DOI : 10.5958/0974-0112.2017.00097.4

Indian J. Hort. 74(4), December 2017: 498-504

Diagnosis of nutrient imbalance by Diagnostic and Recommended Integrated System in pomegranate growing soils of south-western Maharashtra

A.B. Gosavi*, A.N. Deshpande and A. Maity**

Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra

ABSTRACT

Diagnostic and Recommended Integrated System (DRIS) approach was employed to develop soil diagnostic norms of major, secondary and micronutrients for pomegranate cv. Bhagwa. For this purpose, pomegranate growing 150 orchards having Bhagwa variety of 4-to 6-year-old under drip irrigation with *hasta bahar* were selected from south western Maharashtra (Solapur, Satara and Sangli districts). The DRIS norms developed for soil nutrients along with DRIS indices and order of nutrient requirement in the selected orchards at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages of pomegranate are presented and discussed in this paper. The DRIS norms developed for very low, low, optimum, high and very high status of soil nutrients in pomegranate at various crop growth stages can serve as nutrient guide and diagnose the nutrient deficiency and excess or imbalance of nutrients. In this study, the DRIS indices indicated that calcium was the most needed plant nutrient by pomegranate at 50 per cent flowering, fruit development and even at Ist harvesting stage.

Key words: Pomegranate, soil nutrients, DRIS norm, indices.

INTRODUCTION

Pomegranate (*Punica granatum* L.) is the important horticultural crop of semi-arid and arid regions of India. History, for origin of the crop, indicates that pomegranate is originated from Iran and then shifted to Afghanistan, Pakistan, India, and United States (Sarkhosh *et al*.,11; Navale, 7). The fruit is symbolic of plenty and very much liked for its cool, refreshing juice and valued for its medicinal properties. The juice has sugar content of 12 to 16 per cent, phosphorous 70 mg, magnesium 12 mg, iron 0.3 mg, sodium 0.3-1.8 mg per 100 mg of edible part (Shulman *et al.*, 12).

Since, pomegranate is a hardy crop, it thrives well under light soils as well limited irrigation conditions in Maharashtra (Deshpande and Patil, 4). They reported that the status of N, P, K, Ca and Mg in soils of pomegranate orchards from Solapur district of Maharashtra is sufficiently high. The distribution of all the nutrients (N, P and K) decreased with increasing depth of soils in both the profiles and both types of gardens. The higher values of EC, $CaCO_3$, Ex. Mg content and lower values of organic carbon, available N, P, K and Ex. Ca were observed in neglected gardens as compared with well managed gardens.

In a review paper on DRIS, Bangroo *et al.* (1) concluded that DRIS norms should be developed for specific conditions, in which all other factors to be correlated with yield or quality (or any other variable) be known and isolated: cultivar, climate, soil and crop management, productivity *etc.*, attaining the specific objectives. After establishment of new promising variety Bhagwa, in south western Maharashtra, separate recommendation regarding nutrition of this variety is necessary for precision farming and hence the study was undertaken.

MATERIALS AND METHODS

A survey 150 cultivators of growing pomegranate from the south western Maharashtra (Solapur, Satara and Sangli districts) was undertaken during 2011-12. The selection of farmers in each district was done on the basis of area under pomegranate in the district as compared to the total area in south western Maharashtra. The farmers having Bhagwa variety of 4- to 6-year-old, grown on drip irrigation in *Hasta bahar* were selected for study. Soil samples from 0-30 cm depth at *bahar*, 50 per cent flowering, fruit development and Ist harvest stage of pomegranate were collected and brought to the laboratory. They were air-dried in shade, ground with mortar and pestle and passed through 2 mm sieve for analysis. Sieved soil samples were stored in cloth bags with proper labeling for analysis. The soil analysis was done by following the standard procedures.

