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Studies on 'Kinnow' (*Citrus reticulata* Blanco.) Decline in Relation to Soil-Plant Nutritional Status

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Abstract

'Kinnow' decline was studied in relation to soil plant nutritional status under semi arid condition of Hisar (India). There were no differences between the soil pH, electrical conductivity and calcium carbonate of healthy and declining trees. The soil under the healthy trees had significantly higher organic carbon (0.46%) than that under declining trees (0.35%). The nutrients *viz.,* N, P, Zn, Cu, Mn and Fe in the soil under healthy and declining trees did not differ significantly except K. Leaf N, Zn, Cu, Mn and Fe were significantly more in the healthy trees. The deficiency of N, P, Zn and Mn in the leaves of both categories of trees could be attributed to low contents of these nutrients in the soil under healthy and declining trees. Growth, yield and fruit quality were better in healthy trees as compared to declining trees. The yield on kg per tree basis in declining trees reduced (8.43 kg/tree) as compared to that in healthy trees (20.74 kg/tree). Low organic carbon, soil N, Zn and Mn content could be associated with the declining problem of 'Kinnow'.

Keywords: 'Kinnow' decline, 'Kinnow' mandarin, nutritional status, soil-plant

Introduction

'Kinnow', a mandarin hybrid of King tangor and Willow leaf mandarin developed at University of California Research Center, Riverside, California (USA) in 1915 and released in 1935 had gained popularity during last 30 years with its area under cultivation increasing manifolds in Punjab, Rajasthan, Haryana and Himachal Pradesh States of India. This area increase might have been due to Kinnow's easy adaptability to varied agro-climatic conditions, heavy bearing and excellent juice quality characters which boosted its cultivation. Mandarins are particularly prone to decline. Arora *et al.* (1985) reported maximum incidence of decline in mandarin cvs 'Honey' (69.66 %), 'Dancy' (57.59%) and 'Kinnow' (55.25%) followed by sweet orange cvs 'Jaffa' (50.44%) and 'Campell Valencia' (43.13%) and 'Pearl tangelo' (51.37%). The healthy trees showed better nutrient status than the declining trees of Mandrin in Himachal Pradesh (Sharma and Mahajan, 1990). Nutritional disorders may be one of the contributory factors to citrus decline. Earlier studies in central India indicated that large-scale multinutrient deficiencies were responsible for the decline in citrus orchard productivity (Srivastava and Singh, 2004). Besides these factors, the soil and plant nutrients status and physico-chemical properties of soil play an important role in maintaining the health and vigour of the trees. The above mentioned factors lead to the changes in the nutritional, physiological and biochemical constituents in the plants. In present investigation, an effort has been made to study 'Kinnow' decline in relation to soil-plant nutritional status.

Materials and methods

The material for the present study comprised 24 trees of 'Kinnow' where, twelve trees each showing more than 60% healthy and more than 60% declining status were earmarked in February, 2009. The declining trees were apparently in debilitated state of health as compared to the vigorously growing healthy trees. There was preponderance of dead wood with many chlorites, senescent foliage in declining trees as against profuse lush green foliage with no apparent dead wood in healthy trees. Data was collected on various physiological and biochemical parameters at various stages of growth of the earmarked trees. Five randomly selected shoots from all sides of the tree were tagged in the month of February for recording shoot length, number of leaves per shoots and percent drying of shoot. Yield parameters *viz.,* number of fruits, average fruit weight, fruit length, fruit breadth and yield were recorded during the month of November. Total number of fruits was counted in November on each tree before harvesting. Length and breadth of five randomly picked fruits from each tree was recorded with digital Vernier Calipers and the average expressed in centimeters. Fruit weight was estimated by taking a sample of five randomly selected fruits from each tree

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and the average fruit weight has been expressed in grams per fruit. Yield per tree was calculated by multiplying the number of fruits with the average fruit weight.

