

Original Research Article

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Impact of Potassium-Boron Interaction on Leaf Nutrient Content and Nut Setting of Coconut

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ABSTRACT

The experiment was conducted for two consecutive years during 2014-15 and 2015-16 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, West Bengal located at 43 m above mean sea level with 26°19'86" N latitude and 89°23'53" E longitude. The study was aimed to evaluate the effect of potassium-boron interaction on leaf nutrient content and nut setting of coconut in the boron deficient soils of *terai* zone of West Bengal. The experiment was carried out in a 7.5 m x 7.5 m. spaced 11 years old plantation planted with cv. ECT and laid out in Factorial randomized block design having 9 treatments replicated four times with 3 different levels of Potassium (900, 1200 and 1500 g of K₂O per palm) and Boron (25, 50, and 100 g borax/palm). Soil samples were collected from 0 to 30 cm depth within a radius of 1.5 m of the trunk of each palm of the entire experimental area of the plantation and the leaf samples from 14th frond was taken for analysing boron and potassium at 6th and 12th months after soil application of potassium and boron. The results revealed that the leaf potassium content showed an increasing trend for the intermediate levels of boron. However, higher leaf boron content recorded with higher rate of boron application. The treatment receiving intermediate dose of potassium and boron registered higher number of female flowers and fruit setting.

Keywords

Coconut, Leaf boron and potassium, Female flower, Fruit setting.

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Introduction

Coconut (*Cocos nucifera* L.) plays a significant role in the daily lives of people in over 90 countries spread along the tropical belt about 10 million people rely on coconuts as their main source of food and income. Boron is one of the micronutrients frequently reported to be in low in tropical soils; the low boron level in turn affects the nutrition and productivity of coconut palms cultivated in tropical climates as in North Bengal coconut growing soils and it plays very important role

in boost up pollination and seed production. Also, it is intimately related to potassium movement in plants (Cakmak and Romheld, 1997). The studies of Sayeed (1955) revealed that of the 311 buttons produced by a normal tree annually, only 48 developed into nuts. Thus, only 15% of the buttons turns to nuts, while the remaining 85% goes waste. In the area a little information has received about mineral nutrition with respect to fruit setting in coconut palms. The most important

observation indicate that mineral deficiencies mainly micronutrients, cause reductions due to high leaching and poor containing parent materials of soils as result number of female flowers per spadix which eventually drop off the palm a condition known as abortion of immature fruits (Holanda *et al.*, 2007). Boron is one of most important micronutrient for yield limiting factor in coconut plantation (Santos *et al.*, 2004). Potassium is also essential for the activation and functioning of over 60 enzymes of the plant systems. In the deficiency of potassium, the rates of the respected biochemical (enzymatic) reactions are drastically slowed down - far below the level required for the normal plant growth and development. The other notable functions of the nutrient in plants are the maintenance of cation-anion balance of in the cell, (Marschner, 2012). Report on boron and potassium on nut setting in coconut palms are scarcely found in the literature. Considering such a context, low available boron status and low to medium available K status of the coconut growing soils present study was to evaluate the effects of boron and potassium applied to soil by analysing the concentration of leaf nutrient contents in relation to nut setting.

Materials and Methods

The experiment was carried out during 2014-15 and 2015-16 at the Instructional farm of the Department of Plantation Crops and Processing, Uttar Banga Krishi Viswavidyalaya, West Bengal, India and located at 43 m above mean sea level at 26°19'86''N latitude and 89°23'53'' E longitude. The experimental soil was sandy loam in texture having acidic pH (5.45) with low in available K (87.45 kg/ha) and B (0.59 mg/kg). The experiment was laid out in Factorial Randomised Block Design in a nine years old 7.5 m x 7.5 m spaced East Coast Tall coconut plantation with three different

levels of potassium viz. K₁, K₂, and K₃ @ 900, 1200 and 1500 g of K₂O and three levels of boron viz. B₁, B₂, and B₃ @ 25, 50, and 100 g borax comprising of nine treatment combinations replicated four times. All the palms were fertilized uniformly with 500 g N and 320 g of P₂O₅ per palm along with the required amount of boron and potassium as per the treatment combinations. N P K and B were applied in the form of urea (46% N), single super phosphate (16% P₂O₅), muriate of potash (60% K₂O) and borax (10.5 % B) respectively. Half of the doses of the nutrients were applied at pre monsoon; the remaining half was applied at post monsoon at 180 cm away from the base of the palms (De Silva, 1968) in both the year under study. The initial soil samples (0-30 cm) were collected randomly before commencement of the study, thereafter sampling was done at 6 months intervals at a depth of 0-30 cm from 1.8 m away from the trunk of the palm. The leaf samples were collected from the index leaf (14th frond) for analysis before application of the fertilizers and subsequently at 6 and 12 months after application for the determination of boron and potassium content of leaf (Reuter and Robinson, 1997). K content of leaf digest was determined by flame photometer as described by Muhr *et al.*, (1965) and leaf B content was analysed by Berger and Truog (1939). The number of female flowers per spadix was counted at the time of opening of spadix and button stage of the nuts of well tagged and labelled palms. Fruit setting percentage was calculated by dividing the number of fruit sets by the total number of female flowers multiplied by 100.

$$\text{Fruit Setting percentage (\%)} = \frac{\text{Initial number of fruit sets}}{\text{Total number of female flowers}} \times 100$$

The observations recorded in field and laboratory from different treatments were subjected to statistical analysis by adopting randomised block design as described by

Panase and Sukhatme (1967). Treatments variations were tested for significance under different parameters were performed using Last Significant Difference (LSD) test at 5% level of significance ($P < 0.05$) by adopting F test (Cochran and Cox, 1975). For determination of critical difference at 5% level of significance Fisher and Yates table was consulted. Pooled analysis over two years was also done as per method described by Gomez and Gomez (1983). Analysis of variance for each parameter was performed using ProcGlm of Statistical Analysis System (SAS) software (Version 9.3).