For DRIS analysis the orchards were grouped into two different classes on the basis of yield as per the standard method given by Beaufils (2). The highest yield of pomegranate was recorded 25.98 Mg ha^{-1}. The yield of 20.00 Mg ha^{-1} was 77 per

*Corresponding author's E-mail: gosaviavi@rediffmail.com

**ICAR-National Research Centre on Pomegranate, Solapur, Maharashtra

cent of the highest yield. This yield was identified as a line of demarcation between the high and low yielding groups. The procedure as initially developed by Beaufils (2), modified by Bhargava (3) was used through a computer based programme for development of DRIS norms.

Following equation was developed for calculation of DRIS indices of soil nitrogen.

N = 1/9 {(f (N/P) + f (N/K) + f (N/S) + (N/Na) + f (N/B) + f (N/Mg) + f (N/Fe) + f (N/Mn) + f (N/Cu) + f (N/Zn)}

Similarly for P, K, Ca, Mg, S, Fe, Mn, Cu, Zn, B and Mo, equations were developed.

Where $f(N/P) = \left\{\frac{N/P}{n/p}\right\}\left\{\frac{1000}{CV}\right\} - 1$ when N/P>n/p

and

$fc(N/P) = 1 - \left\{\frac{N/P}{n/p}\right\}\left\{\frac{1000}{CV}\right\}$ when N/P<n/p

Where, N/P is the actual value of the ratio of N and P in the soil under diagnosis. The n/p is the value of the norm (which is the mean value of high yielding plots) and CV is the coefficient of variation for population of high yielding plots.

The norms for classification of nutrients in leaves were derived using them as mean of high yielding orchards as the mean for optimum. The range of mean was the value derived from mean -4/3 standard deviation to +4/3 standard deviation. The range of low was obtained by calculating -4/3 standard deviation to -8/3 standard deviation and the values below mean -8/3 standard deviation were considered as deficient. The value from mean +4/3 standard deviation to mean +8/3 standard deviation was considered as an excesses (Bhargava, 3).

RESULTS AND DISCUSSION

The DRIS norms developed for other chemical properties of soil (Tables 1 to 4) revealed that, optimum level for pH were 7.78 to 8.88, 7.79 to 8.85, 7.86 to 8.87 and 7.92 to 8.89 at *bahar*, 50 per cent flowering, fruit development and Ist harvest stages, respectively. While for electrical conductivity the norms were 0.20 to 0.46, 0.19 to 0.48, 0.19 to 0.50 and 0.21 to 0.50 dSm^{-1}, for organic carbon those were 4.1 to 9.7, 4.3 to 9.6, 4.5 to 9.8 and 4.6 to 9.8 g kg^{-1} and for calcium carbonate the DRIS norms are 86.6-156.3, 91.8-155.5, 91.5-148.5 and 86.8-136.6 g kg^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages respectively. Raghupathi and Bhargava (8) observed the range of pH from 8.1 to 8.8 with the optimum DRIS norms of pH from 8.2 to 8.6, whereas for electrical conductivity the norms were 0.08 to 0.31 dS m^{-1} in the pomegranate orchards of Bijapur district of northern Karnataka. Deshpande and Patil (4) reported the range of pH from 7.6 to 9.4, electrical conductivity from 0.10 to 0.95 dSm^{-1} and organic carbon from 0.40 to 1.21 per cent for soils of the pomegranate growing orchards in Solapur area.

DRIS norms for available nitrogen at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages were 161.50 to 255.50, 152.20 to 241.90,

Table 1. DRIS norms for soil available nutrients at *bahar* stage of pomegranate.

