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Development of DRIS based soil fertility and leaf nutrient standards for improving the efficiency of Kinnow mandarin (*Citrus reticulata* Blanco) in semi-arid region of Rajasthan

A.K. SRIVASTAVA[1], AMIT MISHRA[1]*, CHANDRABHAN, A.K. SRIVASTAVA[2] AND S.K. BAIRWA

Agricultural Research Station (Swami Keshavanand Rajasthan Agricultural University), Sriganganagar- 335001 Rajasthan,

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ABSTRACT

The study was carried out during 2015-16 at district Sriganganagar under semi arid region of Rajasthan India with the aim to diagnose the soil fertility indicator by using DRIS norms to improve the kinnow orchards efficiency. A total 105 kinnow mandarin orchards were selected through the preliminary survey, all the selected orchards were divided equally 35 each in low, medium and high efficiency based on the yield. The soil and plant sample were collected from the orchards and subjected to analyze by using standard analysis protocols. Five tier DRIS norms were used for determining the soil properties limiting factor. The high efficient orchards had low pH (8.1) and $CaCO_3$, (23.4 g kg^{-1}) whereas, comparatively more organic carbon (2.7 g kg^{-1}) , phosphorus (38.2 kg ha^{-1}) and potassium (296.2 kg ha^{-1}) than medium and low efficient orchards. The nitrogen, phosphorus and potassium contents were also high in high yield orchards and ultimately responsible for the better quality parameters viz. fruit weight (170.35 g), Juice (49.51 %), total soluble sugar (12.88 %) and low acidity (0.81 %) in high efficient orchards. The five tier DRIS norms suggested that < 8.8 pH, < 89.0 g kg^{-1} CaCO3, < 2.5 g kg^{-1} organic carbon and 14.2 kg ha^{-1} phosphorus were limiting soil fertility indicators in relation to fruit yield less than 14.5 t ha^{-1} for kinnow mandarin orchards of semi arid region of Rajasthan. It is evident from the DRIS norms in relation to soil properties and plant tissue concentration yield should be considered as low when it is less than 14.5 to 20.2 t ha^{-1}. It is therefore imperative to manage these parameters for the better quality production and sustainability of kinnow orchards.

Keywords: Kinnow mandarin, orchards efficiency, Soil Fertility, Leaf Nutrient and DRIS norms

INTRODUCTION

Kinnow is cultivated throughout North India. Punjab, Rajasthan, Haryana, Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh are major growing states. India is one of the dominant producer kinnow mandrin in the world. In Rajasthan during 2019-20, Kinnow occupies 11.1 thousand hectare area under cultivation and production has 264.03 thousand MT, whereas, Sriganganagar district is well known for its area and production, district occupied 9.0 thousand hectare and its production has been realized 215.30 thousand MT, which was realized 81.5 percent of total Kinnow production in Rajasthan state (GOR, 2019). The Soils of Rajasthan are categorized under *Aridsols* order, which is inherently poor in soil fertility, the organic carbon status is categorized low to medium. The poor organic carbon status may be due high pH of soils and high temperature which dissolve the soil organic carbon. The major plant nutrient available nitrogen, phosphorus and potassium are indicator of soil fertility. Calcium carbonate content in soil influences the orchard performance. It is therefore, periodic monitoring and their management of soil fertility are indispensible for sustainable kinnow mandarin production. Improper management of soil fertility leads to deteriorate productivity of the crops and also quality of the produce eventually lower market price of the production. Further, The fertilizer application either blanket recommendation or soil test based fertilizer recommendations, both the recommendations are suitable for the orchards as requirement of tree and other management practice ignored for the development of the fertilizer recommendation. The Diagnosis and Recommendation Integrated System (DRIS) based approach of fertilizer management is proven way of sustainable fruit production. As DRIS norms can be developed from soil properties and plant nutrient concentration, as both parameters are tools for the determination of nutrient status in citrus orchards

Corresponding Author Email: amitkatayani@gmail.com
[1]Banda University of Agriculture & Technology, Banda-21001, Uttar Pradesh
[2]ICAR-Central Citrus Research institute, Nagpur- 440010, Maharashtra