The soil samples were collected from each of healthy and declining trees from the area between three fourth of the radius of the tree canopy to the drip line of the tree canopy. The samples were collected with the help of soil auger from 0-20 cm depth in the month of November, 2009. The electrical conductivity of the soil in supernatant solution of 1:2 soil-water ratio was measured with the help of electrical conductivity meter (Richards, 1968) and expressed as dSm^{-1}. The soil pH was measured from the soil saturation extract as per the procedure given by Richards (1968) on pH meter. The calcium carbonate in soil samples was determined by the method of Puri (1949) and expressed as percent. Organic carbon was determined by the method of Walkley and Black as reported by Jackson (1973) and expressed in percent. The available nitrogen (ppm) in soil samples was determined by the method of Subbiah and Asija (1956). The available phosphorus (ppm) in soil samples was determined by following the procedure of Olsen *et al.* (1954). The available potassium (ppm) of the soil samples was determined from the soil saturation on flame photometer. The DTPA (Diethylene triamine pentaacetic acid) extract of soil was prepared (Lindsay and Norvell, 1978) and the concentration (ppm) of these micronutrients was determined with the help of atomic absorption spectrophotometer (ASS).

For determining leaf nutrient status, five to six month old healthy thirty leaf samples from non-fruiting terminals were collected in the month of August and washed with running tap water followed by 0.1% HCL and two washings through distilled water. The washed leaf samples were surface dried and then oven dried at 70°C for 48 hours. The dried leaf samples were ground and digested as described by Jackson (1967) for determination of N, P, and K. For micronutrients viz. Zn, Fe, Mn and Cu, the 0.5 g of ground plant samples were digested (Piper, 1966) and measured on atomic absorption spectrophotometer. The nitrogen content was determined by the method described by Jackson (1973). The phosphorus content was determined by vando-molybdophosphoric acid yellow colour method described by Jackson (1973). Potassium content was determined from the digested extract on flame photometer. The content was calculated and expressed in per cent on dry weight basis. The statistical analyses of data were done by two sampled t-test.

Results and discussion

Comparison of soil pH under healthy vs. declining trees showed no significant difference (Tab. 1). In Egypt, evaluation of Balady lime, Cleopatra mandarin, and sour orange seedlings at various soil pH showed a reduction in growth by 9.8, 25.4, and 40.1% at soil pH 6.0, 7.0, and 8.0, respectively (Shawky *et al.*, 1980). Likewise the electrical conductivity under both healthy (0.44-0.53 dSm^{-1}) and declining (0.45-0.54 dSm^{-1}) trees showed no significant difference and was well within the critical limit of 0.9-1.7 dSm^{-1} as suggested by Bielorai *et al.* (1988). The organic carbon content of the soils varied significantly between healthy (0.46%) and declining trees (0.35%).

Tab. 1. Soil physico-chemical properties of healthy declining trees of 'Kinnow' mandarin

Tree Category	pH	EC (%)	$CaCO_3$ (%)	OC (%)
Healthy	8.00	0.49	1.81	0.46
Declining	8.02	0.50	1.70	0.35
Significance	NS	NS	NS	**

EC= Electrical conductivity, OC= Organic carbon, NS= Non-significant, **= Significant at 1% level

Lime-induced chlorosis is known as one of the commonest forms of decline due to immobilization of available micronutrients like Fe, Mn, and Zn. No significant differences were observed with respect to soil $CaCO_3$ between healthy trees (1.25-2.25%) and declining trees (1.25-2.00%). Soil $CaCO_3$ content under healthy trees was comparatively higher than those under declining trees (Tab. 4). Such observations need to be viewed from the angle of strong association of $CaCO_3$ nodules with micronutrient-containing minerals, and, in due course of time, these trapped nutrients are released and added to the available pool of nutrients.

Available N, P, Zn, Mn, Fe and Cu of soil did not vary significantly between healthy and declining trees however (Tab. 2), K content was significantly more in soil of healthy trees (393.2 K_2O kg/ha) than that in declining trees (360.6 K_2O kg/ha).

Leaf nutrient status of healthy or declining trees proved to be more closely related to the fruit yield variation than soil available nutrients (Srivastava and Singh, 2004). Similar observations were also obtained with regard to impact of leaf nutrients status on 'Kinnow' mandarin decline. Nutrients like N, Fe, Mn, Cu and Zn showed a significant variation when their nutrient status in healthy vs. declining trees was compared (Tab. 3). Macronutrient such as N was higher in healthy trees than declining trees whereas leaf P and K did not vary significantly between healthy and declining trees. Leaf micronutrients (Fe, Mn, Zn, and Cu) were, significantly higher in healthy trees than declining trees (Tab. 4). Zinc deficiency has long been stated associated with citrus decline (Wutscher, 1983).

