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NUTRIENT PROFILE OF PASSIONFRUIT LEAF AND FRUIT AS INFLUENCED BY INTEGRATED PLANT NUTRIENT MANAGEMENT

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ABSTRACT

A study was conducted over a period of one year (2008-09) to assess the nutrient status of leaf and fruit of passionfruit cv. Kaveri with the application of biofertilizers and conventional fertilizers under the low hill conditions of Nagaland. Altogether 13 treatments were evaluated for yield and changes in soil fertility and nutrient status of leaf and fruits of passionfruit. The highest fruit yield per plant was observed with 25% NPK+Azospirillum (7.89 kg) with fruit weight of 90.67 g followed by 25% NPK+Phospotica (7.6 kg) with fruit weight of 88.67g. These observations suggested that exclusive inorganic fertilization although maintained high NPK level in index leaves (4.95% N, 0.22% P, and 2.32% K) and fruit (1.87% N, 0.28% P and 1.48% K). Yield was much better at lower concentration ranges (3.92-4.15% N, 0.16-0.22% P and 2.07-2.15% K) and fruit (1.41-1.44% N, 0.27-0.32% P, and 0.91-1.12% K). Changes in soil fertility demonstrated the highest fruit yield at 227.8-340.4 kg ha^{-1} available N, 24.4-34.5 kgha^{-1} P, and 64.6-70.7 kg ha^{-1} K. These studies, provided strong evidence that starter dose of inorganic fertilizers is necessary to improve fruit yield and there was substantial improvement of nutrient status of soil even after the harvest of fruits with significant variations amongst the different treatments.

Key words: Integrated nutrient management, yield, leaf NPK, fruit NPK, soil fertility, passionfruit

INTRODUCTION

Passionfruit is the fruit of the exotic passionflower (*Passiflora*), which, although native to Brazil and northeastern Argentina, is now cultivated in many tropical and subtropical regions of the world. It is a woody perennial climber (vine) of the family Passifloraceae. The Purple passionfruit *Passiflora edulis* Sims is better adapted to sub-tropical highland areas while the Yellow passionfruit *Passiflora edulis* f. *flavicarpa* Degener is recommended for growing in tropical low land areas. Kaveri is the hybrid of these two species which has vigorous growth and high yielding character. The fruit has high antioxidant property besides its numerous uses in dessert and juice preparation. There is an ever increasing demand for higher agricultural produce and products for human nutritional security. The increase in productivity of fruit crops can be achieved with balanced and efficient use of fertilizers and other inputs since the possibilities of bringing more land under cultivation for greater production without disturbing the ecological balance of the environment are rather remote. Aholistic benchmark analysis of various components leading to remunerative soil and plant nutritionmanagement is imperative to sustain the pressure of increasing nutrient demand in crop production systems. Biofertilizer is a natural product carrying living microorganisms derived from the root or cultivated soil. Therefore, they do not have any ill effect on soil health and environment. Besides their role in atmospheric nitrogen fixation and phosphorous solubilisation also help in stimulating the plant growth hormones providing better nutrient uptake and increased tolerance towards drought and moisture stress. A small dose of biofertilizer is sufficient to produce desirable results because each gram of carrier of biofertilizers contains at least 10 million viable cells of a specific strain (Anandaraj and Delapierre, 2010). Under high intensive cropping system, the interactive advantages of combining organic and inorganic sources of nutrients in INM have proved superior to the use of each component separately (Singh and Yadav, 1992). To ensure sustainability in the cultivation process, one has to develop location specific technology for balanced use of nutrient inputs in order to obtain higher production while maintaining the ecological balance in the soil microflora. The present investigation highlights the effect of integrated application of biofertilizers with conventional fertilizers and their influence on the yield, content of major nutrients in fruits and leaves and overall nutrient use efficiency by passionfruit plants.