Results and Discussion

Effect of boron and potassium application and their interactions on leaf K content

The results pertaining to the effect of application of boron at different levels on leaf K content are presented in Table 1 and Figure 1 and showed that there was a little variation in leaf K content between the two consecutive years of study. However, with increase in the level of boron application from B_1 to B_2 , there was significant increase in leaf K content. Increased K uptake at an optimum level of soil boron has been reported by Samet *et al.*, (2015) in pepper. With further increase in boron application rate, the leaf K content decreased substantially. This decrease was might be due to the toxic concentration of boron in the soil at B_3 level of boron application. Mengel and Kirkby (2001) reported that excess supply of boron in growth medium reduced uptake of K and *vice versa*.

The results in relation to the effect of potassium applications at different graded levels on the leaf K content are also depicted in Table 1 and Figure 2 and showed that there was high consistency in leaf K content between the results of the two years. In any case, with increase in potassium supply, the

nutrient continues to be increasingly absorbed as seen in increased leaf K content. Venkitaswamy *et al.*, (2011) also reported results in similar lines.

The results revealed that the leaf K content was the highest in B_1K_3 treatment followed by B_2K_3 and B_2K_2 treatments and it was lowest in B_3K_1 followed by B_1K_1 and B_3K_3 (Table 1 and Fig. 3). Boron-potassium interactions at the applied levels and combinations caused the differences in the leaf K content. The results of the study suggested that, there was synergistic interaction effect between K and B in the case of B_1K_3 , B_2K_3 , and B_2K_2 treatments resulting in increased K uptake. The interaction between these two nutrients was antagonistic also in B_3K_1 and B_3K_3 combinations. Mengel and Kirkby (2001) observed that B and K interaction was negative with an excess supply of boron. All the levels of boron and potassium and their interaction effects pertaining to leaf K content were showed progressively decreasing trend from 6 month to 12 months after soil application of boron and potassium.

Effect of application of boron and potassium and their interactions on leaf B content

The results pertaining to the effect of boron application at different rates on leaf B content are presented in Table 1 and Figure 4. A careful approval of results showed a negligible variation in leaf B content between the results of the two years. With increase in the level of boron application, there was significant and proportionate increase in leaf boron content. B content in leaf increased. Similar results have been reported by Moura *et al.*, (2013) and Nistane *et al.*, (2011) in coconut. On the other hand, with increase in the level of potassium from K_1 to K_2 , there was little increase in the leaf boron content from 23.63 to 23.78 in 2015-16 at 6 months after application and it was statistically at *par*

with each other. With further increase in potassium level, there was sharp decrease in boron content of the leaves from 23.78 to 21.05 in 2015-16 and it was statistically significant. This variation suggests negative interaction between B and K at excess levels of available K due possibly to cation-anion imbalance as has been reported earlier by Samet *et al.*, (2015). The same trend was observed in 2014-15 and also in the case of pooled results for the two years (Table 1 and Fig. 5).

A perusal of data presented in Table 1 and Figure 6 showed that the leaf B content was the highest in B₃K₁ treatment followed by B₃K₃ and B₃K₂ treatments. Boron-potassium interactions at the applied rates and combinations might have caused the differences in the leaf B content. This type of effect may be due to excess application of potassium caused to decrease in leaf B content. The results of the study suggest that as regards to leaf B content, there was synergistic interaction effect between potassium and boron in certain cases and antagonistic interaction in some cases.

The results of the study are in agreement with those of present findings confirmed the findings of Ranade-Malvi (2011). Further, it appears that the individual effects of boron and potassium and also their interaction effects pertaining to the leaf boron content had a decreasing trend from 6 to 12 months after soil application of boron and potassium.

The continued decrease in leaf boron content may be because of the fact that during this period (6 to 12 months), boron might have been utilized in fruit setting, boosts up pollination, seed development, formation of meristematic tissues, synthesis of cell wall, lignifications maintenances of cell wall structure integrity nitrogen metabolism, and protein biosynthesis. A similar result was also reported by Ahmad *et al.*, (2009).

Effect of boron and potassium application and their interaction on the number of female flower production of coconut

Data presented in Table 2 and Figure 7 clearly showed that with regard to boron application there was high consistency in the number of female flowers per spadix per palm per year between the results of the two years. In the present study with increase in the level of boron from B₁ to B₂, there was significant increase in the number of female flowers per spadix per palm per year. Boron at B₁ level resulted in less number of female flowers could be due to low available B content of the soil. Similar results on the reduction of female flowers were reported earlier by Siqueira *et al.*, (1997) and Holanda *et al.*, (2007).

Boron is intimately related to all processes concerned with flowering in plants (Gupta, 2007). These flowering related functions might have contributed to the increased number of female flowers per spadix per year at a higher boron level. Increased number of female flowers per palm per year with an increase in boron content of the soils has earlier been reported by Kamalakshamma *et al.*, (2001) in coconut.