Parameter	Very low	Low	Optimum	High	Very high
pH (1:2.5)	<7.21	7.21-7.77	7.78-8.88	8.88-9.44	>9.44
EC (dS m^{-1})	<0.06	0.06-0.19	0.20-0.46	0.47-0.59	>0.59
OC (g kg^{-1})	<01.1	1.1-4.0	4.1-9.7	9.8-12.6	>12.6
$CaCO_3$ (g kg^{-1})	<51.6	51.6-86.5	86.6-156.3	156.4-191.2	>191.2
Av. N (kg ha^{-1})	<114.3	114.3-161.4	161.5-255.5	255.6-302.5	>302.5
Av. P (kg ha^{-1})	<6.14	6.14-11.77	11.78-23.01	23.02-28.63	>28.63
Av. K (kg ha^{-1})	<127.9	127.9-232.2	232.3-440.9	441-545.2	>545.2
Ex. Ca (cmol (p^+) kg^{-1})	<18	18-27.64	27.65-46.92	46.93-56.55	>56.55
Ex. Mg (cmol (p^+) kg^{-1})	<5.26	5.26-10.80	10.81-21.89	21.9-27.43	>27.43
Ex. Na (mg kg^{-1})	<0.11	0.11-0.22	0.23-0.45	0.46-0.56	>0.56
S (mg kg^{-1})	<1.92	1.92-6.93	6.94-16.95	16.96-21.96	>21.96
DTPA Cu (mg kg^{-1})	<0.14	0.14-2.11	2.12-6.06	6.07-8.03	>8.03
DTPA Fe (mg kg^{-1})	<1.12	1.12-3.70	3.71-8.85	8.86-11.43	>11.43
DTPA Mn (mg kg^{-1})	<3.59	3.59-7.71	7.72-15.96	15.97-20.08	>20.08
DTPA Zn (mg kg^{-1})	<0.31	0.31-0.51	0.52-0.92	0.92-1.12	>1.12
B (mg kg^{-1})	<0.04	0.04-0.16	0.17-0.40	0.41-0.52	>0.52
Mo (mg kg^{-1})	<0.01	0.01-0.05	0.06-0.13	0.14-0.18	>0.18

153.60 to 228.80 and 141.70 to 222.00 kg ha^{-1}, respectively. The highest requirement of nitrogen was observed at *bahar* stage (206.83 kg ha^{-1}) for pomegranate. Raghupathi and Bhargava (9) reported the optimum range 44 to 103 mg kg^{-1} for available soil nitrogen. Deshpande and Patil (4) observed the range of available nitrogen from 113 to 310 kg ha^{-1} in the pomegranate orchards of Solapur region.

Table 2. DRIS norms for soil available nutrients at flowering stage of pomegranate.

Parameter	Very low	Low	Optimum	High	Very high
pH (1:2.5)	<7.25	7.25-7.78	7.79-8.85	8.86-9.38	>9.38
EC (dS m^{-1})	<0.04	0.04-0.18	0.19-0.48	0.49-0.62	>0.62
OC (g kg^{-1})	<1.5	1.5-4.2	4.3-9.6	9.7-12.4	>12.4
$CaCO_3$ (g kg^{-1})	<59.9	59.9-91.7	91.8-155.5	155.6-187.3	>187.3
Av. N (kg ha^{-1})	<107.2	107.2-152.1	152.2-241.9	242.0-286.8	>286.8
Av. P (kg ha^{-1})	<8.09	8.09-13.4	13.5-23.9	24-29.2	>29.2
Av. K (kg ha^{-1})	<199	199-310	311-533	534-644	>644
Ex. Ca (cmol (p$^+$)kg^{-1})	<22.2	22.2-30.1	30.2-46.0	46.1-53.9	>53.9
Ex. Mg (cmol (p$^+$)kg^{-1})	<8.2	8.2-13.2	13.3-23.2	23.3-28.2	>28.2
Ex. Na (mg kg^{-1})	<0.13	0.13-0.23	0.24-0.43	0.44-0.54	>0.54
S (mg kg^{-1})	<2.16	2.16-7.18	7.19-17.24	17.25-22.27	>22.27
DTPA Cu (mg kg^{-1})	<0.74	0.74-2.78	2.79-6.85	6.86-8.88	>8.88
DTPA Fe (mg kg^{-1})	<0.62	0.62-3.01	3.02-7.77	7.78-10.15	>10.15
DTPA Mn (mg kg^{-1})	<5.03	5.03-9.73	9.74-19.12	19.13-23.82	>23.82
DTPA Zn (mg kg^{-1})	<0.22	0.22-0.47	0.48-0.96	0.97-1.21	>1.21
B (mg kg^{-1})	<0.06	0.06-0.21	0.22-0.50	0.51-0.60	>0.60
Mo (mg kg^{-1})	<0.01	0.01-0.05	0.06-0.14	0.14-0.18	>0.18

Table 3. DRIS norms for soil available nutrients at fruit development stage of pomegranate.