MATERIALS AND METHODS

A field experiment was conducted during 2008-2009 at Horticulture Experimental Farm, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland, situated at

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29°45'43"N latitude and 93°53'04"E longitude at an elevation of 305 m above msl. The experimental site lies in humid sub-tropical zone with an average rainfall ranging from 2000 mm – 2500 mm. The trial was laid out in a randomized block design with thirteen treatments and three replications. Treatments were 100% NPK, 75% NPK+*Azospirillum,* 75% NPK+*Azotobacter,* 75% NPK+Phosphotica, 50% NPK+*Azospirillum,* 50% NPK+*Azotobacter,* 50% NPK+Phosphotica, 25% NPK+*Azospirillum,* 25% NPK+*Azotobacter,* 25% NPK+ Phosphotica, *Azospirillum*+Phosphotica, *Azotobacter*+Phosphotica, *Azospirillum* + *Azotobacter* + Phosphotica. The fertilizers in the form of urea, single super phosphate and muriate of potash @ 110g N: 60g P:100g K were applied in two split doses at the time of planting and six months after planting. Biofertilizers were applied in two split doses @ 20 g per plant after 15 days of fertilizer application. Uniform cultural practices were performed on the plants during their growth and development. The index leaf (recently matured leaf opposite to recently opened flower) were collected, washed, dried and ground for leaf analysis and the tagged fruits of uniform maturity were used for nutrient content studies. Nitrogen content of leaf and fruit were determined by Kjeldahl method (Black, 1965). Phosphorus was determined by vanado-molybdate yellow colour method (Jackson, 1973) and potassium by flame photometer (Chapman and Pratt, 1961) in di-acid (HNO_3:$HClO_4$) digested samples. The soil pH was determined by digital pH meter, organic carbon by Walkley and Black rapid titration method as described by Piper (1966), available N by alkaline permanganate method (Subbiah and Asija, 1956), available P by Bray's method (Bray and Kurtz, 1945) and available K by neutral 1N ammonium acetate (Hanway and Heidal, 1952). The statistical analyses were carried out as per the method described by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Fruit yield and its attributes

The numbers of fruits per plant were found maximum (88.0) with the application of 25% NPK +*Azospirillum* followed by 25% NPK+Phosphotica (85.67 fruits/plant). Inoculation of microbial fertilizers in the form of nitrogen fixing and phosphate solubulising bacteria might have promoted nutrient availability and their uptake by the plants that had positive effect on the reproductive aspects of fruits. The average fruit weight showed a reciprocal increase with the dosage of inorganic fertilizers and was found to record highest with 25% NPK+*Azotobacter* (100g). Further, it was observed that the application of 50 and 25% NPK with biofertilizers resulted in fruit weights which were statistically at par with one another. Similar results were reported in custard apple where highest fruit weight was obtained with the application of 50% NPK+biofertilizers (Balakrishnan *et al.,* 2001). Treatment with *Azotobacter* recorded the highest weight of individual fruit in guava cv. Allabahad Safeda (Ram and Rajput, 2000). The increase in the fruit weight could be due to the more divergence of available nutrients in plant to the sink. The yield of fruits per plant (7.98 Kg) and per hectare (99.72 q ha^{-1}) was found greater with 25% NPK+*Azospirillum* followed by plants applied with 25% NPK + Phosphotica (7.60 kg $plant^{-1}$ and 94.97 q ha^{-1}) which were found to be statistically at par (Table 1).

Table 1: Influence of various biofertilizers and their combination with NPK on the yield and yield attributes of passionfruit cv. Kaveri

Treatments	Yield/plant (kg)	Yield (q ha^{-1})	Fruits / plant	Fruit weight (g)
100% NPK	2.20	27.55	41.00	54.00
75% NPK + *Azospirillum*	2.38	29.69	42.33	56.00
75% NPK + *Azotobacter*	2.14	26.72	34.00	62.67
75% NPK + Phosphotica	3.13	39.12	39.00	80.00
50% NPK + *Azospirillum*	5.13	64.10	58.33	88.00
50% NPK + *Azotobacter*	4.68	58.56	51.00	92.00
50% NPK + Phosphotica	3.57	44.58	38.00	94.00
25% NPK + *Azospirillum*	7.98	99.72	88.00	90.67
25% NPK + *Azotobacter*	6.27	78.36	62.67	100.00
25% NPK + Phosphotica	7.60	94.97	85.67	88.67
Azospirillum + Phosphotica	6.04	75.56	72.00	84.00
Azotobacter + Phosphotica	6.10	76.22	72.67	84.00
Azospirillum+*Azotobacter*+Phosphotica	6.51	81.42	80.00	81.33
S Em ±	0.31	3.90	0.37	5.63
LSD (p=0.05)	0.70	8.80	0.80	12.63

