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Establishment of diagnosis and recommendation integrated system norms for plum cv. Santa Rosa

Disha Thakur, A.S. Rehalia and J. Kumar
Department of Pomology, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan 173 230, Himachal Pradesh

ABSTRACT

The leaf sampling survey was carried out in plum orchards of Kullu district of Himachal Pradesh during 2008 and 2009. Five locations, *viz.*, Naggar, Raison, Nagabagh, Gahar and Badah were selected. From each location five orchards were selected according to multistage sampling technique. The data on fruit yield, soil and leaf nutrient status were recorded. Forty four DRIS norms were developed from database of 1000 observations of leaf nutrient composition and yield. The DRIS norms expressions that produced highest ratio were selected as DRIS norm. The nutrient expressions N/P, N/K, N/Ca, N/Mg, K/P, Ca/P, Mg/P, Ca/K, Mg/K, Ca/Mg, Fe/N, Mn/N, Fe/P, Mn/P, Cu/P, B/P, Fe/K, Zn/K, Mn/K, Cu/K, Fe/Ca, Ca/Zn, Ca/Mn, Cu/Ca, B/Ca, Fe/Mg, Zn/Mg, Mg/Mn, B/Mg, Fe/Zn, Fe/Mn, Zn/Mn, Cu/Zn, B/Zn, Cu/Mn and B/Mn were found to produce highest variance ratio, thus these expression have a significant contribution for yield in plum and orchards were diagnosed on the basis of norms developed. The expressions N/Zn, N × Cu, N/B, B/K, Cu/Mg, Fe/Cu, Fe/B and Cu/B produced non-significant variance ratios were also treated as norms as they have neutral effect on the index calculation. The studies revealed deficiency of N, Fe and Cu in 4 per cent orchards, whereas, excess of N, Fe and Cu were diagnosed in 8, 36 and 12 per cent of the orchards respectively. Deficiency of P, K, Mg, Zn, Mn and B was diagnosed in 12, 20, 12, 24, 8 and 32 per cent orchards, respectively. Only 52 per cent of the orchards were diagnosed for Mg excess. The order of limiting nutrients in different orchards revealed that B was most limiting nutrient and 32% orchards showed its deficiency, while 24% orchards showed zinc deficiency.

Key words: DRIS, mutrient norms, plum.

INTRODUCTION

Leaf analysis of plant as an analytical tool gives fairly good indication of nutritional status and also helps to confirm the visual deficiency symptoms. Ever since with the development of various methodologies of plant analysis different concepts of interpretation based on the use of either standard values (Kenworthy, 8) sufficiency ranges (Shear and Faust, 11), balance index (Kenworthy, 7), boundary line concept (Bhargava *et al*., 3), diagnosis and recommendation integrated system (DRIS) (Beaufils, 1) has been propounded to find out optimum nutrient levels necessary for growth and production. Amongst these techniques, DRIS approach has been followed by large number of workers because of its advantages over other methods. The major advantages offered by DRIS approach are its ability to make a diagnosis at any stage of crop development and to list the nutrient elements in order of their importance, which are responsible for limiting the yield. Thus, DRIS approach provides a complete logical agreement with the requirement of balanced nutrition concept. Systematic studies are lacking in plum. Therefore, study was conducted to develop DRIS norms and to diagnose the limiting nutrients for plum, grown in Himachal Pradesh.

*Corresponding author's E-mail: dishathakur_83@rediffmail.com

MATERIALS AND METHODS

The study was conducted in Kullu district of Himachal Pradesh. The soils of the plum orchards under survey were sandy loam having pH of 5.90 to 7.02 with high organic carbon content of 1.56 to 2.09 percent. Five locations, *viz.*, Raison, Nagabagh, Naggar, Gahar and Badah were selected in Kullu area. Five bearing orchards at each location were selected randomly. For the selection of trees of uniform size and growth, tree girth was recorded at 15 cm above the graft union. Twenty uniform and healthy trees of Santa Rosa in each orchard in the age group of 12-15 were selected. Leaf samples from the selected trees were collected from the middle of the current year growth between July-August as per the procedure suggested by Kenworthy (7).

Nitrogen was estimated by using Kjeltech 2300 auto analyzer unit. Phosphorus in the plant digest was estimated by Vanado-molybdophosphoric yellow colour method using double beam UV-VIS spectrophotometer (Jackson, 6). Potassium was estimated by flame photometric method (Piper, 10)

while calcium, magnesium, iron, manganese, copper, zinc and boron were determined by Perkin Elmer Analyst 400 atomic absorption spectrophotometer. Data on N, P, K, Ca, and Mg was expressed in percent on dry weight basis while those for micronutrients in ppm on dry weight basis.

DRIS norms were derived by using the procedure derived by several workers Beaufils (1), Sumner (13), and Walworth and Sumner (14). The norms were derived from a database of 1000 observations on leaf nutrients and yield recorded during 2008 and 2009 from five plum growing areas of the Kullu valley. The observation units were arranged in an ascending order of yield. Tree yield of 155 kg/tree or above to formed high yielding population. Whereas, trees with the yielding capacity of below 55 kg/tree were treated as low yielding population.