Yield parameters viz., number of fruit/tree, fruit weight and yield (kg/tree) of healthy vs. declining trees differed significantly (Tab. 4). The difference among growth parameters was also significant between healthy and declining trees. The normal growth is an important feature of a good healthy tree, which varies with the nature of abnormalities encountered. Shoot dieback and stunted growth leading to reduced tree volume as the age progresses is commonly observed in citrus decline (Randhawa and Srivastava, 1986).

Tab. 2. Soil fertility status in healthy vs. declining trees of 'Kinnow' mandarin orchard

Tree Category	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/tree)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
Healthy	138.4	28.3	393.2	0.67	2.61	4.95	0.28
Declining	136.7	30.2	360.6	0.60	2.52	4.75	0.25
Significance	NS	NS	**	NS	NS	NS	NS

NS= Non-significant, **= Significant at 1% level

Tab. 3. Leaf tissue nutrient status in healthy vs. declining trees of 'Kinnow' mandarin orchard

Tree Category	N (%)	P (%)	K (%)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
Healthy	1.96	0.15	0.99	16.89	37.47	121.20	16.51
Declining	1.70	0.16	0.96	13.07	26.30	102.93	11.93
Significance	**	NS	NS	**	*	**	**

NS= Non-significant, **= Significant at 1% level, *= Significant at 5% level

Tab. 4. Yield parameters of healthy and declining trees of 'Kinnow' mandarin

Tree Category	No. of fruits/tree	Fruit weight (g)	Yield (kg/tree)	Fruit length (cm)	Fruit breadth (cm)	Shoot length(cm)	Numbers of leaves/shoot	% drying shoots/branch
Healthy	133.41	155.92	20.74	6.14	5.32	17.48	21.83	29.36
Declining	61.50	136.09	8.43	5.98	5.08	13.71	16.23	39.48
Significance	**	*	**	NS	NS	*	*	**

NS= Non-significant, **= Significant at 1% level, *= Significant at 5% level

Reduction in number of leaves has direct effect on leaf area and thus decreased the leaf area of the whole tree. Reduction in leaf area has a direct bearing on the productivity of the tree as well. Reduction in leaf area in declining citrus trees was also reported by Kanwar and Randhawa (1960). Blight affected citrus trees had fewer and smaller leaves, lesser leaf area per tree than healthy ones (Syvertsen *et al.,* 1980), likewise the soil salinisation can also affect leaf area (Patil and Bhambota, 1978). The reduction in leaf area in the present study could be attributed physiological and nutritional disorders and old age of the orchard. The declining trees as observed in present study wore a deserted look along with drastic reduction in canopy, sparse, pale green to chlorotic foliage, abundance of dead wood due to dieback, which were in sharp contrast to the profusely growing healthy trees with lush green, abundant foliage and gigantic canopy. Similar observations were reported by Diware and Kolte (1990) and Huchche (1999). The yield was found to be significantly lower, in declining trees. Yadav *et al.* (1997) reported reduction in yield with the reduction in tree canopy in Nagpur mandarin. Reduction in number of fruit per tree, fruit weight and yield per tree was observed by Huchche (1999). Deterioration of cropping and fruit quality in declining citrus trees has also been reported by earlier workers (Nunez *et al.,* 1994). Randhawa (1970) reported that citrus fruits from declining trees were smaller in size and malformed. The yield of healthy trees was more than that of declining trees but yield of healthy trees was also lower than normal yield of healthy 'Kinnow' tree, it could be due to the old age (>15 years) of the orchard and physiological and nutritional disorders.

Conclusions

It can be concluded from the present study that low organic carbon, soil nitrogen, soil zinc and soil manganese contents could be associated with declining of 'Kinnow' mandarin under Hisar conditions. The lower leaf nutrient contents of declining trees indicated that it was a problem of transport and redistribution within the plant rather than the uptake of the elements. Although, the yield of healthy trees was found to be more than declining trees but it was lower than the average yield of a 'Kinnow' tree, which could be due to the old age of the orchard. However, rating various nutritional constraints in the order of their increasing or decreasing influence on yield would further help to evolve a more purposeful nutrient management programme and, thereby, counter citrus decline more effectively than straight nutrient constraint diagnosis, while adding sustainability in quality citrus production. To address this objective, nutrients like N, P, K, Fe, Mn and Zn are of major significance, which should be a part of the fertilization program on a regular basis.

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