This finding is in conformity with the report of a field study carried out in Tamil Nadu on custard apple where the highest fruit yield was with the application of *Azotobacter, G. fasciculatun, Azospirillum, Phosphobacteria* and 50% NPK (Balakrishnan *et al.*, 2001). A perusal of table 1 clearly shows that the lowest yield (26.72 q ha^{-1}) and fruit number per plant (34.0) was observed in plants treated with 75% NPK+*Azotobacter* closely followed by 100% NPK in fruit yield (27.55 q ha^{-1}). The higher yield response obtained from low chemical fertilizer input plus biofertilizer application could be due to the positive changes in the nature of soil which may have affected the nutrient utilization capacity of the plant. Moreover, beneficial microbial populations in the root zone are stimulated by the increased availability of these exudates which in turn enhances biological activity and increase the availability of nutrient to plants. Further, it was observed in the field that there was prolong flowering and fruiting in plants with biofertilizers combined with lower or no chemical fertilizer application which led to higher yield from these treatments.

Content of NPK in leaves and fruits

The leaf analysis of passionfruit reveals that the different biofertilizers and their combinations with various doses of inorganic fertilizers resulted in significant variations in N content but not in P and K content (Table 2). Hariprakasarao *et al.* (1988) reported significant variations in leaf K in studies with application of various levels of inorganic N, P, and K on passionfruit plants. The N and K content in leaf tissue (4.95 and 2.32 %) and fruits (1.87 and 1.48%) were highest in plants with 100% NPK application. There was significant variations in the N, P and K content in fruit tissues and 75% NPK+Phosphotica application resulted in highest P content in leaf (0.24%) and fruit (0.41%). The greatest fruit yield were obtained from plants with treatments of 25% or 50% NPK+ biofertilizers whose corresponding leaf N content was found to be in the range of 3.92-4.62%. Reports from Borges and Lima (2003) also suggest that the optimum leaf N content in passionfruit for healthy growth and development was 47.5-52.5 g Kg^{-1} N. The present findings may be indicative that the optimum dose of nutrient application lies with low doses of chemical fertilizers in combination with biofertilizers. Similarly, the optimum levels of P and K in the leaf tissues of passionfruit could be deduced as 0.17–0.22% and 2.07–2.15% respectively from the present investigation with the application of 25% or 50% NPK + biofertilizers. These results find credence with those reported by Borges and Lima (2003) where adequate ranges of macro nutrients in passionfruit leaves should be, 2.5-3.5 g Kg^{-1} P and 20.0-25.0 g Kg^{-1} K.

Table 2: Effect of various inputs on the NPK content (%) in leaf and fruit

Treatments	Leaf			Fruit		
	N	P	K	N	P	K
100% NPK	4.95	0.22	2.32	1.87	0.28	1.48
75% NPK + *Azospirillum*	4.76	0.19	2.05	1.49	0.33	1.43
75% NPK + *Azotobacter*	4.48	0.21	1.94	1.36	0.35	1.10
75% NPK + Phosphotica	4.67	0.24	2.22	1.32	0.41	1.20
50% NPK + *Azospirillum*	4.57	0.17	2.11	1.31	0.27	1.02
50% NPK + *Azotobacter*	4.53	0.18	2.13	1.52	0.28	1.20
50% NPK + Phosphotica	4.62	0.20	1.98	1.36	0.31	1.05
25% NPK + *Azospirillum*	3.92	0.16	2.07	1.44	0.27	0.91
25% NPK + *Azotobacter*	3.66	0.20	2.15	1.21	0.29	1.03
25% NPK + Phosphotica	4.15	0.22	2.15	1.41	0.32	1.12
Azospirillum + Phosphotica	4.43	0.21	2.04	1.33	0.31	1.10
Azotobacter + Phosphotica	4.29	0.21	2.13	1.35	0.31	1.19
Azospirillum + *Azotobacter* + Phosphotica	4.20	0.21	2.18	1.21	0.32	0.92
SEm ±	0.34	0.03	0.08	0.15	0.02	0.05
LSD (p=0.05)	0.71	NS	NS	0.31	0.06	0.17