(Srivastava and Singh, 2004). further DRIS norms had been developed to determine the most limiting factor of soil properties and nutrient concentration plant for several fruit orchards including *Citrus* (Srivastava and Singh 2004, Raghupathi *et al.* (2013), Disha *et al.* (2012) and Savita and Anjaneyulu (2008), DRIS also identifying the imbalances, deficiencies and excesses in plant nutrients and ranking them in order of importance. DRIS five tier system norms is more efficient for the fertilizer recommendation in fruit crops (Lakshmi *et al.,* 2017). The aim of fertilizer management is to increase the net income of grower which depends upon fruit quality and judicious use of fertilizers and to decrease the environment losses. The leaf analysis also indicates the requirement of nutrients, therefore site specific fertility management is the key for higher production of better quality fruit. The limited work of determination of soil fertility had done particularly in north India especially on Kinnow mandarin. The keeping the above facts under consideration the present study planned to determine the effect of soil fertility on orchards efficiency and to develop comprehensive soil and plant nutrient based DRIS approach for the improvement of orchards efficiency.

MATERIALS AND METHODS

The proposed study was carried out under AICRP on Fruits at Agricultural Research Station located at Sriganganagar , Rajasthan, India which comes under Zone Ib. The zone has extreme climatic conditions with the scorching summer, cold winter and mild rainy season. The rainfall in the zone ranged from 185 to 590 mm during the period of 1980 to 2001 with an average value of 322 mm. On an average 75 per cent of the total rainfall received from June to September. The temperature in the zone fluctuates from as low as 10 ^{o} C to as high as 48 ^{0} C. June is the hottest month and January is the coldest month of the year. The average monthly pan evaporation fluctuates from 49.4 mm in December to 337.6 mm in May with annual value of 1865.7 mm. A total of 105 kinnow mandarin orchards were selected through the preliminary survey, all the selected orchards were divided 35 each in low, medium and high efficiency based on the yield. Numbers of orchards were considered as a replication. Two trees from each in low, medium and high yielding orchards were marked for taking samples of leaf and soil for nutrient analysis. All orchards age varied from 10-15 years. The soils of study area were sandy intexture. The each study year's soil samples were collected from the depth of 0-20 cm through standard protocol. The time of sampling was almost same during all the study years. The soil samples collected were analyzed for pH, electrical conductivity (EC), organic carbon, $CaCO_3$ by adopting standard procedures (Jackson, 1973). Available N, available phosphorus and available potassium were estimated by method proposed by Subbiah and Asija (1956), Olsen *et al.,* (1954) and Hanway and Heidel, (1952), respectively. The 6 to 8 month old matured leaves were selected from the different parts of tree for the analysis of nitrogen, phosphorus and potassium concentration in tissues. The leaves were washed with dilute hydrochloric acid and distilled water before the drying and grinding. Thereafter N, P and K concentrations in leaf were determined by adopting standard procedures. The yield of the orchards was also recorded during the study years. The quality indices such as fruit weight, Juice (%), rind thickness, polar diameter, transverse diameter, total soluble sugar (TSS) (%) and acidity (%) was also measured by adopting standard procedures.

Five year average soil, plant and quality parameter data were subjected to univariate statistical analysis for the description of the different parameter. DRIS based indices of soil and plant nutrient based was developed from the data. The DRIS norm modified by Bhargava (2002) was used for the development of DRIS indices. DRIS norms for soils were calculated as per procedure developed by Filho (2004).The norms for classification of nutrients in soils were derived using them as mean of high yielding orchards as the mean for optimum. The range of optimum was the value derived from mean - 4/3 to +4/3 standard deviation. The range of low was obtained by calculating –4/3 to mean –8/3 standard deviation, and the value below mean –8/3 standard deviation was considered deficient. The value from mean +4.3 to mean +8.3 standard deviation was measured as an excess (Bhargava 2002, Srivastava and Singh 2007, 2008a, 2008b). As such, new five-tier system of classification of soil characteristics has been established as new ratings for soil fertility, viz. deficient, low, optimum, high and excess for each soil parameter.

