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Effect of Application of K and Na on Growth and Yield of Coleus (Solenostemon Rotundifolius)

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Abstract: *Potassium (K) is considered essential for the growth of all plants. Tuber crops, especially, have a high requirement of K. But no potash fertilizer is manufactured in India. Muriate of potash, the sole source of K, is being imported and this makes the material costly. Sodium is essential only for halophytes. But it is reported to have beneficial effects on the growth of many plants when used in combination with K. In this study, the interactive effect of K and sodium on the growth, yield and nutrient concentration of coleus, a minor tuber crop of the tropical region was investigated in field experiment. Treatments of 50 and 100 kg K* ha^{-1} *in combination with 50, 75 and 100 kg Na* ha^{-1} *were tested in randomized bloc design with full recommended dose of 100 kg K* ha^{-1} *as control. A synergistic interaction between K and Na at 50:50 proportions was noticed as revealed by the observed higher values of growth parameters.*

Keywords: *Sodium · Potassium · Coleus · MOP · Nutrients*

1. Introduction

Potassium (K) is one of the major nutrients required for the growth of all plants. Root crops, especially, have a high requirement for K compared with cereals. It plays the key role in the root yield of tuber crops by increasing photosynthetic efficiency. A high level of K increases leaf area duration and suppresses excessive leaf growth resulting in higher root yield (Hahn 1977). Sodium is reported to be essential only for halophytes. Even though sodium is not considered as an essential element for higher plants, beneficial effects have been reported in many plants by application of sodium salts, especially in soils with low K status. Tisdale et al. (1992) reported that under limited K supply, Na can perform some of the normal functions of K such as Maintenance of ionic balance, which is necessary for physiological processes. It was observed by Ivahupa et al. (2006) that Na ameliorated symptoms of K deficiency and increased growth in tuber crops like tannia, and sweet potato. According to Marschner (1995) the increased growth observed in the case of many natrophilic species in presence of Na^+ in the culture solution is attained by a stimulation of cell and therefore leaf expansion. This is attributed to sodium working more efficiently that K^+ as an osmoticum, thereby allowing greater turgor pressure to develop in cells causing enhanced expansion and growth. Similar growth stimulative effects of Na have been reported in cassava by sudharmaidevi and Padmaja (1999). The beneficial aspects of Na^+ in plants have prompted the practice of applying NaCl (as common salt) as a fertilizer to crop plants.

Coleus (Solenostemon rotundifolius), also known as Chinese potato is a minor tuber crop grown in the tropics, especially in India and Sri Lanka. It is a short duration crop of 4-6 months, cultivated for its edible tubers, which have special flavor and taste and used as vegetable. The plant is a small, herbaceous, bushy annual with succulent stems and aromatic leaves. It has got comparatively a high requirement of K than the other elements. But K fertilizer (muriate of potash) is being imported in India and therefore is costly. Hence it became necessary to find out a cheap, indigenous material which can be used as substitute for muriate of potash. Studies conducted earlier by Sudharmaidevi and Padmaja (1999) in cassava have shown that Na as common salt, used as a partial substitute for K of muriate of potash, increased yields of cassava tubers. They observed a synergistic interaction between K and Na leading to a better growth and thereby yield. Hence this study was undertaken to find out the effects of interaction of K and Na on the growth, yield and nutrient concentration of coleus, a minor tuber corp.

2. MATERIALS AND METHODS

A field experiment was conducted at the College of Agriculture, Kerala Agricultural University, Thiruvananthapuram (8^{o}30/E latitude, 29 m above MSL), with Sridhara variety of Coleus. The treatments included 50 and 100 kg K ha^{-1} in combination with 50, 75 and 100 kg Na ha^{-1}. The full recommended dose of 100 kg K ha^{-1} was taken as control. K was supplied as muriate of potash (50%) and Na was supplied as common salt (39.3% Na). Cattle manure, N and P were applied uniformly to all plots at the rates of 10 t ha^{-1} 60 and 60 kg ha^{-1}, respectively. The mean rainfall of the location during the cropping season was 639.0 mm, the mean maximum and minimum temperature were 32.2 and 20.7 ^{o}C, respectively. The soil of the experimental site (Rhodic Haplustult) was acidic in reaction with an electrical conductivity of 0.01 d Sm^{-1}. The physical and chemical characteristics of the soil are given in Table 1. The experiment was laid out in randomized block design with seven treatments and three replications.

Plants spread was measured by taking the diameter of the spread of selected plants in each plot. Leaf Area Index was calculated as described by Watson (1952).