However, with further increase in boron level, the number of female flowers per spadix per year decreased and recorded lower value even compared to B₁ level of boron also in both the year under study. As boron is a micronutrient and the range in the change from deficient to toxic concentration is extremely narrow and is often exceeded while applying boron fertilizers (Gupta, 2007). It appears that in the increase in boron level from B₂ to B₃, the boron levels of the soils might have reached toxic level which in turn caused a decrease female flower production. A similar line results were reported by Lakshmiipathi *et al.*, (2015) noticed that decreased number of hermaphrodite flower production per panicle with increasing levels of boron.

Table.1 Effect of boron and potassium application and their interaction on potassium and boron content of leaves

Levels of Boron	Leaf K content (%)						Leaf B content (mg/kg)					
	6 months (December)			12 months (June)			6 months (December)			12 months (June)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
B₁	1.72	1.73	1.73	1.03	1.03	1.03	14.09	14.52	14.30	8.932	9.034	8.983
B₂	1.82	1.84	1.83	1.06	1.05	1.06	22.58	22.67	22.62	11.79	12.05	11.92
B₃	1.31	1.31	1.31	0.86	0.86	0.86	30.79	31.27	31.03	14.77	14.61	14.69
SE(m)±	0.01	0.01	0.01	0.01	0.01	0.01	0.16	0.19	0.15	0.25	0.25	0.22
LSD (P=0.05)	0.02	0.01	0.01	0.02	0.03	0.02	0.48	0.56	0.43	0.72	0.73	0.63
Levels of Potassium	6 months (December)			12 months (June)			6 months (December)			12 months (June)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
	K₁	1.12	1.12	1.12	0.86	0.85	0.86	23.22	23.63	23.42	12.25	12.34
K₂	1.74	1.75	1.75	1.03	1.03	1.03	23.24	23.78	23.51	12.39	12.37	12.38
K₃	1.99	2.00	2.00	1.06	1.05	1.06	21.00	21.05	21.02	10.84	10.98	10.91
SE(m)±	0.01	0.00	0.01	0.01	0.01	0.01	0.16	0.19	0.15	0.25	0.25	0.22
LSD (P=0.05)	0.02	0.01	0.01	0.02	0.03	0.02	0.48	0.56	0.43	0.72	0.73	0.63
Treatment combinations	6 months (December)			12 months (June)			6 months (December)			12 months (June)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
	B₁K₁	1.10	1.10	1.10	0.83	0.83	0.83	14.22	14.73	14.47	9.60	9.48
B₁K₂	1.75	1.75	1.75	1.04	1.03	1.03	15.73	15.98	15.85	9.98	10.26	10.12
B₁K₃	2.32	2.33	2.33	1.22	1.22	1.22	12.31	12.85	12.58	7.22	7.36	7.29
B₂K₁	1.29	1.30	1.29	0.99	0.98	0.98	22.08	22.32	22.20	11.39	11.76	11.58
B₂K₂	1.96	1.97	1.97	1.10	1.10	1.10	25.00	24.05	24.52	13.05	13.31	13.18
B₂K₃	2.21	2.24	2.23	1.10	1.08	1.09	20.67	20.05	20.36	10.91	11.06	10.99
B₃K₁	0.97	0.97	0.97	0.75	0.75	0.75	33.42	34.29	33.86	16.18	15.87	16.02
B₃K₂	1.52	1.53	1.52	0.96	0.96	0.96	28.93	29.28	29.11	13.72	13.45	13.58
B₃K₃	1.43	1.44	1.43	0.85	0.86	0.86	30.02	30.24	30.13	14.40	14.52	14.46
SE(m)±	0.01	0.01	0.01	0.01	0.02	0.01	0.28	0.33	0.25	0.43	0.43	0.37
LSD (P=0.05)	0.04	0.02	0.02	0.03	0.04	0.03	0.84	0.97	0.74	1.25	1.26	1.09

Table.2 Effect of boron and potassium application and their interaction on the number of female flowers production and fruit setting percentage

Number of female flowers per spadix per palm per year				Fruit setting percentage		
Levels of Boron	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
B ₁	304.67	313.00	308.83	21.24	22.03	21.63
B ₂	340.33	346.92	343.63	28.45	29.61	29.03
B ₃	256.17	252.92	254.54	17.81	17.97	17.89
SE(m)±	0.60	0.78	0.37	0.47	0.33	0.28
LSD (P=0.05)	1.77	2.99	1.70	1.39	0.96	0.83
Levels of Potassium	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
K ₁	276.00	279.00	277.50	20.88	21.43	21.15
K ₂	322.00	325.92	323.96	24.75	25.95	23.35
K ₃	303.17	307.92	305.54	21.87	22.22	22.04
SE(m)±	4.76	4.95	3.80	0.47	0.33	0.28
LSD (P=0.05)	13.96	14.53	11.14	1.39	0.96	0.83
Treatments	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
B ₁ K ₁	286.25	292.75	289.50	19.48	20.84	20.16
B ₁ K ₂	325.75	333.75	329.75	25.15	25.41	25.28
B ₁ K ₃	302.00	312.50	307.25	19.08	18.00	18.54
B ₂ K ₁	297.25	302.50	299.88	26.27	27.08	26.67
B ₂ K ₂	375.25	382.50	378.88	30.11	32.50	31.31
B ₂ K ₃	348.50	355.75	352.13	28.98	29.24	29.11
B ₃ K ₁	244.50	241.75	243.13	16.90	16.37	16.63
B ₃ K ₂	265.00	261.50	263.25	18.98	19.96	19.47
B ₃ K ₃	259.00	255.50	257.25	17.54	17.57	17.55
SE(m)±	8.24	8.57	6.57	0.82	0.56	0.49
LSD (P=0.05)	24.18	25.17	19.30	2.41	1.66	1.43

The number of nuts harvested from the mature bunches of 5 randomly selected palms were calculated for each treatment.