RESULTS AND DISCUSSION

It is evident from the soil fertility indicators (Table 1), that the variation in yield of kinnow orchards was observed in respect to soil chemical properties. The low efficient orchards had high pH and electrical conductivity and low organic carbon. The $CaCO_3$ content was high in low efficiency orchards as compared to medium to low efficiency orchards. The $CaCO_3$ restricts the proliferation of the roots thereby prevent the nutrient supply to the plant. The critical limit of $CaCO_3$ is beyond the 5%, the value more 5 % adversely affects plantation productivity. The nitrogen content was low irrespective of the efficiency of orchards. The available phosphorus was very low in low efficient orchards. The phosphorus plays a role in root development and analyzed value was found to be very low in low efficiency orchards. The potassium content was low in low efficient orchards while high in medium and high efficiency orchards. As nutrients are the major contributors in plant and ultimately decides the productivity of the soils. Very poor organic carbon and phosphorus and high in $CaCO_3$ might be the major cause behind the low efficiency of the kinnow orchards (Srivastava and Singh 2003a, 2003b). Whereas, the high efficient orchards had comparatively better soil properties such as low in pH, $CaCO_3$ and slightly high organic carbon.

Table 1: Variation in soil fertility status in relation to fruit yield of Kinnow Mandarin

Parameters	Low efficient		Medium efficient		High efficient	
	Low	CV (%)	Medium	CV (%)	High	CV (%)
pH	8.42	3.51	8.29	3.56	8.10	4.49
EC (dS/m^{-1})	1.20	66.01	0.42	35.86	0.26	29.26
OC (g kg^{-1})	1.80	36.30	2.10	21.61	2.70	21.80
$CaCO_3$ (g kg^{-1})	89.9	31.89	37.4	24.99	23.4	48.90
Available N (kg ha^{-1})	91.97	10.12	109.87	8.88	122.20	8.24
Available P_2O_5 (kg ha^{-1})	18.35	24.87	24.89	25.13	38.20	16.14
Available K_2O (kg ha^{-1})	220.50	25.85	268.79	21.37	296.22	23.50
Yield (t ha^{-1})	17.76		31.02		47.35	

The critical limit of kinnow mandarin for N 2.3 %, P 0.09 % and K 0.72 % developed for the North West India (Chahill *et al.*, 1991) used for the description of tissue content in different orchards. The concentration of leaf nutrient in different efficient orchards varied significantly. Impact of soil properties is clearly visible in nutrient concentration of tissues. The nitrogen, phosphorus and potassium contents in kinnow leaf tissues were lower than the medium and high efficient orchards. The nitrogen content in low efficient plantation was lower than critical limit, whereas, phosphorus and potassium contents were more than critical limit, as leaves are source for fruit and poor nutrient content of leaves may adversely affect the production of the orchard (Table 2).

Table 2: Variation in leaf nutrient composition in relation to fruit yield of Kinnow Mandarin

Parameters	Low efficient		Medium efficient		High efficient	
	Low	CV (%)	Medium	CV (%)	High	CV (%)
Nitrogen (%)	1.78	18.88	2.25	19.24	2.78	14.66
Phosphorus (%)	0.11	50.10	0.14	26.44	0.21	26.24
Potassium (%)	1.09	30.43	1.29	21.69	1.52	15.03
Yield (t ha^{-1})	17.76		31.02		47.35	

All the fruit quality parameters were found to be comparatively better in high yield orchards followed by the medium yielding orchards. Fruit weight, Juice and TSS viz. 170.35 g fruit^{-1}, 49.51% and 12.88% were higher than the low efficient orchards, respectively. While, the acidity was high in low efficient orchard, it is therefore, evident from the soil properties and nutrient concentration in tissues, that these properties influenced the quality of the fruit. As quality of fruits is main determining factor of the price of fruit (Table 3).

Table 3: Variation in fruit quality parameters at various field levels of Kinnow Mandarin

Parameters	Low efficient		Medium efficient		High efficient	
	Low	CV (%)	Medium	CV (%)	High	CV (%)
Fruit weight (g fruit^{-1})	127.78	5.87	148.79	10.09	170.35	11.89
Juice (%)	43.10	8.67	47.14	11.79	49.51	5.58
Rind thickness (cm)	0.35	11.85	0.29	9.16	0.26	14.24
Polar Dia. (cm)	4.97	10.78	5.72	7.60	6.10	5.68
Trans. Dia. (cm)	5.76	9.60	6.76	6.92	7.42	3.53
TSS (%)	8.30	7.78	11.20	8.67	12.88	7.99
Acidity (%)	1.192	25.87	0.992	26.59	0.81	20.58

