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Management of K, S, Ca and Mg for productivity improvement of kacholam (*Kaempferia galanga* L.) intercropped in coconut

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Kacholam (*Kaempferia galanga* L.) is a high value medicinal and aromatic herb which is in great demand in the medicinal and perfumery industries. The rhizomes also find an important place in indigenous medicine. Kacholam is well suited for cultivating in shaded conditions. Nair *et al.* (1991) showed that yield of plumbago, rauvolfia, catharanthus and kacholam when grown under natural shade of coconut, was on par with the yield obtained under open conditions. Being suited for intercropping in coconut and arecanut plantations, kacholam has attained the status of a cash crop in homesteads of Kerala, where the climatic and soil conditions are optimum to the cultivation of the crop. Kacholam is reported to respond to application of sulphur (S) and magnesium (Mg) and it is also opined that the recommendation of potassium (K) for the crop is inadequate (Gangadharan, 2003). Similarly, Bose *et al.* (2008) have reported that inclusion of S and Mg in the fertilization schedule dramatically improved the fresh yields of turmeric in the depleted red lateritic soils of West Bengal. Hence, an experiment was laid out to study the effect of increased dose of K and application of S, Ca and Mg on the yield and quality of kacholam.

The experiment was carried out in the Department of Agronomy, College of Horticulture, Vellanikkara during the year 2010-11. The soil of the experiment site is sandy clay loam in texture, with a pH of 5.3. Available N, P, K, Ca, Mg and S contents in the soil were 756, 22.3, 356, 21, 76.2, and 22.4 kg ha^{-1} respectively. The experiment was laid out in randomised block design with 3 replications. Spacing adopted was 20 x 15 cm. The experimental site was a coconut garden with the palms spaced at 7.5 m, and kacholam was planted in the interspaces of coconut. In the coconut garden consisting of 35 to 40 year old palms, light infiltration, as measured by a digital lux meter, was about 40 per cent. The experiment consisted of twelve treatments with different combinations of fertilizers. Treatments were as follows;

T_1 : POP (Package of practices) *i.e.*, 20 T farmyard manure (FYM) and 50:50:50 kg N, P and K ha^{-1}; (½ N, entire P and ½ K applied 1 month after planting (MAP) and ½ N and ½ K applied 3 MAP).

T_2 : 10 T FYM and NPK as in POP

T_3 : POP plus 20 kg S ha^{-1} applied 1 MAP

T_4 : POP plus 20 kg S ha^{-1} applied 3 MAP

T_5 : POP plus additional 25 kg K ha^{-1} applied 3 MAP

T_6 : T_5 plus 20 kg S ha^{-1} applied 1 MAP

T_7 : T_5 plus 20 kg S ha^{-1} applied 3 MAP

T_8 : POP plus 20 kg S and 20 kg Ca ha^{-1} applied 1 MAP

T_9 : POP plus 20 kg S and 20 kg Mg ha^{-1} applied 1 MAP

T_{10}: NPK (as in POP) alone

T_{11}: FYM (as in POP) alone

T_{12}: Absolute control

Sulphur was applied in the form of ammonium sulphate, while Ca and Mg were applied as calcium sulphate and magnesium sulphate.

Rhizome bits were planted during May-June with the receipt of 4 to 5 pre-monsoon showers. Observations were recorded on dry matter accumulation, rhizome yield, oleoresin and essential oil contents. Harvesting was done during January, when yellowing and drying of leaves was observed. The essential oil (% v/w) content was estimated using Clevenger's apparatus and oleoresin content (% v/w) by soxhlet extraction method. The data was analysed using the statistical package MSTAT-C (Freed, 1986).

Data on dry matter accumulation (dry weight of both leaves and roots) recorded at 2½ and 5 months after planting, fresh rhizome yield, oleoresin and essential oil contents are presented in Table 1. Rhizome formation had not started at 2½ months' stage. At this stage, application of S and Mg along with POP recommendation (treatment T_9) resulted in highest dry matter production, *i.e.*, 1122 kg ha^{-1}. A comparable dry matter accumulation was recorded in T_2 when FYM dose was reduced to half. T_3 and T_8 were on a par with these treatments. At 5 months after planting, treatment differences were not so significant. All the treatments where POP was adopted produced similar dry matter, except for T_5. In the last three treatments, where either farmyard manure or fertilizers or both were avoided, dry matter production was significantly less. Absolute control produced the lowest value of 1350 kg ha^{-1}.

Significant difference was observed between treatments with respect to fresh rhizome yields. Treatments, where S was applied alone either as first (T_3) or second (T_4) top dressing along with package of practice recommendation produced higher yields (8.56 and 8.19 t ha^{-1} respectively) along with T_9 (8.24 t ha^{-1}), in which both S and Mg were top dressed. Treatments where an additional dose of K was given (T_5, T_6 and T_7) recorded lower rhizome yields. Absolute control (complete avoidance of fertilizer and manures) recorded the lowest yield of 4.43 t ha^{-1}. The role of S in increasing rhizome yield in kacholam is strongly brought out. The beneficial effects of Ca and Mg are also evident. Similar report was made by Singh and Dwivedi (1993) that maximum tuber yields in potato were obtained when S was applied through gypsum. Sulphur being one of the recommended fertilizers for ginger in Bangladesh where it is applied at a dose of 20 kg ha^{-1} (Halder *et al*., 2007) further substantiates the positive effect of S on productivity of rhizomatous crops. Gangadharan and Menon (2003) had speculated on the improvement in the development of qualitative

