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Effect of silica and potash on yield and quality of cashewnut (*Anacardium occidentale* L.) in lateritic soils of Konkan

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Abstract
A field experiment was conducted to study the 'Effect of silica and potash on yield and quality of cashewnut (*Anacardium occidentale* L.) in lateritic soils of Konkan', at Rukhi Block of All India Co-ordinated Research Project on Irrigation Water Management, Central Experimental Station, Wakawali, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, during the year 2022-23 to 2023-24. The experiment was laid out in Factorial Randomized Block Design consisting two factors viz. three levels of potash (K_0, K_1 and K_2) and five levels of silica with soil (S_0, S_1, S_2) and foliar application (S_3 and S_4) at flowering and nut development stage, comprising fifteen treatment combinations and three replications. There were two trees were selected for each treatment. Total ninty uniform cashew trees of variety *Vengurla*-4 were selected from the orchard at the slope of the hill. The quality parameters includes protein and oil content (%), in which protein was significantly affected by various treatments.

Keywords: Silica, potash, cashewnut, yield, quality, lateritic soils

Introduction
Cashew is grown on a diverse range of soils, from the sandy sea-coast to laterite hill slopes, pure sandy soils to sandy loam, laterite soil, deep loam and red latosols, but many of these soils have low effective cation exchange capacities and low exchangeable base status. It is also grown on black soils in Tamil Nadu and Andhra Pradesh to a limited extent. Although it is grown in almost all types of soils, it performs better in well drained, brown forest soils, red sandy loam and light coastal soil with a high water holding capacity and rich in organic matter. Bulk of the cashew-growing soils in India are lateritic, red and coastal sands which are acidic in nature and poor in soil fertility. The run-off and soil erosion are very high in steep slopes. The deficiencies of nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), zinc (Zn), boron (B) and molybdenum (Mo) are on the rise in cashew growing soils. Cashew plant being deep rooted removes large quantities of nutrients from the soil. Due to its extensive root system, cashew can draw its nutrients from large volume of soil, and as a result it can perform reasonably well on poor soils where other crops fail to do so. It has been estimated that for every one kg of cashew nut produced the plant depletes the soil by 64.1 g N, 2.05 g P, 24.7 g K.

Potassium is the second largest nutrient next to N required by cashew. Potassium is necessary for several basic physiological functions like the formation of sugars and starch, synthesis of proteins, normal cell division and growth, and neutralization of organic acids. It helps reduce the influence of adverse weather conditions like drought, cold, and flooding. Significant positive effects of K on growth, nut weight and yield of cashew are reported by several researchers. Of different sources of K fertilizers, muriate of potash (potassium chloride) is most commonly used fertilizer in cashew.

Silicon (Si) is the second most common element on earth's crust. It comprises approximately 28% of the earth crust and supposed to be beneficial element to improve plant growth, development and productivity. Besides this, silicon is also helpful in promoting mechanical strength, light interception and resistance to various biotic and abiotic stresses, improving both quantity and quality of production.

Although Si is universal in nature, evidence of its essence for higher plants is still lacking. According to scientific literature, however, Si is conducive to the healthy growth of plants directly or indirectly. Si may be applied through soil as well as foliar application. Under stressful conditions, it acts as a bio stimulant and exhibits optimistic results. The use of silicon fertilizers provides rigidity and reverses the succulence induced by high nitrogen, paving the way for a higher crop yield.

An attempt has to be made by managing strategies which are essential for the successful maintenance of commercial cashew plantation. Considering the rapidly increasing demand for cashew products large quantity of seeds are required for processing, which can be achieved by developing high yielding varieties and bringing the new area under plantation but there is limitation. The nutrients applied to cashewnut orchards are subjected to leaching due to high rainfall. Therefore, nutrient management under such condition deserves proper attention.

