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Nutrient Requirement in Different Stages of Khasi Mandarin (*Citrus reticulata*, Blanco) in Assam

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ABSTRACT

An experiment was carried out in matured Khasi mandarin plot at the Barekuri village of Tinsukia in Assam to standardize the nutrient requirement in Khasi mandarin and its effect on yield, quality and nutrient content of Khasi mandarin and soil status of Khasi mandarin plot. The experiment has been conducted for six years. The experiment was laid out with 5 m × 5 m spacing along with 4 treatments, 5 replication and designed with RBD. Among the four treatments, T_2 treatments were found better for maximize yield and fruit quality of matured Khasi mandarin. Treatment (T_2) containing fertilizer application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during January- February, 30:40:10 per cent of RDF during March- April, 30:35:10 per cent of RDF during May- June 20:25:30 per cent of RDF during July- August, 10:0:25 per cent of RDF during September- October and 10:0:25 per cent of per cent of RDF during November-December was found better in terms of yield, quality of Khasi mandarin and fertility status of soil. Regarding, fruit qualities, higher juice content (47.72%), maximum TSS (11.20°Brix) and maximum number of fruits per tree (342) were observed in above mentioned treatment (T_2). Maximum soil nutrient status and NPK content on leaf were recorded under the same T_2 treatment. The maximum B: C ratio (2.20) was found in the same T_2 treatment.

Keywords Khasi mandarin, Fertilizer, Recommended dose of fertilizer.

INTRODUCTION

Khasi mandarin (*Citrus reticulata* Blanco) is the most economically important citrus fruit crops available in north-eastern region. The Khasi mandarin (*Citrus reticulata*), commonly known as orange, produced in this region is famous in India for its superior quality in respect of its flavor, juice content, soluble sugar and acidity ratio. The soil climatic conditions of this region are most suitable for its production and it has the potentiality to generate livelihood in the rural areas substantially. The nutritional requirement of Khasi mandarin varied widely owing to its perennial in nature. Mandarins, being a commercially important fruit crop, proper and correct dose of nutrients need to be evaluated to ensure quality of fruits, high economic productivity and sustaining the nutrition of the plant at a desirable level. Nutrient refers to all those compounds which are required by the plant as a source of body building material and for the energy, without which, it will not be able to complete its life cycle. The fruit tree nutrition is concerned

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with the provision of plant with nutrients as well as nutrient uptake and their distribution in the plant. Plant nutrient management can influence flowering, fruit set, fruit size, vegetative growth and other plant characteristics. The high nitrogen demands in tree during the main critical phases of flowering and fruiting process determine tree yield and productivity according to that, fruit set, fruit persistent number and initial fruit size were taken place during this period of time. Adequate supply of N is very much essential in citrus trees for rapid growth and development of young non-bearing trees as well as to promote flower initiation, development as well as fruit set and to support optimum yield of good quality fruit. However excessive leaf N concentration has resulted in a decrease in fruit yield due to the effect of luxurious consumption of N. Therefore, a standard practice in citrus trees is necessary to adjust or correct dose of N levels during each new cropping cycle, either as foliar or soil applications (Paul Jacobus *et al.* 2016). Phosphorus is the essential elements that absorbed as phosphate and play role in the group's photosynthesis, activities regulations and boosts the plant growth. It may play important roles in regulation of fruit quality due to its functions in energy transformation, carbon fixation and photosynthates transportation. Applications of P fertilizer improved fruit quality in citrus, as supported by the increases of TSS, ratio of TSS and TA, sugar accumulations (Songwei *et al.* 2021). Potassium is the most significant nutrient which regulates the value of fruits through its influence on the size of fruit, appearance of the fruit, fruit color, and vitamin contents. Potassium rates increase fruit size and total juice acidity while decrease the total soluble solids content of juice because of increased peel thickness (Toor *et al.* 2021).