Parameter	Very low	Low	Optimum	High	Very high
pH (1:2.5)	<7.34	7.34-7.85	7.86-8.87	8.88-9.38	>9.38
EC (dS m^{-1})	<0.02	0.02-0.18	0.19-0.50	0.51-0.66	>0.66
OC (g kg^{-1})	<1.7	1.7-4.4	4.5-9.8	9.8-12.4	>12.4
$CaCO_3$ (g kg^{-1})	<60.9	60.9-90	91.5-148.5	149-177	>177
Av. N (kg ha^{-1})	<115.8	115.8-153.5	153.6-228.8	228.9-266.5	>266.5
Av. P (kg ha^{-1})	<7.59	7.59-13	13.1-24.1	24.2-29.6	>29.6
Av. K (kg ha^{-1})	<149.3	149.3-311.2	311.3-635.5	635.6-797.6	>797.6
Ex. Ca (cmol (p$^+$) kg^{-1})	<22.2	22.2-29.6	29.7-44.3	44.4-51.7	>51.7
Ex. Mg (cmol (p$^+$) kg^{-1})	<6.7	6.7-11.8	11.9-22.1	22.2-27.3	>27.3
Ex. Na (mg kg^{-1})	<0.13	0.13-0.23	0.24-0.43	0.44-0.53	>0.53
S (mg kg^{-1})	<2.19	2.19-7.35	7.36-17.69	17.7-22.86	>22.86
DTPA Cu (mg kg^{-1})	<0.77	0.77-2.88	2.89-7.11	7.12-9.22	>9.22
DTPA Fe (mg kg^{-1})	<1.92	1.92-3.53	3.54-6.74	6.75-8.35	>8.35
DTPA Mn (mg kg^{-1})	<6.59	6.59-10.24	10.25-17.52	17.53-21.17	>21.17
DTPA Zn (mg kg^{-1})	<0.24	0.24-0.49	0.50-1.00	1.01-1.25	>1.25
B (mg kg^{-1})	<0.1	0.1-0.23	0.24-0.50	0.51-0.63	>0.63
Mo (mg kg^{-1})	<0.01	0.01-0.05	0.06-0.13	0.14-0.17	>0.17

Table 4. DRIS norms for soil available nutrients at first harvesting stage of pomegranate.

Parameter	Very low	Low	Optimum	High	Very high
pH (1:2.5)	<7.42	7.43-7.91	7.92-8.89	8.90-9.38	>9.38
EC (dS m^{-1})	<0.05	0.06-0.20	0.21.-0.50	0.51-0.65	>0.65
OC (g kg^{-1})	<1.9	2.0-4.5	4.6-9.8	9.9-12.5	>12.5
$CaCO_3$ (g kg^{-1})	<61.7	61.8-86.7	86.8-136.6	136.7-161.5	>161.5
Av. N (kg ha^{-1})	<101.4	101.5-141.6	141.7-222	222.1-262.0	>262.0
Av. P (kg ha^{-1})	<7.44	7.45-12.71	12.72-23.25	23.26-28.52	>28.52
Av. K (kg ha^{-1})	<78.40	78.5-245.6	245.7-580.5	580.6-747.8	>747.8
Ex. Ca (cmol (p^+) kg^{-1})	<21.7	21.8-28.4	28.5-41.6	41.7-48.2	>48.2
Ex. Mg (cmol (p^+) kg^{-1})	<5.9	6.0-10.1	10.2-18.8	18.9-23.1	>23.1
Ex. Na (mg kg^{-1})	<0.10	0.11-0.20	0.21-0.40	0.41-0.50	>0.50
S (mg kg^{-1})	<2.26	2.27-7.35	7.35-17.53	17.54-22.62	>22.62
DTPA Cu (mg kg^{-1})	<0.77	0.78-2.63	2.64-6.37	6.38-8.23	>8.23
DTPA Fe (mgk g^{-1})	<0.52	0.53-2.34	2.35-5.89	5.9-7.66	>7.66
DTPA Mn (mg kg^{-1})	<4.37	4.38-8.50	8.51-16.77	16.78-20.90	>20.90
DTPA Zn (mg kg^{-1})	<0.23	0.24-0.47	0.48-0.95	0.96-1.19	>1.19
B (mg kg^{-1})	<0.01	0.02-0.15	0.16-0.44	0.45-0.59	>0.59
Mo (mg kg^{-1})	<0.01	0.02-0.05	0.06-0.13	0.14-0.17	>0.17