Material and Methods

The field experiment was conducted on typical lateritic soil under the Very High Rainfall Lateritic Zone (VRL) of the Konkan region of the Ratnagiri district during kharif season of the year 2022-23 and 2023-24. The field experiment was laid out in Factorial Randomized Block Design (FRBD) comprising of fifteen treatment combinations replicated thrice All India Co-ordinated Research Project on Irrigation Water Management, Rukhi Block, Central Experiment Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.). The treatment details were as Absolute control (K_0S_0), No Potash + 100 g Si granules plant^{-1} (K_0S_1), No Potash + 200 g Si granules plant^{-1} (K_0S_2), No Potash + 0.8% Silicic acid @ 1 ml L^{-1} (K_0S_3), No Potash + 0.8% Silicic acid @ 2 ml L^{-1} (K_0S_4), 250 g K_2O tree^{-1} + No Silica (K_1S_0), 250 g K_2O tree^{-1} + 100 g Si granules plant^{-1} (K_1S_1), 250 g K_2O tree^{-1} + 200 g Si granules plant^{-1} (K_1S_2), 250 g K_2O tree^{-1} + 0.8% Silicic acid @ 1ml L^{-1} (K_1S_3), 250 g K_2O tree^{-1} + 0.8% Silicic acid @ 2 ml L^{-1} (K_1S_4), 375 g K_2O tree^{-1} + No Silica (K_2S_0), 375 g K_2O tree^{-1} + 100 g Si granules plant^{-1} (K_2S_1), 375 g K_2O tree^{-1} + 200 g Si granules plant^{-1} (K_2S_2), 375 g K_2O tree^{-1} + 0.8% Silicic acid @ 1 ml L^{-1} (K_2S_3), 375 g K_2O tree^{-1} + 0.8% Silicic acid @ 2 ml L^{-1} (K_2S_4). The various yield and quality parameters were calculated as per the details given below.

Results and Discussion

A. Effect of silica and potash application on yield of cashewnut.

Nut yield (kg tree^{-1} and q ha^{-1})

The data regarding the nut yield as affected by various treatments are showed in Table 1.

Table 1: Effect of silica and potash application on nut yield (kg tree^{-1} and q ha^{-1})

Year-2022-23

Treatments	kg tree^{-1}				q ha^{-1}			
	K_0	K_1	K_2	Mean	K_0	K_1	K_2	Mean
S_0	10.32	12.43	12.04	11.60	21.05	25.36	24.56	23.66
S_1	11.37	13.12	13.18	12.56	23.19	26.77	26.89	25.62
S_2	11.86	11.99	14.75	12.87	24.19	24.47	30.09	26.25
S_3	12.08	12.19	12.20	12.16	24.64	24.87	24.89	24.80
S_4	13.39	11.90	12.04	12.44	27.32	24.28	24.56	25.39
Mean	11.80	12.33	12.84	12.32	24.08	25.15	26.20	25.14
	K	S	K X S		K	S	K X S	
S.Em.+	0.22	0.28	0.49		0.45	0.58	1.00	
C.D. at 5%	0.64	0.82	1.42		1.30	1.68	2.90	
	SIG	SIG	SIG		SIG	SIG	SIG	

Year-2023-24

Treatments	kg tree^{-1}				q ha^{-1}			
	K_0	K_1	K_2	Mean	K_0	K_1	K_2	Mean
S_0	11.90	10.72	11.41	11.34	24.27	21.88	23.28	23.14
S_1	12.11	14.31	15.68	14.04	24.71	29.20	31.99	28.63
S_2	12.31	16.05	14.55	14.30	25.11	32.74	29.68	29.17
S_3	11.66	12.52	15.81	13.33	23.79	25.53	32.26	27.19
S_4	13.45	11.95	15.34	13.58	27.44	24.37	31.29	27.70
Mean	12.29	13.11	14.56	13.32	25.06	26.74	29.70	27.17
	K	S	K X S		K	S	K X S	
S.Em.+	0.22	0.29	0.50		0.46	0.59	1.02	
C.D. at 5%	0.65	0.84	1.45		1.32	1.71	2.96	
	SIG	SIG	SIG		SIG	SIG	SIG	

Effect of different levels of silica

Nut yield was significantly impacted by the varying silica levels. In 2022-23 and 2023-24, the nut yield varied from 23.66 to 26.25 q ha^{-1} and 23.14 to 29.17 q ha^{-1}, respectively. Treatment S_2, which received 200 g of OSA through silica granules tree^{-1}, showed the highest nut output (26.25 q ha^{-1}) in the year 2022-23, which was at par with the treatments S_1, S_3, and S_4. In 2023-24, treatment S_2, which received 200 g of OSA through silica granules tree^{-1}, produced the maximum nut production (29.17 q ha^{-1}), which was at par with the treatments S_1 and S_4.

Effect of different levels of K

The different levels of K showed a significant influence on nut yield. The nut yield ranged from 24.08 to 26.20 q ha^{-1} and 25.06 to 29.7 0 q ha^{-1} in the year 2022-23 and 2023-24;

respectively. The highest nut yield (26.20 and 29.70 q ha^{-1}) was observed in the treatment K_2 i.e. treatment receiving 375 g of K_2O $tree^{-1}$ and was at par with the treatment K_1 in the year 2022-23 and significantly superior over treatments K_0 and K_1 in the year 2023-24.