Notation for the treatments	Levels of boron and potassium
• T ₁ : B ₁ K ₁	25 g borax/palm + 900 g K ₂ O/palm
• T ₂ : B ₁ K ₂	25 g borax/palm + 1200 g K ₂ O/palm
• T ₃ : B ₁ K ₃	25 g borax/palm + 1500 g K ₂ O/palm
• T ₄ : B ₂ K ₁	50 g borax/palm + 900 g K ₂ O/palm
• T ₅ : B ₂ K ₂	50 g borax /palm + 1200 g K ₂ O/palm
• T ₆ : B ₂ K ₃	50 g borax/palm + 1500 g K ₂ O/palm
• T ₇ : B ₃ K ₁	100 g borax/palm + 900 g K ₂ O/palm
• T ₈ : B ₃ K ₂	100 g borax/palm + 1200 g K ₂ O/palm
• T ₉ : B ₃ K ₃	100 g borax /palm + 1500 g K ₂ O/palm

Fig.1 Effect of soil application of B on leaf K content (%) after 6 and 12 months of application

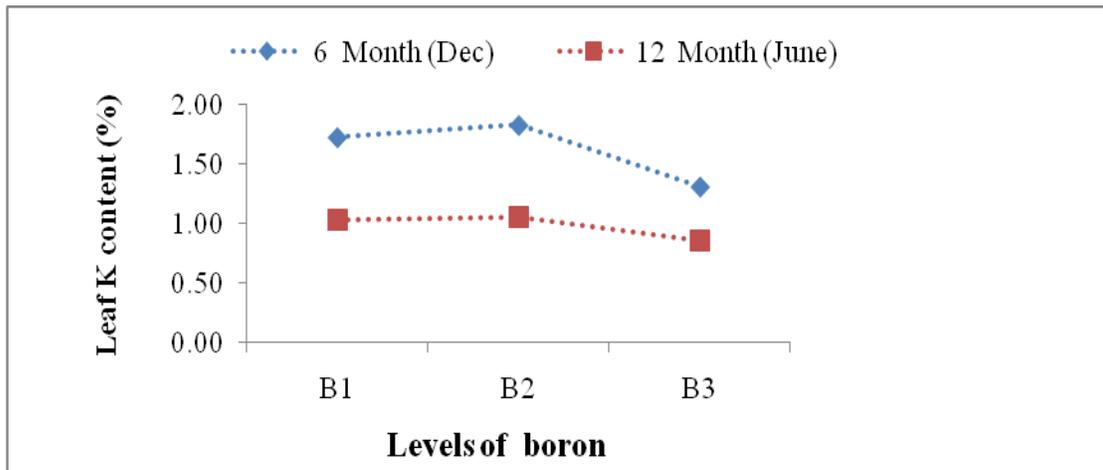


Fig.2 Effect of soil application of potassium on leaf K content (%) after 6 and 12 months of application

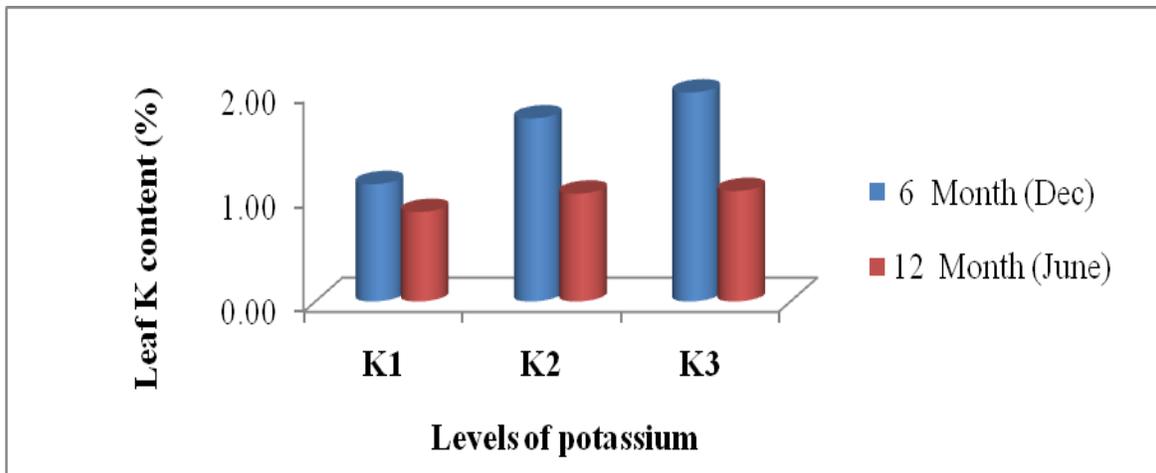


Fig.3 Interaction effect of boron and potassium on leaf potassium content (%) after 6 and 12 months of application