The DRIS norms for available phosphorus were 11.78 to 23.01, 13.50 to 23.90, 13.10 to 24.10 and 12.72 to 23.25 kg ha^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages respectively. The highest P requirement of the crop was observed at 50 per cent flowering and fruit development stage (19.52 and 19.28 kg ha^{-1}, respectively). Raghupathi and Bhargava (9) reported the optimum P requirement 10.7 to 20.7 mg kg^{-1} for Ganesh variety. The potassium DRIS norms at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages were 232 to 440, 311 to 533, 311 to 635 and 245 to 580 kg ha^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages, respectively. Highest requirement of potassium was observed at fruit development stage (416.2 kg ha^{-1}) since more potassium was essential for higher and quality fruit production (Raghupathi and Bhargava, 8; Raghupathi and Bhargava, 9; Gimenez *et al*., 6; Bhargava, 3). The DRIS norms reported by Raghupathi and Bhargava (9) for potassium were 73 to 115 mg kg^{-1}.

The optimum DRIS norms for exchangeable calcium at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages were 27.65 to 46.92, 30.2 to 46.0, 29.7 to 44.3 and 28.5 to 41.6 cmol (p+) kg^{-1}, respectively. For exchangeable magnesium, the norms were 10.8 to 21.9, 13.3 to 23.2, 11.9 to 22.1 and 10.2 to 18.8 mg kg^{-1} at respective crop growth stages. The DRIS norms for sodium are also developed and those were 0.23 to 0.45, 0.24 to 0.43, 0.24 to 0.43 and 0.21 to 0.40 mg kg^{-1}, whereas the norms for sulpher were 6.94 to 16.95, 7.19 to 17.24, 7.36 to 17.69 and 7.35 to 17.53 mg kg^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages, respectively. Raghupathi and Bhargava (9) reported the optimum S requirement 87 to 209 mg kg^{-1} for pomegranate.

Regarding micronutrients, the DRIS norms for DTPA copper were 2.12 to 6.06, 2.79 to 6.85, 2.89 to 7.11 and 2.64 to 6.37 mg kg^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages, respectively. Raghupathi and Bhargava (9) reported the optimum copper requirement 0.85 to 1.91 mg kg^{-1} for Ganesh pomegranate. The DRIS norms for DTPA iron at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages were 3.71 to 8.85 3.02 to 7.77, 3.54 to 6.74 and 2.35 to 5.89 mg kg^{-1}, respectively. Raghupathi and Bhargava (9) reported the optimum DRIS norms for iron from 0.25 to 0.70 mg kg^{-1} for Ganesh variety.

Regarding DTPA extractable manganese, the DRIS norms developed were 7.72 to 15.96, 9.74 to 19.12, 10.25 to 17.52 and 8.51 to 16.77 mg kg^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages, respectively. The optimum DRIS norms for DTPA zinc at respective crop growth stages were 0.52 to 0.92, 0.48 to 0.96, 0.50 to 1.00 and 0.48

to 0.95 mg kg^{-1}, respectively. Higher requirement of zinc among various crop growth stages was observed at fruit development stage. Raghupathi and Bhargava (9) reported the optimum DRIS norms for zinc from 0.29 to 1.09 mg kg^{-1}.