The interaction effect

The different levels of silica and levels of K showed a significant influence on nut yield. The nut yield ranged from 21.05 to 30.09 q ha^{-1} and 21.88 to 32.74 q ha^{-1} in the year 2022-23 and 2023-24; respectively. The highest nut yield (30.09 q ha^{-1}) was observed in treatment K_2S_2 i.e. treatment receiving 375 g of K_2O $tree^{-1}$ along with 200 g of OSA through silica granules $tree^{-1}$ and was at par with the interactions K_0S_4 during first year of experimentation. In the year 2023-24, the highest nut yield (32.74 q ha^{-1}) was observed in treatment K_1S_2 i.e. treatment receiving 250 g of 68 K_2O $tree^{-1}$ along with 200 g of OSA through silica granules $tree^{-1}$ and was at par with the interactions K_2S_1, K_2S_3 and K_2S_4.

The pronounced increase in the content of nitrogen, phosphorus and potassium in plants by addition of potassium to soil could be due to increase in yields as well as increase in the concentration of NPK in stover and kernels. According to Abdul Salam (1997) the response of cashew to the major nutrients is in the order of N, K and P. The N and K nutrition play significant role in enhancing the production and productivity of 69 cashew.

Latha *et al*., (1996) [4] conducted an experiment on response of cashew to nutrient application in laterite soil at College of Horticulture, Vellanikkara, and resulted potash is identified to play an important role in the production of cofactors and enzymes and consequently higher metabolic activities. K is reported to promote the growth of meristematic tissues. A yield level of 8-9 kg $tree^{-1}$ was obtained at higher levels of individual nutrients or at their combinations. This yield was seven times higher than the yield in the absolute control where no fertilizer application was done since planting and sixteen times higher than the average national productivity.

There was significant increase in the yield with increased levels of silicon. This might be due to role of silicon in improvement of photosynthetic activity, water and nutrient use efficiency. That ultimately results into better vegetative growth. The higher yield was mainly associated with increased leaf area and number of nuts. The accumulation of silicon in plant parts reduces its lodging and enhanced resistance against biotic and abiotic stress. All these factors ultimately might have resulted into higher yield (Sudhakar *et al*., 2006) [11]. These results are in conformity with the findings of Mongia *et al*. (2003) [6], Singh *et al*. (2007) [10], Arekar (2012) [2] and Jawahar *et al*. (2015) [3].

Further, in this connection, Malav and Ramani (2017) [5] explained that the increase in the yield with Si application could be due to beneficial effects because increased availability of silicon viz., decreasing mutual shading by improving leaf erectness, decreasing susceptibility to lodging, decreasing the incidence of infections with root parasites and pathogens, leaf pathogens and preventing manganese and iron toxicity or both. Increased water use efficiency observed with the application of Si, probably might be due to prevention of excessive transpiration.

The beneficial response of silica and potash through different treatments the nut yield in cashew orchard was found to be increased over absolute control during both years of the experimentation, might be attributed to the availability of sufficient amount of plant nutrients throughout the year to the crop, improvement of soil environment resulting in higher root proliferation leading to better absorption of moisture and nutrients, plant vigor and ultimately higher yield.

B. Effect of silica and potash application on quality of cashewnut

Protein content (%)

The data regarding the protein content of the nut as affected by various treatments is showed in Table 2.

Effect of different levels of silica

The different levels of silica showed a significant influence on nut protein content. The nut protein content ranged from 21.12 to 21.62% and 21.69 to 22.42%. The highest nut protein content (21.62% and 22.42%) was observed in treatment S_2 i.e. treatment receiving 200 g of OSA through silica granules $tree^{-1}$, during both the year of experiment 2022-23 and 2023-24; respectively.

Effect of different levels of K

The different levels of K showed a significant influence on protein content of nuts. The value of nut protein content ranged from 20.85 to 22.01% and 21.45 to 23.27%. The highest nut protein content (22.01 and 23.27%) was observed in treatment K_2 i.e. treatment receiving 375 g of K_2O through MOP $tree^{-1}$, in the year 2022-23 and 2023-24; respectively.

Table 2: Effect of silica and potash application on quality of cashewnut.