Khasi mandarin is a perennial crop and it is considered as highly nutrient responsive crop. Multiple nutrient deficiency is common in most of the mandarin orchards in north eastern states. So, it is paramount importance to standardize the stage wise nutrient requirement during different growth period starting from flower initiation to harvesting stage of Khasi mandarin. For higher yield and better quality, it has been necessary to determine the stage wise nutrient requirement in Khasi mandarin in north eastern region.

MATERIALS AND METHODS

An experiment was carried out in matured Khasi mandarin plot at the Barekuri village of Tinsukia in Assam to standardize the nutrient requirement/dose in Khasi mandarin and its effect on yield, quality and soil status of Khasi mandarin plot. The experiment was laid out with 5 m × 5 m spacing along with four different treatments viz., T_1= Nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during Jan-Feb, 40:50:0 per cent of RDF during March- April, 40:50:0 per cent of RDF during May-June, 20:0:50 per cent of RDF during July- August, 0:0:25 per cent of RDF during September- October and 0:0:25 per cent of per cent of RDF during November-December, T_2 = Nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during Jan- Feb, 30:40:10 per cent of RDF during March- April, 30:35:10 per cent of RDF during May- June, 20:25:30 per cent of RDF during July-August, 10:0:25 per cent of RDF during September-October and 10:0:25 per cent of per cent of RDF during November-December, T_3 = Nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during Jan- Feb, 30:40:0 per cent of RDF during March-April, 30:35:0 per cent of RDF during May-June, 40:25: 30 per cent of RDF during July- August, 0:0:35 per cent of RDF during September- October and 0:0:35 per cent of per cent of RDF during November-December, T_4 (Control) = In control plot the recommended doses of fertilizer N, P_2O_5 and K_2O i.e., 600:300:600 g N, P_2O_5 and K_2O /pl/yr were applied along with 7.5 kg mustard oil cake /pl/yr in two splits. The treatments were applied in Randomized Block Design with four replications having four plants each.

Growth parameters (Plant height, Stem girth, East-West spread, North -South spread, canopy volume) were measured by using standard procedure. Soil chemical properties (pH, organic carbon, available nitrogen, available phosphorus, and available potassium) over the years were determined as per the method outlined by Jackson (1973). Number of fruits, average fruit weight, and other quality parameters (juice content, TSS, acidity, ascorbic acid, shelf life, yield) were estimated by adopting the standard techniques. Leaf samples were collected during the month of March (after flowering). Leaf N content was estimated by Kjeldhal Method (Jackson 1973), P

content was estimated by vanadomolybdo phosphoric acid yellow color method as described by Jackson (1973) and K contents were estimated by ammonium acetate extraction method using Flame photometer (Jackson 1973). S content in leaf was estimated by Turbidimetric method outlined by Chesnin and Yien (1951). Ca, Mg were determined using complexometric titration method (Baruah and Barthakur 1998). Fe, Mn, Cu and Zn were measured by using DTPA extractable method by using Atomic Absorption Spectrophotometer (Soltanpour and Schuwab 1977). Benefit: Cost ratio was determined after pooling the data over the years of experiment. The data generated in six consecutive years were pooled and used to prepare analysis of variance table and accordingly CD and SE (m) were computed as described by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Nutrient status of soil and leaf of Khasi mandarin

Before conducting the experiment, the initial soil pH, organic carbon content, initial available N, P_2O_5 and K_2O content in soils were measured. Initially soils were acidic (pH 5.08) in nature with high organic carbon contents (0.81%). Initial available N, P_2O_5 and K_2O content in soils were found to be low (Table 1).

After application of above said treatments maximum available N, P_2O_5 and K_2O content with higher organic carbon contents in soils were observed in T_2 treatment involving nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during January- February, 30:40:10 per cent of RDF during March- April, 30:35:10 per cent of RDF during May- June, 20:25:30 per cent of RDF during July- August, 10:0:25 per cent of RDF during September- October and 10:0:25 per cent of per cent of RDF during November-December.

Table 1. Effect of stage wise application of nutrient on soil status of Khasi mandarin (compiled data).