The optimum DRIS norms for boron were 0.17 to 0.40, 0.22 to 0.50, 0.24 to 0.50 and 0.16 to 0.44 mg kg^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages. While, DRIS norms for molybdenum were 0.06-0.13, 0.06-0.14, 0.06-0.13 and 0.06-0.13 mg kg^{-1} at *bahar*, 50 per cent flowering, fruit development and Ist harvesting stages respectively.

The DRIS indices developed for soil nutrients of pomegranate at *bahar* stage, 50% flowering, fruit development and Ist harvesting stage are presented in Tables 5 and 6. More the negative index more is the imbalance of that nutrient at that crop growth stage (Beaufils, 2; Bhargava, 3; Francisco, 5; Raghupathi *et al.*, 10). The DRIS indices indicated that even those nutrients in most of the orchards were under optimum category, there was imbalance of those nutrients at fruit development stage, which should be given proper attention.

The data for mean DRIS indices at *bahar* stage revealed that in major nutrients, the indices for nitrogen, phosphorous and potassium were -10.37, -5.00 and -1.84, respectively. This indicates even 85 per cent orchards were at optimum level of nitrogen at *bahar* stage, the ratios of nitrogen with other nutrients were not in balance state, which shows negative values of DRIS index which is the superiority of DRIS norms over critical level values. At 50 per cent flowering stage, indices for nitrogen, phosphorous and potassium were -12.10, -8.20 and -1.32, respectively. The non application of nitrogenous fertilizers by farmers at flowering stage would be the reason for its higher requirement and imbalance among the major nutrients. The data on DRIS indices revealed that, the indices for nitrogen, phosphorous and potassium were -10.99, -12.06 and -0.61, respectively at fruit development stage. The results revealed that the mean DRIS indices for available nitrogen, phosphorous and potassium contents were -7.24 -2.79 and -0.47, respectively. At harvesting stage, higher imbalance in nitrogen content was observed, whereas potassium was mostly at balanced state over other nutrients.

For secondary nutrients, at *bahar* stage, the indices for calcium, magnesium, sodium and sulphur were -8.42, 16.13, -6.33 and 0.47, respectively. This indicates the requirement of calcium and sodium at *bahar* stage. The magnesium was in excess state whereas sulphur was mostly in balanced state. At 50% flowering stage, the DRIS indices for calcium, magnesium, sodium and sulphur contents of the soil were -13.25, 21.07, -9.60 and 0.94, respectively. Higher calcium requirement for the flowering of pomegranate is reported by many research workers which is justified here by DRIS indices. The sulphur content was almost at balanced state at this stage. The

Table 5. Mean, minimum and maximum of DRIS indices for soil nutrients at *bahar* and 50% flowering stage of pomegranate.

Nutrient	*Bahar* stage			50% flowering stage		
	Mean	Min.	Max.	Mean	Min.	Max.
Av. N	-10.37	-84.79	30.30	-12.10	-120.33	31.65
Av. P	-5.00	-51.88	63.01	-8.20	-49.38	29.03
Av. K	-1.84	-122.28	51.95	-1.32	-87.42	32.03
Ex. Ca	-8.42	-84.28	24.37	-13.25	-109.43	36.93
Ex. Mg	16.13	-31.89	190.18	21.07	-28.81	318.24
Ex. Na	-6.33	-48.16	54.64	-9.60	-85.92	39.83
S	0.47	-60.02	70.30	0.94	-49.75	50.56
DTPA Cu	0.80	-47.49	68.60	4.52	-58.16	74.86
DTPA Fe	1.65	-51.49	122.36	-4.86	-68.52	87.33
DTPA Mn	-3.63	-57.63	37.80	-2.95	-34.36	43.14
DTPA Zn	5.56	-25.41	102.61	4.52	-45.63	52.61
B	-0.33	-85.80	63.62	-11.15	-154.12	107.41
Mo	0.13	-35.69	48.55	0.24	-52.23	77.43

Table 6. Mean, minimum and maximum of DRIS indices for soil nutrients at fruit development and Ist harvesting stage of pomegranate.

