stresses such as temperatures, salinity, heavy metal and aluminium toxicity. Silicon also promotes the growth and yield of all annual and vegetable crops[11,18]. Silicon (Si) is used as a secondary element for plant growth and provide beneficial effects on soil and plant growth. Plant receives lower level of Si exhibit poor growth, development and reproduction with varying degrees depending on plant species, Silicon deficiency in plants makes them more susceptible to various bacterial and fungal diseases that adversely affect crop yield and quality. Low silicon uptake has been proven to increase the susceptibility of crop to diseases and insect pests[1,19,26]. Crop cultivation without silicon addition and continuous straw removal depleted available silicon in the soil. The depletion of plant available Si in soils where crop is grown could be a possible limiting factor that contributes to declining yields. This indicates that Si can become a yield limiting component for production; as a result, exogenous Si application may be necessary for an efficient and sustainable crop production[20]. Keeping the above facts in consideration, the present investigation was carried out to study effect of silicon nutrition on growth, yield and economics of kodomillet.

A field experiment was conducted at Ambagarathur Village, Thirunallar Taluk of Karaikal District during *Kharif* season (June–October, 2021) to study the effect of silicon nutrition on growth, yield and economics of kodomillet. The soil of the experimental field is sandy clay loam in texture. The soil was low in available nitrogen, high in available phosphorus, high in available potassium and low available silicon. The experiment was laid out in Randomized Block Design (RBD) with three replications.The treatments comprised of T_1 - RDF (44:22:0 kg NPK ha^{-1}), T_2 - RDF + 25 kg Si ha^{-1} through fly ash, T_3 - RDF + 50 kg Si ha^{-1} through fly ash, T_4 - RDF + 75 kg Si ha^{-1} through fly ash, T_5 - RDF + 25 kg Si ha^{-1} through fly ash + Silicate Solubilizing Bacteria (SSB), T_6 - RDF + 50 kg Si ha^{-1} through fly ash + Silicate Solubilizing Bacteria (SSB), T_7 - RDF + 75 kg Si ha^{-1} through fly ash + Silicate Solubilizing Bacteria (SSB), T_8 - RDF + 25 kg Si ha^{-1} through Silicon Enriched Farmyard Manure (SiEFYM), T_9 - RDF + 50 kg Si ha^{-1} through Silicon Enriched Farmyard Manure (SiEFYM), T_{10} - RDF + 75 kg Si ha^{-1} through Silicon Enriched Farmyard Manure (SiEFYM). Kodomillet variety CO3 was used in this study and was fertilized with of 40:22:0 kg NPK ha^{-1}. 50% N and 100% P_2O_5 were applied as basal. The remaining 50% N was top dressed in two equal splits at tillering and flowering stages. Fly ash, SSB and SiEFYM were applied as basal as per the treatments. Biometric observations were recorded at critical stages. The data were statistically analyzed as suggested by Gomez[12].

Growth Attributes :

The results of the study indicated that growth parameters such as plant height, number of tillers $hill^{-1}$, leaf area index and dry matter production of kodomillet crop were significantly influenced by the silicon nutrition (Table-1).

Among the various treatments tried, application of 75 kg Si ha^{-1} through SiEFYM along with RDF (T_{10}) recorded remarkably higher plant height (48.05, 83.00 and 96.04 cm during tillering, flowering and at harvesting stages, respectively), more number of tillers $hill^{-1}$ (10.08), higher LAI (4.30 and 6.02 during tillering and flowering stages, respectively) and higher DMP (3580, 4691 and 6173 kg ha^{-1} during tillering, flowering and at harvesting stages, respectively) of kodomillet. This might be due decomposition of SiEFYM releases more of silicon in available forms to plants or release of silicon mobilising compounds such as phytosiderophores to roots and induction of polypeptides involved in silicon uptake and translocation to shoots[7]. The high organic carbon content coupled with acidic reaction under reduced conditions could have favoured the formation of organic complexes and increased the availability of Si to plants by the action of SSB resulting in higher growth attributes. This is an agreement with the findings of Ahmad *et al.*[2] and Bamboriya *et al.*[5]. The lesser values of growth attributes were observed under control (T_1). Higher plant height of kodomillet might owe to increased cell division, elongation and expansion caused by silicon. This was in agreement with the findings of Yavarzadeh *et al.*[33], who reported that increase in plant height could be due to deposition of silica on the plant tissues causing erectness of leaves and stem. Tillering is the formation of growing auxiliary buds that are obviously related with the nutritional state of the mother clump. Since tillers get carbohydrates and nutrients from the mother clump during their early growth phase, and this was enhanced by silicon treatment. This is in agreement with the findings of Liang[16].