Treatments	Soil properties				
	pH	OC %	Av N	Av P_2O_5 kg ha^{-1}	Av K_2O
T_1	5.26	0.99	385	20.5	180.6
T_2	5.27	1.12	390	21.1	185.0
T_3	5.64	1.18	442	22.2	195.5
T_4	5.95	1.25	476	24.4	276.5
SEm	0.04	0.03	3.9	1.1	2.5
CD at 5%	0.12	0.09	11.7	3.3	7.5
Initial	5.08	0.81	280	18.5	169.9

Statistical analysis revealed that significant differences was found in soil parameters i.e., organic carbon content, available N, P_2O_5 and K_2O content in soil (Table 1).

Though leaf nutrient content of N, P and K and Zn, Ca were found maximum in T_2 treatment (Table 2) in Khasi mandarin but no significant differences were observed in leaf nutrient content of N, P and K, Ca, Mg, S, Fe, Mn, Cu and Zn.

Growth, yield and quality attributes of mandarin

Maximum plant height (6.25 m) and canopy volume (51.21 m^3) were observed under the treatment (T_2) treatment involving nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during January- February, 30:40:10 per cent of RDF during March- April, 30:35:10 per cent of RDF during May- June, 20:25:30 per cent of RDF during July- August, 10:0:25 per cent of RDF during September- October and 10:0:25 per cent of per cent of RDF during November-December.

This could be explained by the, facilitation of actions N+, P+ and K+ exchange, sustained availability of nutrients, and thereby the uptake by the plants resulting in better growth Nitrogen availability in adequate amount during critical stage of fruit initiation and development is necessary to support optimum yield of good quality fruit (Mahmoud and Gad 2020) (Table 3).

The higher yield (21.06 t ha^{-1}) was found in T_2 treatment involving nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during January- February, 30:40:10 per cent of RDF during March- April, 30:35:10 per cent of RDF during May- June, 20:25:30 per cent of RDF during July- August, 10:0:25 per cent of RDF during September- October and 10:0:25 per cent of per cent of RDF during November-December

Table 2. Effect of stage wise application of nutrient on leaf nutrient content of Khasi mandarin plants (compiled data).

Tree	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
T_1	1.79	0.17	0.98	0.74	0.34	0.07	90.6	36.6	2.6	9.7
T_2	1.86	0.18	0.89	0.74	0.35	0.06	87.2	37.5	3.1	9.7
T_3	1.84	0.18	0.89	0.78	0.38	0.06	89.6	37.4	2.6	9.8
T_4	1.96	0.20	0.96	0.86	0.43	0.07	91.5	36.7	3.6	10.5
SEm	0.03	0.01	0.04	0.04	0.03	0.01	0.40	0.40	0.30	0.4
CD at 5%	-	-	-	-	-	-	-	-	-	-

Table 3. Effect of stage wise application of nutrient on growth, quality, yield and B:C ratio of mandarin (compiled data).

Treatments	Plant height (m)	Canopy volume (m^3)	Average fruit weight	Juice (%)	Acidity (%)	TSS (°Brix)	Ascorbic acid (mg/ 100 ml)	Nos of fruit per tree	Shelf life (days)	t/ha	B:C ratio
T_1	6.24	50.40	151.98	45.67	0.42	10.30	44.12	274	15	16.66	1.07
T_2	6.25	51.21	153.98	47.72	0.36	11.29	46.07	342	17	21.06	2.20
T_3	6.14	51.65	152.93	44.57	0.43	9.70	43.34	298	16	18.23	1.23
T_4	6.18	51.02	154.61	44.59	0.45	9.54	43.58	241	16	14.90	1.14
SEm	0.03	1.20	0.9	0.05	0.03	0.06	0.03	9.0	0.03	1.4	-
CD at 5%	NS	3.6	2.7	-	-	0.24	-	27.0	-	4.2	-