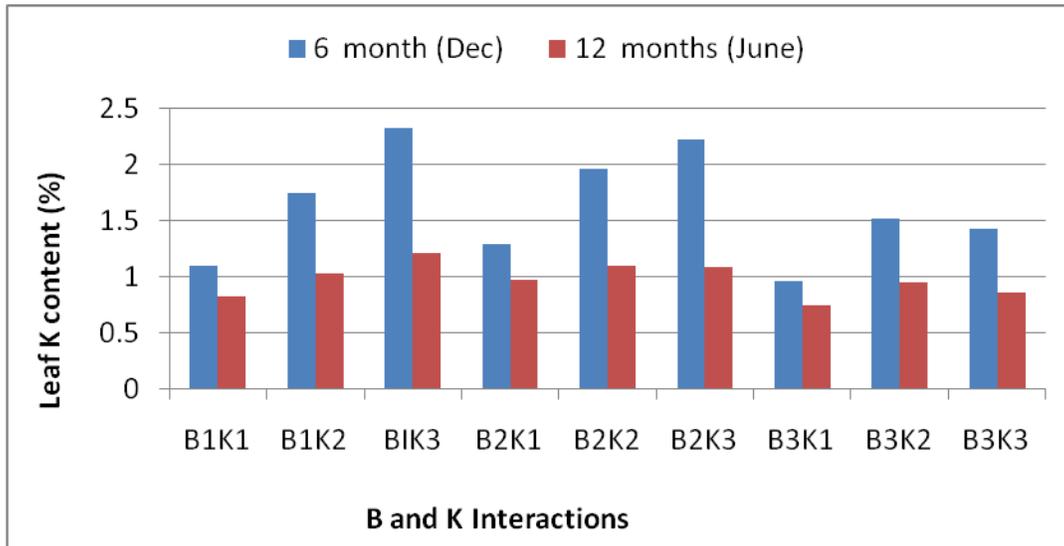


Fig.4 Effect of application of boron on leaf boron content (mg/kg) after 6 and 12 months of application

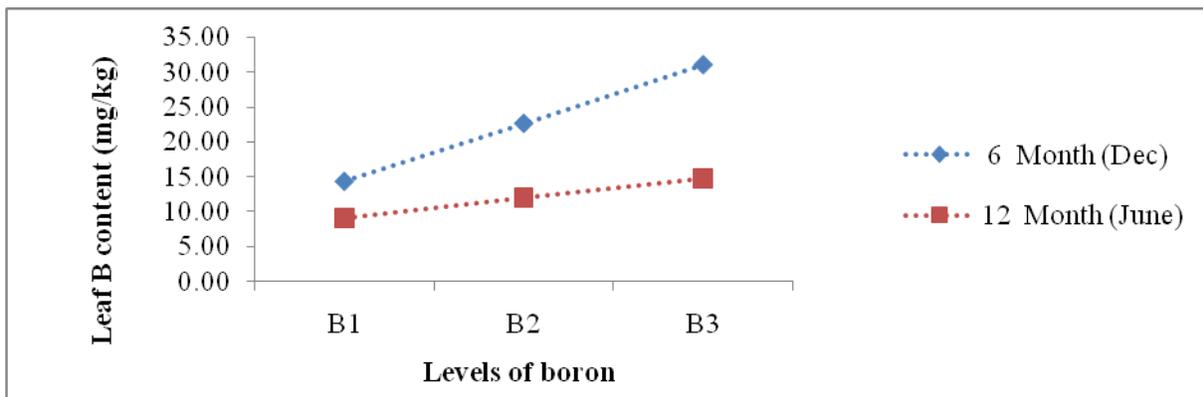


Fig.5 Effect of application of potassium on leaf boron content (mg/kg) after 6 and 12 months of application

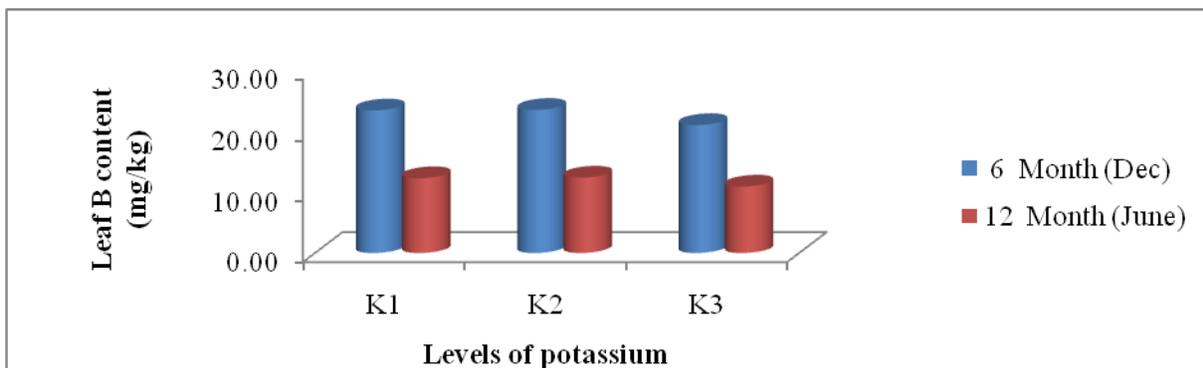


Fig.6 Interaction effect of boron and potassium on leaf boron content (mg/kg) after 6 and 12 months of application