Nutrient	Fruit development stage			Ist harvesting stage		
	Mean	Min.	Max.	Mean	Min.	Max.
Av. N	-10.99	-101.18	32.29	-7.24	-75.23	39.75
Av. P	-12.06	-96.26	31.83	-2.79	-37.66	24.00
Av. K	-0.61	-61.24	35.34	-0.47	-86.43	39.48
Ex. Ca	-12.87	-111.91	38.03	-15.77	-98.67	19.75
Ex. Mg	19.42	-24.78	223.39	19.09	-39.00	175.86
Ex. Na	-9.85	-76.90	24.49	-7.74	-56.29	30.17
S	1.83	-36.59	48.04	1.72	-56.24	55.12
DTPA Cu	1.73	-67.55	56.56	-0.05	-81.58	75.20
DTPA Fe	-3.62	-99.12	38.80	-3.64	-68.41	45.77
DTPA Mn	0.22	-35.33	71.72	-4.65	-103.13	56.37
DTPA Zn	3.57	-28.25	39.96	2.22	-29.36	50.44
B	-3.48	-55.71	27.61	-3.64	-72.74	51.85
Mo	-0.18	-63.89	59.81	-0.22	-53.26	42.13

DRIS indices at fruit development stage for calcium, magnesium, sulphur and sodium were -12.87, 19.42, 1.83 and -9.85, respectively. It indicated that among the secondary nutrients, sodium followed by iron were the imbalanced nutrients, whereas magnesium was the abundant nutrient and at Ist harvesting stage, the mean DRIS indices for calcium, magnesium, sulphur and sodium were -15.77 and 19.09, 1.72 and -7.74, respectively indicating higher calcium requirements at this stage.

In micronutrients content, the DRIS indices at *bahar* stage for copper, iron, manganese, zinc, boron and molybdenum were 0.80, 1.65, -3.83, 5.56, -0.33 and 0.13, respectively. This indicates the requirement of manganese at this stage, whereas molybdenum was mostly at balanced state. At 50% flowering stage the indices for copper, iron, manganese, zinc, boron and molybdenum were 4.52, -4.86, -2.95, 4.52, -11.15 and 0.24, respectively indicating the requirement of iron, manganese and boron at this stage, while molybdenum status particularly showed balanced nutrition at this stage. The DRIS indices at fruit development stage for copper, iron, manganese, zinc, boron and molybdenum were 1.73, -3.62, 0.22, 3.57, -3.48 and -0.18, respectively indicated the requirement of iron and boron. However, copper, manganese and molybdenum were practically at balanced state, whereas at Ist harvesting stage, DRIS indices for copper, iron, manganese, zinc, boron and molybdenum were -0.05, -3.64, -4.65, 2.22, -3.64 and -0.22, respectively. This indicated the imbalance of micronutrients, *viz.*, iron, manganese and boron, while, copper was mostly at balanced state over rest of the nutrients.

The order of nutrient requirement of pomegranate at different crop growth stages using soil DRIS indices indicated that calcium was the most needed plant nutrient by pomegranate at 50 per cent flowering, fruit development and even at Ist harvesting stage. The soil nutrients, *viz.* calcium and nitrogen should be looked seriously for supply through fertilizers from beginning to harvesting of pomegranate. It was interesting to note that, role of sodium as a beneficial nutrient for pomegranate at each sampling stage was pointed out by DRIS indices. Supplement of phosphorous manganese and potassium was necessary at *bahar*, 50 per cent flowering stage and iron was needed at 50 per cent flowering, fruit development and Ist harvesting stages. At *bahar*, iron and zinc were at sufficient levels because most of the farmers apply $FeSO_4$ and $ZnSO_4$ as a basal dose, however as the time proceeds, iron becomes deficient due to faster oxidation in soil or otherwise requirement of iron by pomegranate is increased as the *bahar* proceeds further. Sulphur and molybdenum remained in balanced state and magnesium was always in excess quantity throughout the *bahar* period. The reason behind sulphur sufficiency was application of single super phosphate as a basal dose. The sufficiency level of magnesium might be due to application of dolomite through fertilizers as well as high status of magnesium and molybdenum in soil and low requirement of magnesium, copper and molybdenum by pomegranate showed these nutrients either in balance level or in excess.