Year-2022-23

Treatments	Nut protein content (%)				Nut oil content (%)			
	K_0	**K_1**	**K_2**	**Mean**	**K_0**	**K_1**	**K_2**	**Mean**
S_0	20.47	20.44	22.45	21.12	42.33	43.00	42.33	42.56
S_1	20.97	21.69	21.75	21.47	43.33	43.67	46.00	44.33
S_2	20.70	22.16	21.99	21.62	41.00	46.00	47.00	44.67
S_3	21.56	21.64	21.15	21.45	42.33	45.67	44.33	44.15
S_4	20.54	20.72	22.71	21.32	42.33	44.00	45.33	43.89
Mean	20.85	21.33	22.01	21.40	42.27	44.47	45.00	43.91
	K	S	K X S		K	S	K X S	
S.Em.+	0.09	0.11	0.19		1.3	1.6	2.8	
C.D. at 5%	0.25	0.32	0.56		3.7	4.7	8.2	
	SIG	SIG	SIG		NS	NS	NS	

Year-2023-24

Treatments	Nut protein content (%)				Nut oil content (%)			
	K_0	**K_1**	**K_2**	**Mean**	**K_0**	**K_1**	**K_2**	**Mean**
S_0	21.25	20.87	22.94	21.69	42.67	44.00	44.67	43.78
S_1	21.21	22.37	23.41	22.33	41.33	45.33	49.33	45.30
S_2	21.73	22.64	22.88	22.42	46.33	43.33	47.33	45.65
S_3	21.52	22.11	23.40	22.35	41.67	44.00	46.67	44.11
S_4	21.54	21.95	23.69	22.39	42.00	45.00	45.00	44.00
Mean	21.45	21.99	23.27	22.24	42.80	44.33	46.60	44.58
	K	S	K X S		K	S	K X S	
S.Em.+	0.11	0.14	0.24		0.6	0.7	1.2	
C.D. at 5%	0.31	0.40	0.69		1.6	2.1	3.6	
	SIG	SIG	SIG		SIG	NS	NS	

The interaction effect

The different levels of silica and levels of K showed a significant influence on nut protein content. The value of nut protein content ranged from 20.44 to 22.71% and 20.87 to

23.69%. The highest nut protein content (22.71 and 23.69%) was observed in treatment K_2S_4 i.e. treatment receiving 375 g of K_2O through MOP tree^{-1} along with foliar application of 2 ml of silicic acid through silixol liter^{-1} tree^{-1} during both the years of experimentation 2022-23 and 2023-24; respectively.

In general, due to application of silica and potash through different treatments the protein content in cashew kernel was found to be increased over absolute control during both years of the experimentation. These ranges are agreement with Ohler (1979) [7] and Rico (2015) [8]. The beneficial effect of foliar sprays on fruit quality were attributed to their vital role in stimulating both cell division as well as biosynthesis and translocation of food in favors of enhancing growth and fruiting of tree (Sarrwy *et al*. 2010) [9]. Tandon (1992) [12], in addition to this, reported the positive interaction of N and S in plant as both these nutrients are vital constituents of protein.

Oil content (%)

The data regarding the oil content of the nut as affected by various treatments is presented in Table 2.

Effect of different levels of silica

The different levels of silica did not show any significant influence on oil content of nuts during first year of experiment, but it is significantly affected during second year of experimentation 2023-24. The nut oil content ranged from 42.56 to 44.67% and 43.78 to 45.65%. The highest oil content (44.67% and 45.65%) was observed in treatment S_2 i.e. treatment receiving 200 g of OSA through silica granules tree^{-1} in the year 2022-23 and 2023-24; respectively.

Effect of different levels of K

The different levels of K did not show any significant influence on oil content of nuts. The value of nut oil content ranged from 42.27 to 45.00% and 42.80 to 46.60%. The highest nut oil content (45.00 and 46.60%) was observed in treatment K_2 i.e. treatment receiving 375 g of K_2O through MOP tree^{-1} during both the year of experimentation, 2022-23 and 2023-24; respectively.

The interaction effect

The different levels of silica and levels of K showed non-significant influence on oil content of nuts. The value of nut oil content ranged from 41 to 47% and 41.33 to 49.33 % in the year 2022-23 and 2023-24; respectively. In the year 2022-23, the highest nut protein content (47.00%) was observed in treatment K_2S_2 i.e. treatment receiving 375 g of K_2O through MOP tree^{-1} along with 200 g of OSA through silica granules tree^{-1}. In the year 2023-24, the highest nut protein content (49.33%) was observed in treatment K_2S_1 i.e. treatment receiving 375 g of K_2O through MOP tree^{-1} along with 100 g of OSA through silica granules tree^{-1}.

Conclusion

From the present experimental findings, it is concluded that the combined application of silica and potash through different treatments resulted in increase in protein content of cashew kernel. Further, treatment K_2S_2 i.e treatment receiving application of 375 g of K_2O through MOP and 200 g OSA through silica granules tree^{-1} showed highest nutrients availability that leads to higher yield in the same treatment followed by K_2S_1 i.e treatment receiving application of 375 g of K_2O through MOP and 100 g OSA through silica granules as full basal dose along with RDF and foliar sprays of silicon will sustain productivity in lateritic soils of Konkan.

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