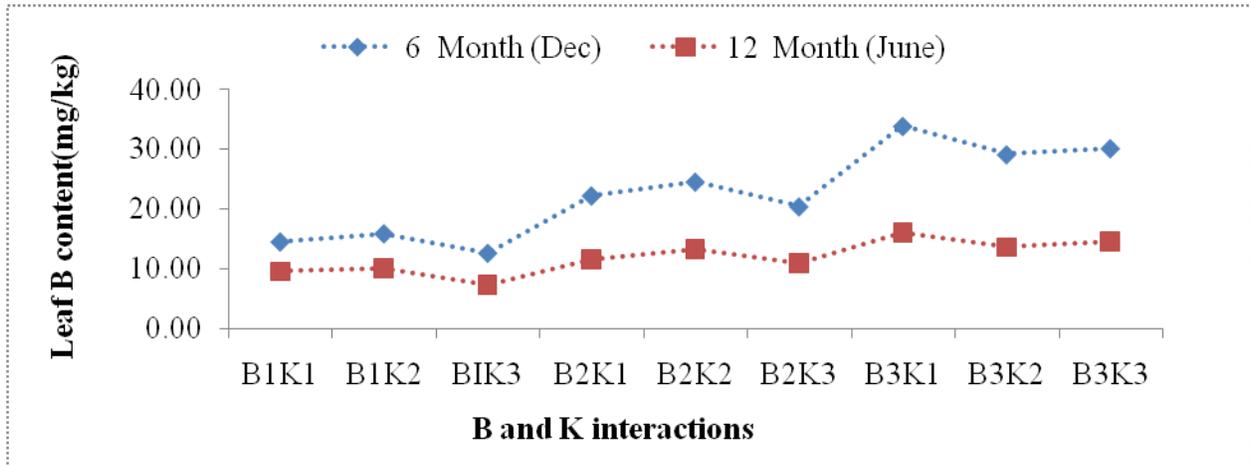


Fig.7 Effect of boron on number of female flowers per spadix per palm per year

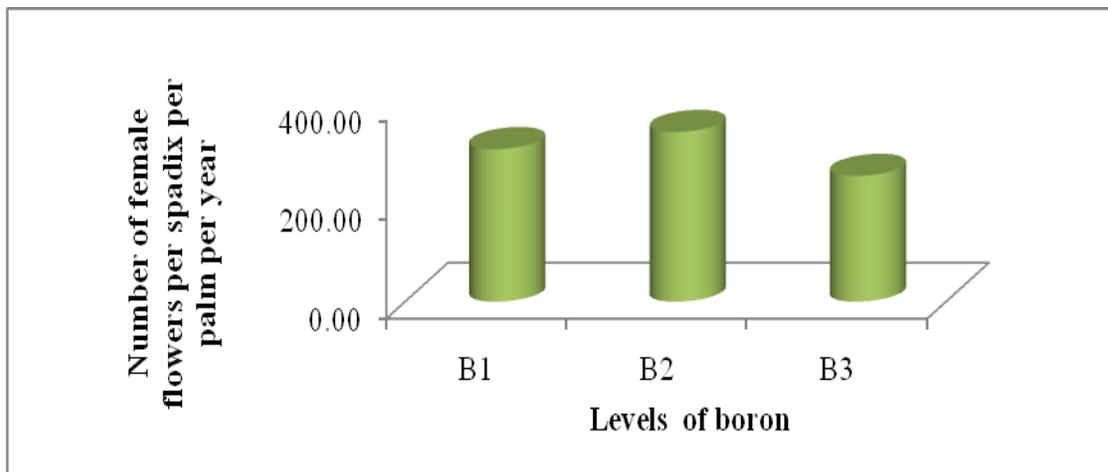


Fig.8 Effect of potassium on number of female flowers per spadix per palm per year

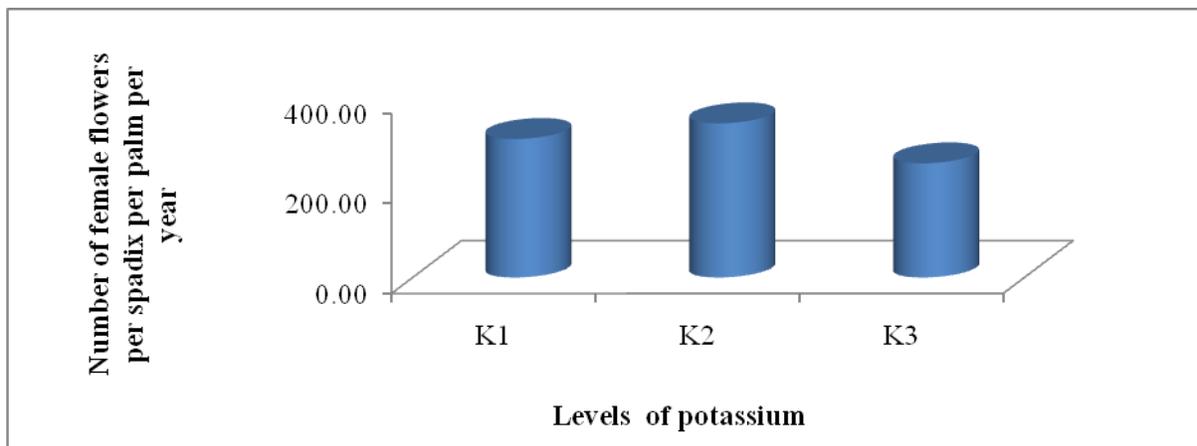


Fig.9 Interaction effect of boron and potassium on number of female flowers per spadix per palm per year