Table 7. Order of nutrient requirement of pomegranate at different growth stages using soil DRIS indices.

Growth stage	Order of nutrient requirement
At *bahar* stage	N>Ca>Na>P>Mn>K>B>Mo>S>Cu>Fe>Zn>Mg
50% flowering	Ca>N>B>Na>P>Fe>Mn>K>Mo>S>Zn>Cu>Mg
Fruit development	Ca>P>N>Na>Fe>B>K>Mo>Mn>Cu>S>Zn>Mg
Ist harvesting	Ca>Na>N>Mn>Fe>B>P>K>Mo>Cu>S>Zn>Mg

REFERENCES

1. Bangroo, S.A., Bhat, M.I., Tahir, A., Aziz, M.A., Bhat, M.A. and Wani, M.A. 2010. Diagnosis and Recommendation Integrated System (DRIS): A Review. *Inter. J. Curr. Res.* **10**: 84-97.
2. Beaufils, E.R. 1973. Diagnosis and recommendation integrated system (DRIS). A general scheme for experimentation and calibration based on principles developed from research in plant nutrition. Pietermararitzburg, University of Natal, *Soil Sci. Bull.* **1**: 132.
3. Bhargava, B.S. 2002 Leaf analysis for nutrient diagnosis, recommendation and management in fruit crops. *J. Indian Soc. Soil Sci.* **50**: 352-73.
4. Deshpande, A.N. and Patil, G.D. 2011. Nutritional survey of pomegranate orchards from Solapur district of Maharashtra. *J. Agric. Res. Tech.* **36**: 263-69.
5. Francisco, D. and Assis Alves Mourão, Filho. 2004. DRIS: concepts and applications on nutritional diagnosis in fruit crops. USP/ESALQ Depto. de Produção Vegetal, 9 - 13418-900 - Piracicaba, SP Brasil.
6. Gimenez, M., Oltra, M.A., Melgarejo, P., Martinez, J., Martinez, J.J. and Ferrandez, M. 2000.

Computer program for calculating pomegranate drip fertigation. Production, processing and marketing of pomegranate in the Mediterranean region: Advances in research and technology. *Proceedings of the Symposium jointly organized by CIHEAM and Escuela Politecnica Superior de Orihuela of the Universidad Miguel Hernandez* (*EPSO-UMH*), Orihuela, Spain, 15-17 October, 1998.

7. Navale, A.M. 2007. Mineral nutrient status of pomegranate orchards in Western Maharashtra, India. *Asian J. Hort.* **2**: 294-97.

8. Raghupathi, H.B. and Bhargava, B.S. 1998a. Diagnosis of nutrient imbalance in pomegranate by diagnosis and recommendation integrated system and compositional nutrient diagnosis, *Comm. Soil Sci. Plant Anal*. **29**: 2881-92.

9. Raghupathi, H.B. and Bhargava, B.S. 1998b. Leaf and soil nutrient diagnostic norms for pomegranate (*Punica granatum* L). *J. Indian Soc. Soil Sci*. **46**: 412-16.

10. Raghupathi, H.B., Reddy, Y.T.N., Rein, M.K. and Bhargava, B.S. 2004. Diagnosis of nutrient imbalance in mango by DRIS and PCA approach. *J. Plant Nutr.* **27**: 1131-48.

11. Sarkhosh, A., Zamani, Z., Fatahi, R. and Ebadi, A. 2006. RAPD markers reveal polymorphism among some Iranian pomegranate (*Punica granatum* L.) genotypes. *Scientific Hort.* **111**: 24-29.

12. Shluman, Y., Fainberstein, Z. and Lavee, S. 1984. Pomegranate fruit development and maturation. *J. Hort. Sci.* **59**: 265-74.

Received : March, 2015; Revised : July, 2017;
Accepted : October, 2017