Table 1. *Physical and chemical characteristics of the soil of the experimental site*

S. no.	Properties	Values
1	pH	5.6
2	EC (d Sm$^{-1)}$	0.01
3	CEC (C mol (p$^+$) kg $^{-1}$	3.2
4	Organic carbon (%)	0.64
5	Available N (kg ha^{-1})	301
6	Available P (kg ha^{-1})	89
7	Available K (kg ha^{-1})	142
8	Available N (kg ha^{-1})	219
9	Exchangeable Ca (c mol kg^{-1})	1.8
10	Exchangeable Mg (c mol kg^{-1})	0.6

Chlorophyll content in samples from first mature leaves of selected plants was determined using a Spectrophotometer (Systronics Model 169). Relative leaf water content was determined by the modified method proposed by Slatyer and Barrs (1965). The economics of cultivations was worked out considering the cost of cultivations and income derived from the plant. Statistical methods of analysis were applied to find out the relationship between variables and to draw definite conclusions.

3. RESULT AND DISCUSSION

Plant Spread

The treatments receiving 50 K + 50 Na showed the highest value of plant spread which was recorded at 2 months after planting (Table 2). There was an increase of 31% in plant spread in this treatment when compared to the control plot of 100 kg K alone. Comparable values were obtained in the case of treatments receiving either K on Na in 50:100 combinations. But when the plants received K and Na at 100:100 combinations, a reduction in plant spread was noticed. The highest value of plant spread in 50:50 combination showed that the two elements interacted synergistically at this concentration. But as the concentration of both elements increased, this synergistic effect was found to decrease. That is expressed by the lower values of plant spread. Stimulation of growth by application of Na has been reported in several plants (Aslam 1975; Elsie et al. 2000; Isroismail 2007).

Number of Functional Leaves

When K and Ka were present in the treatments, the number of functional leaves recorded higher values than treatment with K alone (Table 2). As the concentration of Na and K increased, the number of functional leaves also increased. Prema et al. (1987) reported an increase in number of leaves in coconut when 50% K was substituted by Na. Devasenapathy et al. (1996) obtained an increase in number of functional leaves of coconut when NaCl @ 1 kg tree^{-1} was applied along with full dose of George (1995) also reported a similar finding in sweet potato.

Table 2. *Effect of application of K and Na of the growth characteristics of Coleus*

Treatments	Plants spread (cm)	No. of functional leaves	Relative leaf water content (%)
(1) 100 % K alone	87.6	518	81
(2) 50 % K + 50% Na	114.3	760	83.6
(3) 50 % K + 75% Na	90.0	773	94.0
(4) 50 % K + 100% Na	109.3	793	88.0
(5) 100 % K + 50% Na	104.3	844	87.3
(6) 100 % K + 75% Na	86.3	757	86.7
(7) 100 % K + 100% Na	83.3	878	86.3
CD (0.05)	17.29	246.9	3.08

Relative leaf Water content

Plants treated with both K Na showed an increase in relative leaf water content compared to the plants treated with K alone (Table 2). The highest value of RLWC was registered by treatment 50 kg K + 75 kg Na. the lowest value of RLWC was recorded for the control plot (100 K alone). Coleus, being a semi succulent plant, stores more water in aerial parts. It cannot withstand drought conditions. The high values obtained in medium and high levels of Na along with low levels of K showed that the effect Na in controlling the leaf water potential is effective only at low levels of K. Sudharmaidevi and Padmaja (1997) reported an increase in leaf water content in cassava as a result of substitution of 50% K by Na. Sunu (2001) also reported a similar finding in banana cv. Robusta. Na^{+} and Cl^{-1} ions accumulate mainly in the vacuole rather than the cytoplasm (Greenway and Munns 1980), with their accumulation therefore being conductive to osmotic adjustments and turgor maintenance. Therefore, it can be thought that the plants with a high RLWC may be more efficient than others in withstanding drought.

Leaf Area Index

All the plants treated with Na in addition to K showed significantly higher values of LAI compared to the plants receiving full dose of K alone (Fig. 1). But there was no significant variation between plants receiving different combinations of K and Na. the LAI is a very important factor especially for tuber crops, which influences the overall growth and production of tubers. I cassava, Williams and

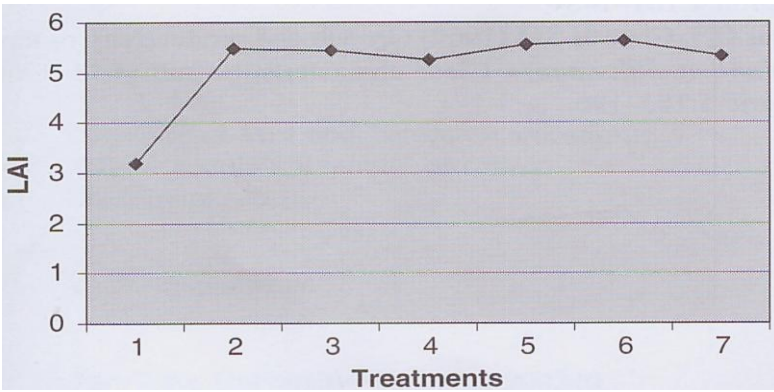

Fig. 1 *Effect of K and Na on LAI of Coleus*

Ghazali (1969) had reported that a high LAI predetermines a high tuber yield, since the development of leaf canopy precedes tuber growth. LAI is a factor contributing to photosynthetic efficiency by providing more area for interception of solar energy. Devasenapathy et. Al. (1996) reported a similar behavior of the plant when NaCl nutrition along with recommended dose of N, P and K was given for coconut.