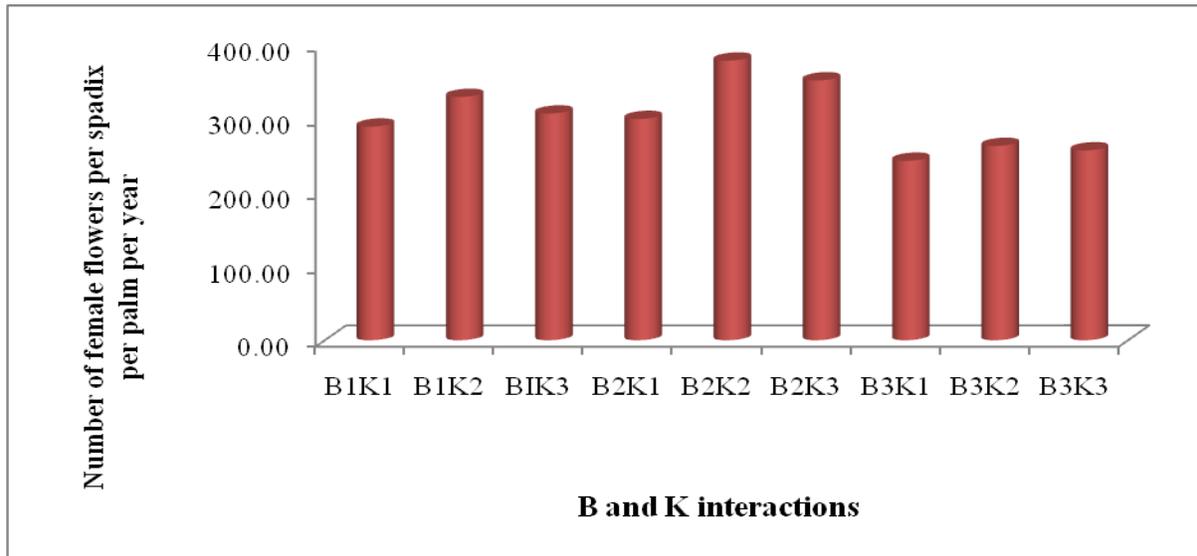


Fig.10 Effect of boron on fruit setting percentage

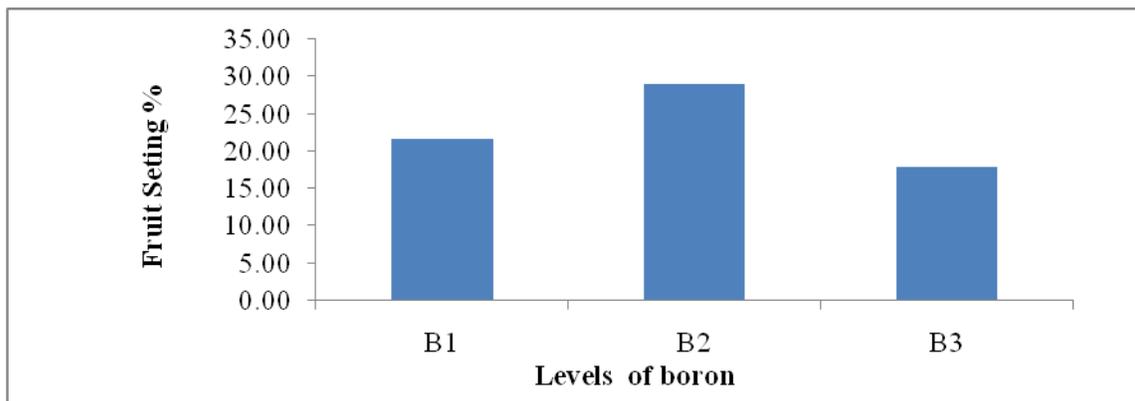


Fig.11 Effect of potassium on fruit setting percentage

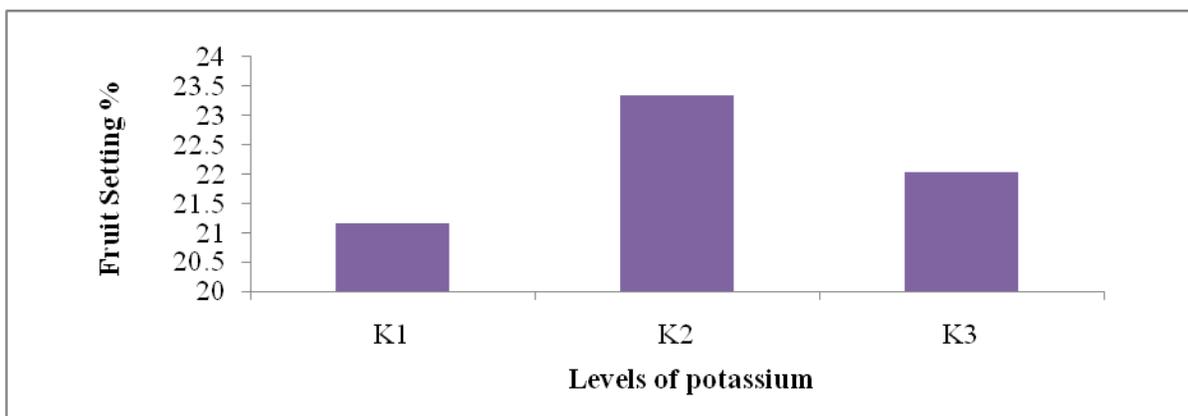
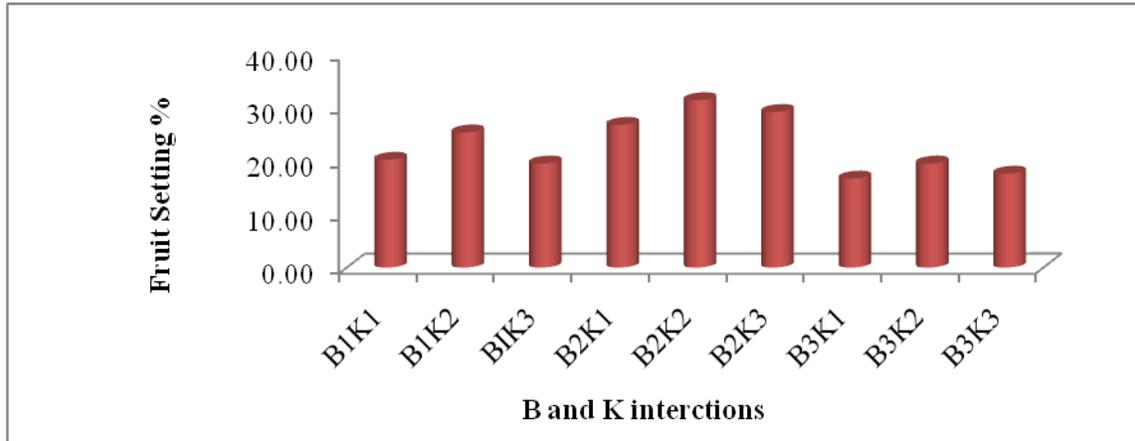


Fig.12 Interaction effect of application of boron and potassium on fruit setting percentage



Effect of graded levels of potassium application on the number of female flowers per spadix per year was also presented in Table 2 and Figure 8. With increase in the level of potassium from K₁ to K₂, there was significant increased in the number of female flowers per spadix per palm per year. The increase in the number of female flowers per spadix with the increased supply of potassium must be due to the additional availability of K in plants. Potassium is intimately involved with the flowering and subsequent reproductive processes in plants (Mengel, 2007). Rosenquist (1980) and Venkitaswamy *et al.*, (2011) also reported increased female flower production in coconut consequent to the application of potassium. With further increase in potassium level, the number of female flowers per spadix per year decrease significantly. Potassium at K₃ level had a depressing effect on the number of female flowers per spadix per year and both the nutrients at their highest level (B₃ & K₃) exhibited negative relationship and affect the availability of K in soil (Table 2 and Fig. 9).

The pooled data revealed that the number of female flowers per spadix per palm per year was the highest in the treatment B₂K₂ followed by B₂K₃ and B₁K₂ treatments. However, at higher concentration of boron i.e.in B₃K₁, B₃K₂ and B₃K₃ treatments the female flower production reduced at a greater extent may be due to destabilizing the equilibrium in soil

environment. Application of boron at an optimal level increases potassium permeability in the cell membrane, while an excess of the same causes negative interaction in plants (Ranade-Malvi, 2011).

Effect of boron and potassium application and their interaction on fruit setting percentage