The highest LAI of kodomillet at tillering and flowering stages was due to erectness of leaves and synthesis of chloroplast resulted in higher concentration of chlorophyll per unit area of leaf tissue. This is in agreement with the findings of Adatia and Besford (1986). Higher photosynthetic activity, effective light utilisation and translocation of absorbed products to sink may be the causes

Table-1. Effect of silicon nutrition on growth attributes of kodomillet

Treat-ments	Plant height (cm)			No. of tillers hill^{-1}	LAI		DMP (kg ha^{-1})		
	Tillering	Flowering	harvesting		Tillering	Flowering	Tillering	Flowering	harvesting
T_1	28.42	57.47	67.61	5.79	0.37	1.10	1556	1908	2511
T_2	31.57	62.00	71.84	6.40	0.86	1.99	1967	2215	3283
T_3	33.68	64.81	75.22	6.97	1.19	2.43	2088	2472	3550
T_4	35.87	67.64	78.60	7.55	1.53	2.88	2214	2764	3893
T_5	36.66	68.00	77.12	7.64	1.78	3.21	2255	2843	3907
T_6	38.88	72.20	81.12	8.21	2.17	3.88	2623	3198	4429
T_7	41.07	75.00	87.12	8.79	3.63	4.43	2781	3584	4845
T_8	42.22	76.42	88.78	8.91	3.34	4.82	2861	3701	4903
T_9	45.18	79.21	92.13	9.52	3.78	5.37	3034	3976	5232
T_{10}	48.05	83.00	96.04	10.08	4.30	6.02	3580	4691	6173
SEm±	0.7	0.93	0.70	0.93	0.70	0.19	0.11	0.15	97
CD (P=0.05)	2.09	2.76	2.09	2.76	2.09	0.56	0.32	0.43	290

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Table-2. Effect of silicon nutrition on yield attributes, yield and economics of kodomillet

Treat-ments	No. of panicles hill^{-1}	No. of filled grains panicle^{-1}	Test Weight (g)	Yield (kg ha^{-1})		Economics			
				Grain	Straw	Cost of cultivation (₹ ha^{-1})	Gross income (₹ ha^{-1})	Net income (₹ ha^{-1})	BCR
T_1	14.28	56.12	6.31	1310	1333	32019	40633	8614	1.26
T_2	17.01	62.04	6.33	1515	1941	32454	47391	14937	1.40
T_3	21.85	65.88	6.34	1590	2064	32479	49764	17284	1.53
T_4	25.55	69.73	6.36	1667	2184	32505	52194	19688	1.60
T_5	26.78	70.02	6.41	1710	2255	33221	53555	20333	1.61
T_6	30.22	73.83	6.44	1823	2505	33247	57195	23947	1.72
T_7	33.56	77.36	6.47	1950	2852	33273	61352	28079	1.84
T_8	35.21	78.27	6.49	2021	2962	35033	63592	28559	1.81
T_9	39.02	81.80	6.50	2138	3369	35033	67509	32476	1.92
T_{10}	44.21	85.33	6.55	2502	3996	35058	79056	43997	2.25
SEm±	0.85	1.17	0.03	24.69	38.18	-	-	-	-
CD (P=0.05)	2.54	3.52	NS	73.43	113.43	-	-	-	-

of the highest DMP under application of 75 kg Si ha^{-1} using SiEFYM and RDF[24]. In addition, Si improves light interception by keeping leaves erect, thereby stimulating canopy photosynthesis. This is in conformity with the reports of Jawahar and Vaiyapuri,[14] and Couto *et al.*[10].

Yield Attributes and Yield :

Silicon nutrition positively influenced on yield attributes and yield of kodomillet (Table-2). Among the different treatment, application of 75 kg Si ha^{-1} through SiEFYM along with RDF (T_{10}) registered the higher number of number of panicles hill^{-1} (44.21) and filled grains panicle^{-1} (85.33) and also recorded higher test weight (6.55 g). Panicle formation is directly related with the number of productive tillers, which resulted in higher number of panicles hill^{-1}. Increase in filled grain number was due to better assimilation of carbohydrate in panicles (Chaudhary and Bodiuzzaman[9]). Higher test weight was attributed to better availability and translocation of nutrients as well as photosynthates from source to sink due to Si. The same treatment recorded highest grain (2502 kg ha^{-1}) and straw yield (3996 kg ha^{-1}) of kodomillet. This might due to effective utilization of plant available Si in the soil released from SiEFYM which increased the higher yield attributing characters resulted in higher grain and straw yield.

Sufficient silicon supply to the crop

enhanced photosynthetic activity and allowed the plant to accumulate sufficient photosynthates, which led to an increase in dry matter production. These factors caused effective translocation, produced more filled grains and higher test weight, which eventually boosted grain and straw yield[23]. These findings were in agreement with the reports of Vishwanath[31], Peera *et al.*[22] and Raquel *et al.*[25]. Highest grain and straw yield due to application of silicon could be due to increased growth and yield characters through reduction in biotic and abiotic stresses which improved plant growth and greater photosynthetic activity (Patil *et al.,*[21] and Singh and Dhillon[29]). The lesser grain and straw yield of kodomillet was recorded under application of RDF alone (T_1).

Economics :

The economics of the kodomillet was significantly influenced by silicon nutrition (Table-2). Among the various treatments tried, application of 75 kg Si ha^{-1} through SiEFYM along with RDF (T_{10}) recorded the higher gross income of ₹ 79056, net income of ₹ 43997 and BCR of ₹ 2.25. This could be due to higher grain and straw yield over other treatments. Similar results were earlier reported by Jawahar *et al.*[13] and Sharma *et al.*[27]. The lesser gross income of ₹ 40633, least net income of ₹ 8614 and BCR of ₹ 1.26 was recorded under application of RDF alone (T_1).

The experimental results enlightened that there was a marked variation on the productivity of kodomillet due to silicon nutrition. In the light of the above said fact, it can be concluded that application of 75 kg Si ha^{-1} through SiEFYM along with recommended dose of fertilizers (T_{10}) is holding immense potentiality to boost the productivity and profitability of kodomillet. Therefore, this treatment can be recommended to the farming community.

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