The five tier DRIS norms developed from the analysis of 105 orchards suggested that optimum value in relation to fruit yield of 20.3 to 35.8 t ha^{-1} soil properties should be ranged from 8.3-8.5 pH, 0.56-0.71 dSm^{-1} EC, 43.0-75.0 g kg^{-1} $CaCO_3$, 4.3-5.8 g kg^{-1}organic carbon, 112.4-123.4 kg ha^{-1} nitrogen, 23.3-28.1 kg ha^{-1} phosphorus and 272.4-301.4 kg ha^{-1} potassium. Whereas, to achieve high fruit yield i.e. > 45.2 t ha^{-1} the DRIS predicated the soil properties should be < 8.0 pH, < 0.92 dSm^{-1} EC, < 25.0 g kg $^{-1}$ $CaCO_3$, >7.1 g kg^{-1} organic carbon, >136.1 Kg ha^{-1} nitrogen, > 36.1 kg ha^{-1} phosphorus and > 334.1 kg ha^{-1} potassium. As per the DRIS norms for the soil properties with proper management of soil fertility indicators growers of kinnow mandarin orchards can get fruit yield > 45.2 t ha^{-1} (Table 4). The results of the study were in confirmation with those of Lakshmi *et al.,* (2017) and Srivastava and Singh (2003a, 2008a) for the *Citrus* orchards.

Table 4: DRIS based soil fertility limit for Kinnow Mandarin orchards

Soil Properties	DRIS Indices				
	Deficient	Low	Optimum	High	Very High
pH (1:2)	>8.8	8.6-8.8	8.3-8.5	8.0-8.2	<8.0
EC (dSm^{-1})	>0.92	0.72-0.92	0.56-0.71	0.28-0.55	<0.28
$CaCO_3$(g kg^{-1})	>89.0	76.0-89.0	43.0-75.0	26.0-42.0	<25.0
Organic Carbon (g kg^{-1})	<2.5	5.0-4.2	4.3-5.8	5.9-7.1	>7.1
Available N (kg ha^{-1})	<95.1	95.2-112.3	112.4-123.4	123.4-136.1	>136.1
Available P (kg ha^{-1})	<14.2	14.2-23.2	23.3-28.1	28.2-36.1	>36.1
Available K (kg ha^{-1})	<228.4	228.4-272.3	272.4-301.4	301.4-334.1	>334.1
Fruit yield (t ha^{-1})	<14.5	14.5-20.2	20.3-35.8	35.9-45.2	>45.2

The DRIS norms for the plant tissue nutrient concentration predicated the low nitrogen (<1.68 %), phosphorus (< 0.10 %) and potassium (<1.18 %) in relation to fruit yield less than 14.5 t ha^{-1} (Table 5). While in order to get "optimum" fruit yield i.e. 20.3-35.8 t ha$^{-1,}$ the nutrient concentration values should be 2.11-2.48 % nitrogen, 0.14-0.16 % phosphorus and 1.35-1.48 % potassium. The "very high" efficiency of orchards (>45.2 t ha^{-1}) considered when nutrient concentration should be > 2.72 % nitrogen, > 0.22 % phosphorus and > 1.68 % potassium. Therefore, the regular monitoring of plant tissue concentration and rectifying the deficiency of nutrients through application of fertilizers may ensure to achieve better yield as per the DRIS norms. The similar results were reported by Bhargava (2002) for fruit crops. Five tier DRIS norms predicted that the yield level should be considered "low" when it was < 14.5 t ha^{-1}, "optimum" 20.3 to 35.8 t ha^{-1} and "very high" > 45.2 t ha^{-1} as per the soil properties and nutrient concentration of plant for the semi arid region.

Table 5: DRIS-based leaf nutrient standards for Kinnow Mandarin orchards

Nutrients	DRIS Indices				
	Deficient	Low	Optimum	High	Excess
Nitrogen (%)	<1.68	1.68-2.10	2.11-2.48	2.48-2.72	>2.72
Phosphorous (%)	<0.10	0.11-0.13	0.14-0.16	0.17-0.22	>0.22
Potassium (%)	<1.18	1.18-1.34	1.35-1.48	1.48-1.68	>1.68
Fruit yield(t ha^{-1})	<14.5	14.5-20.2	20.3-35.8	35.9-45.2	>45.2

Thus, it can be concluded from the present investigation, that these DRIS norms can be used for fertility evaluation and plant tissue nutrient concentration. The rationalization in soil fertility through management of fertilizer and organic manure application is potential to improve quality of produce, increase in yield and ultimately net income of the farmers.

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