Chlorophyll Content

There was no statistically significant difference in the case of total chlorophyll content of leaves when K or Na was given in combination of K alone (table 2). The plots with 50 % K along with different levels of Na registered higher values than those with full K alone of in combinations with different levels of Na. This showed that the synthesis of chlorophyll was not affected if 50 % of Ka was substituted by equivalent Na. The chlorophyll concentration in the leaves of a plant is a direct indication of its photosynthetic efficiency. Hence this parameter assumes much importance, when the growth attributes are taken into consideration according to Ando and Oguchi (1990), Na was found to increase the chlorophyll content of C_4 plants. The stimulative effect of salinity on chlorophyll production was reported by several scientists in different plants (Abdullah and Ahmad 1990; Dhindwal et al. 1992). However, 100 kg K along with 100 kg Na resulted in a lower amount of total chlorophyll content (Table 3)

Tuber Yield

The tuber yield in 50:50 plots statistically superior to the treatments which received full K or K and Na in 100:75 proportions. The highest yield was recorded when Na and K were given in 50:50 combination. This can be attributed to the beneficial interaction of Na and K in plant cells leading to stimulation in all the

Table 3. *Effect of application of K and Na of the growth characteristics of Coleus*

Treatments	Chlorophyll content (mg g^{-1})	No. of functional leaves	Relative leaf water content (%)
(1) 100 % K alone	0.34	326.6	49.6
(2) 50 % K + 50% Na	0.44	416.6	57.0
(3) 50 % K + 75% Na	0.44	406.6	58.6
(4) 50 % K + 100% Na	0.44	400.0	62.3
(5) 100 % K + 50% Na	0.44	343.3	50.0
(6) 100 % K + 75% Na	0.33	296.6	70.6
(7) 100 % K + 100% Na	0.32	343.3	45.3
CD (0.05)	NS	NS	NS

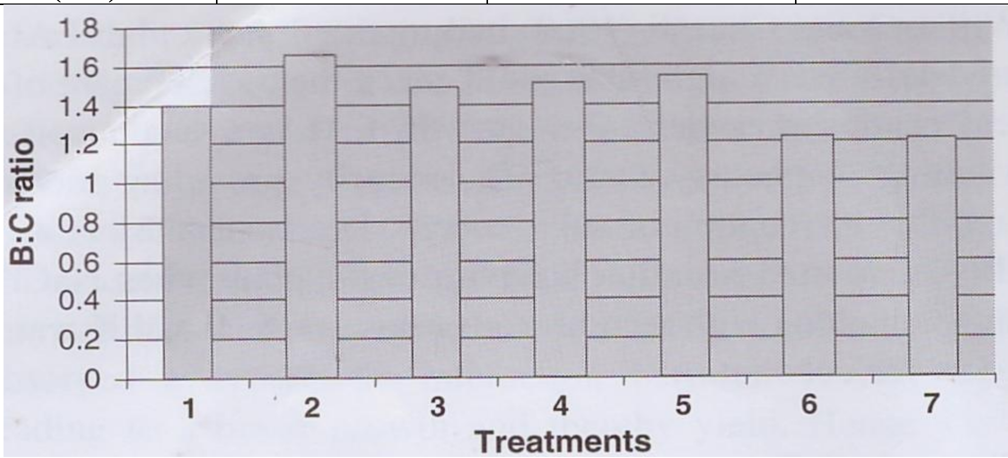

Fig. 2. *B:C ratio of different treatments*

Growth parameters recorded which were evident from their higher values. The rate of nutrient uptake was also higher, which ultimately lead to a higher tuber yield. In the plants treated with K alone, such a synergistic effect could not occur, which resulted in lower growth rate and tuber yield. The top growth is predisposing to tuber yield, the ultimate yield depending on the inherent harvest index of the plant. A high yielder therefore would have a high photosynthetic capacity and partitioning priority in favor of the storage tubers & Okeke et al. 1979). Therefore, from the result obtained in this study, it is reasonable to thing that plants receiving Na plus K in 50:50 combination have a high partitioning efficiency.

Benefit: Cost Ration

When the benefit: cost ration was worked out, it was clear that the treatment 50 50:K Na had the highest return per rupee invested (Fig. 2). Hence application of K and Na is a viable practice in the acidic soils, worldwide.

4. CONCLUSIONS

From the above finding, it can be concluded that application of K and Na at 50 kg ha-1 each is beneficial for the growth and yield of Coleus in acid soils. This practice saves fertilizer cost and boosts up farmer's income and hence can be adopted for economic cultivation of Coleus in the acid soils, worldwide.

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