Fertility status of soil after harvest

The soil pH varied significantly with the different combinations of nutrient inputs where marked increase was recorded in treatments with 75% NPK+*Azospirillum* or *Azotobacter* (5.1 from 4.6). Such increase in pH has also been reported in banana plantation in Assam with the application of recommended dose (RD) NPK and ½ RD of N+RD of P and K. The organic carbon of the top soil showed a decrease in all the treatments after harvest of passionfruit crop except for 100% NPK, 75% NPK+Azotobacter and biofertilizer application. However, the treatments of biofertilizers alone recorded greater amount of organic carbon, which was comparable with treatments of 75% NPK+ biofertilizers (table 3). This could be attributed to the increase in the microbial population and their dehydrogenase activity as indicated by higher microbial biomass in soil (Gogoi *et al.*, 2004)

The N content in soil showed the highest increase with 100% NPK application from the initial available N content (257.2 to 502.7 Kg ha^{-1}). From the estimates of nutrient removal by some fruit crops, it can be opined that the uptake of N by different horticultural crops vary to a great extent, therefore, further studies on this aspect needs to be carried out in passionfruit. Further, the available soil N ranges (227-502 kg ha^{-1}) in the present study are in agreement with a study conducted on different land use system in Nagaland (Sharma *et al.*, 2015), which reported that the available N content of Medziphema soils fell under medium class which indicated that the mineralizable nitrogen fraction under the prevailing climatic condition and acidic nature of soil was rather low. The available P content in soil showed a comparable decrease after harvest of crop although the soil rhizosphere where 50% NPK+Phosphotica recorded a marked increase in the P content (40.0 Kg ha^{-1}). Similar findings were reported in studies of soil condition in banana plantations with the application of PSB along with other biofertilizers and inorganic fertilizers (Gogoi *et al.*, 2004). The possible reason for this effect could be due to production of organic acids by the microbial innoculants. These acids act as a chelating agent and form stable complexes with Fe and Al abundantly available in acid soils and thereby release P to the soil solution making it available for more uptake by plants. The available K in soil after harvest of passionfruit was recorded higher than the initial content in soil in all treatments and 100% NPK application recorded the highest content. The improvement in the soil K could be due to the increase in the microbial population and their activity with the application of biofertilizers. The present findings show consistency with the study in banana plantations where high level of K availability was recorded in soils treated with ½ RD of N+RD of P and K and RD of NPK+*Azospirillum*+PSB (Gogoi *et al.*, 2004).

Table 3: Fertility status of soil before planting and after passionfruit harvest as influenced by various treatments

Treatment	pH	Org. Carbon (g kg^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Soil status after harvest					
100% NPK	4.4	24.5	502.7	35.1	116.2
75% NPK + *Azospirillum*	5.1	21.6	420.9	31.0	95.4
75% NPK + *Azotobacter*	5.1	24.9	275.4	32.0	77.0
75% NPK + Phosphotica	4.5	20.9	297.1	28.1	88.6
50% NPK + *Azospirillum*	4.6	19.8	286.9	20.3	90.4
50% NPK + *Azotobacter*	4.5	21.4	308.7	28.7	91.6
50% NPK + Phosphotica	4.6	21.5	303.3	40.0	78.2
25% NPK + *Azospirillum*	4.5	22.8	340.4	24.4	70.7
25% NPK + *Azotobacter*	4.6	19.5	279.5	32.8	62.6
25% NPK + Phosphotica	4.7	18.4	227.8	34.5	64.6
Azospirillum + Phosphotica	4.6	22.7	246.1	32.8	63.1
Azotobacter + Phosphotica	4.4	25.3	232.9	33.9	65.9
Azospirillum+*Azotobacter* + Phosphotica	4.5	24.7	237.9	34.6	71.0
SEm ±	0.09	0.05	12.08	1.02	1.37
CD at 5%	0.33	0.12	43.74	3.69	4.97
Initial nutrient status of soil	4.6	22.8	257.2	28.0	60.7

For sustainable cultivation of passionfruit it is imperative to follow an integrated use of nutrient sources. The application of biofertilizers as a starter dose improved the export of nutrients to leaf and fruit which paid great dividends in fruit development and yield. Biofertilizers such as *Azospirillum* and Phosphotica which are readily available in the market may be recommended for integrated application together with conventional fertilizers in order to increase productivity of passionfruit in farmer's field. Such application also ensures maintenance of the soil fertility and its sustainability to a large extend.

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