Table 1. Dry matter accumulation, rhizome yield, oleoresin and essential oil contents as influenced by nutrient management

Treatment No.	Treatment	Dry matter (kg ha^{-1})		Fresh yield (t ha^{-1})	Oleoresin (%)	Essential oil (%)
		2 ½ MAP	5 MAP			
T_1	POP	850^{bcd*}	2622^{a}	5.94^{bc*}	3.00^{a*}	0.80^{b}
T_2	POP less 10 t FYM	1083^{a}	2428^{a}	6.28^{b}	2.53^{bc}	0.80^{b}
T_3	POP + S 1 MAP	1017^{ab}	2389^{a}	8.56^{a}	3.07^{a}	1.08^{ab}
T_4	POP + S 3 MAP	833^{bcd}	2361^{a}	8.19^{a}	3.07^{a}	1.49^{a}
T_5	POP + K 3 MAP	866^{bcd}	1917^{b}	5.84^{bc}	2.40^{cd}	0.96^{b}
T_6	POP + K + S 1 MAP	644^{ef}	2617^{a}	5.80^{bc}	2.50^{c}	0.96^{b}
T_7	POP + K + S 3 MAP	761^{cde}	2500^{a}	5.99^{b}	2.43^{cd}	0.93^{b}
T_8	POP + S + Ca	944^{abc}	2417^{a}	7.64^{a}	2.37^{cd}	1.13^{ab}
T_9	POP + S + Mg	1122^{a}	2322^{a}	8.24^{a}	2.33^{cd}	1.26^{ab}
T_{10}	50:50:50 kg N, P, K	749de	1744^{bc}	5.57^{bcd}	2.87^{ab}	1.10^{ab}
T_{11}	FYM alone	566^{f}	1400^{ed}	4.74^{cd}	2.40^{cd}	0.80^{b}
T_{12}	Absolute control	516^{f}	1350^{d}	4.43^{d}	2.07^{d}	0.80^{b}

*In a column, means superscribed by common letters do not differ significantly at 5% level by DMRT
MAP - months after planting; POP - Package of practices recommendations

Table 2. Direct and indirect effect of nutrients on fresh rhizome yield of kacholam

	N	P	K	Ca	Mg	S	Oleo resin	Oil	rc
N	0.0333	-0.0581	0.1105	-0.0760	-0.0390	0.0067	-0.0818	-0.1158	-0.2203
P	-0.0105	0.1849	-0.1328	0.1938	0.1013	-0.0057	0.2139	0.1377	0.6824**
K	-0.0150	0.1001	-0.2452	0.1996	0.0739	0.0129	0.1735	0.1308	0.4305**
Ca	-0.0095	0.1350	-0.1846	0.2652	0.1205	0.0032	0.2101	0.1728	0.7128**
Mg	-0.0086	0.1232	0.1192	0.2104	0.1519	-0.0013	0.2154	0.1362	0.7080**
S	-0.0033	0.0158	0.0470	-0.0126	0.0030	-0.0671	-0.0497	-0.0130	-0.0800
Oleoresin	-0.0089	0.1293	-0.1391	0.1822	0.1070	0.0109	0.3059	0.2208	0.8080**
Oil	-0.0122	0.0807	-0.1017	0.1453	0.0656	0.0028	0.2141	0.3158	0.7100**

Residual: 0.2138

components, *i.e.*, the essential oil and oleoresin contents, in kacholam by the application of $MgSO_4$.

Significant differences among different treatments in the case of essential oil and oleoresin were also observed. Oleoresin content of rhizomes ranged from 2.07 to 3.07 per cent. As in the case of rhizome yield, application of S, either at 1 MAP or 3 MAP (T_3 and T_4) resulted in higher oleoresin content (3.07%). Though the package of practice recommendations (T_1) did not produce high yields, oleoresin content (3%) was seen to be comparable with the best treatment. Highest essential oil content was recorded when S was top dressed 3 MAP (1.49%), followed by the treatment where Ca and Mg were applied along with S (T_9). Similar findings were reported by Kumar *et al*. (2004), who observed that combined application of N and S increased the quercitin content in pluchea. Increasing the K dose resulted in reduction in oleoresin and essential oil contents. This can be related to lower rhizome yields in these treatments. Both oleoresin and essential oil were lowest in absolute control.

To find out the level of contribution of major and secondary nutrients at various growth stages on the rhizome yield, path co-efficient analysis was carried out. Data on the direct and indirect effects of major and secondary nutrients as well as oleoresin content and essential oil content in the rhizomes at harvest on fresh rhizome yield are presented in Table 2.

At harvest, the Ca content showed significant positive effect (0.265) on fresh rhizome yield, while K had a negative effect (-0.245). Oleoresin and essential oil content, as well as P and Mg contents also had positive direct effects. Comparing the values of correlation co-efficients, it was seen that P, K, Ca, Mg, oleoresin and essential oil contents were significantly and positively correlated with fresh rhizome yields. The beneficial effects of Ca and Mg in combination with S are clear, as both these elements were applied in the form of either Ca or Mg sulphates.

Sulphur was identified as an important nutrient, playing a key role in growth, yield and quality of kacholam. The yield, essential oil and oleoresin contents were increased when S was applied, either at one month or three months after planting. Ca and Mg application, in combination with S, also had a positive effect on yields. The involvement of secondary nutrients in quantitative and qualitative yield development necessitates their inclusion in nutritional schedules of crops.

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