followed by T_3 treatment (Table 3). Statistical analysis revealed that significant differences were observed in yield of Khasi mandarin. Improved yield might be due to application of fertilizers in stage wise of the plant as a result of availability of major nutrients at all the essential stages of growth and development. This result is in conformity with the findings of Bhite *et al.* (2018). Fruit yield of acid lime was largely regulated by nitrogen (N) supply because it affects photosynthesis and carbohydrates production, specific leaf weight and carbon allocation to tree plants. Although optimal N availability results in green foliage color and increased crop yields, excess N can lead to luxury consumption by the tree, negative impacts on fruit size and yield. Quaggio *et al.* (2006) reported that, nitrogen rates decreased fruit mass which resulted in increased TSS and juice content of fruits. Nitrogen promoted an accentuated increase in yield of soluble solids per area due to either increased fruit yield or improved fruit characteristics such as juice content and TSS in Valencia sweet orange. The fruit obtained under the treatment T_2 involving nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during January- February, 30:40:10 per cent of RDF during March- April, 30:35:10 per cent of RDF during May- June, 20:25:30 per cent of RDF during July- August, 10:0:25 per cent of RDF during September- October and 10:0:25 per cent of per cent of RDF during November-December was also found significantly superior in quality with higher benefit: Cost ratio (2.20). Higher juice content (47.72%), maximum TSS (11.29°Brix), Ascorbic acid, 46.07% and lowest acidity, 0.36% (Table 3) were observed in above mentioned treatment (T_2). Shelf life was the highest (17 days) though not significant.

CONCLUSION

From the results it is concluded that application of nutrient application of N, P_2O_5 and K_2O at 0:0:0 per cent of RDF during January- February, 30:40:10 per cent of RDF during March- April, 30:35:10 per cent of RDF during May- June, 20:25:30 per cent of RDF during July- August, 10:0:25 per cent of RDF during September- October and 10:0:25 per cent of per cent of RDF during November-December was found to be effective in improving the yield and quality of mandarin compared to the rest of the treatments. Maximum plant height (6.25 m) and canopy volume (51.21 m^3) were observed in treatment T_2. Regarding, fruit qualities, Higher juice content (47.72%), maximum TSS (11.29°Brix) and maximum number of fruits per tree (342) were observed in above mentioned treatment (T_2). Maximum soil nutrient status and higher

organic carbon content were recorded under the same treatment. The maximum B: C ratio (2.20) was found under this treatment. For the benefit of the farmers, the application dose of nutrient of T_2 treatment was calculated as Fertilizers that should be applied in stage wise for better yield and quality of matured Khasi mandarin with fertilizer application of N, P_2O_5 and K_2O at 0:0:0 per cent during January- February, 180 g N: 120 g P_2O_5 and 60 g K_2O during March- April, 180 g N: 105 g P_2O_5 and 60 g K_2O during May- June, 120 g N: 75 g P_2O_5 and 180 g K_2O during July- August , 60 g N: 0 g P_2O_5 and 150 g K_2O during September- October and 60 g N: 0 g P_2O_5 and 150 g K_2O during Nov-Dec should be applied. Fertilizers (Recommended dose of fertilizer - 600 g N: 300 g P_2O_5:600 g K_2O) should be applied in stage wise for better yield and quality of matured Khasi mandarin.

For higher yields of quality fruits on soils in Assam, following nutrient dose is recommended for Khasi mandarin.

•March- April, 30:40:10 per cent of RDF (180 g N: 120 g P_2O_5 and 60 g K_2O).

•May- June, 30:35:10 per cent of RDF (180 g N: 105 g P_2O_5 and 60 g K_2O).

•July- August, 20:25:30 per cent of RDF (120 g N: 75 g P_2O_5 and 180 g K_2O).

•September- October,10:0:25 per cent of RDF (60 g N: 0 g P_2O_5 and 150 g K_2O).

•November-December, 10:0:25 per cent of per cent of RDF (60 g N : 0 g P_2O_5 and 150 g K_2O).

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