Applications at different levels of boron and potassium had a significant effect on the fruit setting process. With increase in the level of boron from B₁ to B₂, there was significant increase in fruit setting and low fruit setting at B₁ level was due to low boron content of the soils. Similar results were reported by Siqueria *et al.*, (1997) and Holanda *et al.*, (2007) and reported low boron content of the soils to be associated with reduction in male flowers fertility, primarily by impairing microsporogenesis and pollen tube growth having subsequent post-fertilization effects. The increased fruit setting was observed with the additional supply of boron at B₂ level. However, with further increase in boron level from B₂ to B₃, the fruit setting decreased sharply in both the years under study as well as in pooled data also. This variation might be attributed to reaching the boron level at the point of saturation and in excess at B₃ levels exert a negative effect on fruit setting. Kamalakshamma *et al.*, (2001) and

Lakshmipathi *et al.*, (2015) also noticed that the fruit setting percentage was decreased with increasing levels of boron in coconut and cashew nut, respectively which is in conformity with the present finding (Table 2 and Fig. 10).

Graded levels of potassium application also exerted a significant effect on the fruit setting process and K₂ level of potassium application recorded highest number of fruit set followed by K₃ level (Table 2 and Fig. 11). A similar result was obtained by Uexkull (1972) in coconut.

Results of boron-potassium interaction effects on the fruit setting process are presented in Table 2 and Figure 12 showed that the fruit setting per cent was the highest in B₂K₂ treatment followed by B₂K₃ and B₂K₁ treatments. Boron-potassium interactions at the applied must have caused the differences in the fruit setting per cent. In the present study, there was synergistic interaction effect between potassium and boron in the case of B₂K₂, B₂K₃, and B₂K₁ treatments. Earlier, Schon *et al.*, (1990) and Ranade-Malvi (2011) noticed that boron at an optimum level increased potassium permeability in the cell membrane, though however, an excess of the nutrient causes toxicity in plants.

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