The mean, standard deviation, variance and coefficient of variation (CV) were calculated for each nutrient concentration as well as for ratios, their reciprocals and their products (e.g. N/P, P/N and N × P)

$$\text{Variance ratio (F)} = \frac{\text{Variance of low yielding sub-population}}{\text{Variance of high yielding sub-population}}$$

Variance ratios were calculated for all forms of nutrient expressions involving each pair of nutrients. The expression having highest and significant ratio, for each pair of nutrients was selected as DRIS norms expression. The DRIS indices were calculated using standard formulae Beaufils (1), Sumner (13) and Walworth and Summer (14). Relative nutrient requirement of plum orchards was estimated using DRIS indices

RESULTS AND DISCUSSION

Diagnosis and Recommendation Integrated System (DRIS) norms were derived from database of 1000 observations on leaf nutrient composition and yield. A total of 485 trees formed the high yielding population and 515 trees formed the low yielding. The nutrient expression, which produced highest variance ratio out of three forms of expression ratio, their reciprocals and their products were selected as DRIS norms (Table 1). The nutrient expression N/P, N/K, N/Ca, N/Mg, K/P, Ca/P, Mg/P, Ca/K, Mg/K, Ca/Mg, Fe/N, Mn/N, Fe/P, Mn/P, Cu/P, B/P, Fe/K, Zn/K, Mn/K, Cu/K, Fe/Ca, Ca/Zn, Ca/Mn, Cu/Ca, B/Ca, Fe/Mg, Zn/Mg, Mg/Mn, B/Mg, Fe/Zn, Fe/Mn, Zn/Mn, Cu/Zn, B/Zn, Cu/Mn and B/Mn produced highest variance ratios among the particular nutrient pair, were selected as DRIS norms as they significantly discriminated between high yielding and low yielding sub populations (Table 1). The expressions N/Zn, N × Cu, N/B, B/K, Cu/Mg, Fe/Cu, Fe/B and Cu/B produced non-significant variance ratios were also treated as norms as they have neutral effect on the index calculation (Summer, 13; Parent and Granger, 9).

The data on leaf nutrient composition, DRIS indices and order of nutrient requirement are presented in Table 2. Leaf N, P, K, Ca and Mg content varied from 2.20 to 2.83, 0.11 to 0.23, 2.23 to 3.26, 1.80 to 2.67 and 0.38 to 0.65 percent, respectively. Iron, Zn, Mn, Cu and B status of plum orchards varied from 245.70 to 277.10, 25.93 to 44.00, 52.20 to 127.40, 7.26 to 14.17 and 22.90 to 31.47 ppm, respectively. The nutrient status of almost all the orchards was diagnosed as optimum, when compared to nutrient ranges given by Chapman (4), and Shear and Faust (11)

The DRIS indices indicate the order of deficiency or sufficiency of each element over the other elements. The element having the more negative value is more deficient than the other having less negative value. Diagnosis made by DRIS approach revealed that DRIS indices for N, P, K, Ca, Mg, Fe, Zn, Mn, Cu and B varied from -2.51 to +12.4, -18.41 to +5.00, +2.90 to +9.36, -7.82 to +7.00, -35.26 to +20.92, -4.56 to +19.45, -31.16 to +10.46, -30.21 to +7.21, -8.46 to +37.42 and -37.00 to +6.56, respectively.

DRIS approach diagnosed deficiency of N, Fe and Cu in 4 per cent orchards. Excess of N, Fe and Cu were diagnosed in 8, 36 and 12 per cent of the orchards respectively. Deficiency of P, K, Mg, Zn, Mn and B were diagnosed in 12, 20, 12, 24, 8 and 32 per cent of the orchards, respectively. Fifty two per cent of the orchards were diagnosed for Mg excess. The order of nutrient requirement in different orchards revealed that B was most limiting nutrient as 32% orchards showed its deficiency, while 24% orchards showed deficiency of zinc. Calcium and K were sufficient in these orchards. The present study on leaf nutrient survey revealed that almost all the plum orchards were found to have optimum nutrient status, however, when diagnosed using DRIS approach boron followed by zinc was found to discriminate between low and high yield.

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Table 1. Diagnosis and recommendation integrated system (DRIS) norms for plum.

Nutrient expression	Norm value	CV (%)	F value
N/P	14.338	14.09	3.32**
N/K	1.167	4.93	5.42**
N/Ca	1.200	6.30	17.01**
N/Mg	5.228	12.53	1.833**
Fe/N	95.782	5.27	4.25**
N/Zn	0.072	15.04	0.71
Mn/N	32.561	9.34	4.82**
NxCu	33.231	12.49	0.97
N/B	0.103	9.64	0.57
K/P	12.284	13.53	7.08**
Ca/P	11.898	15.61	8.53**
Mg/P	2.770	15.75	1.85**
Fe/P	1371.538	14.04	5.99**
Mn/P	464.886	14.37	5.36**
Cu/P	63.597	12.68	2.78**
B/P	189.705	13.9	3.22**
Ca/K	0.975	5.19	9.68**
Mg/K	0.227	14.10	4.97*
Fe/K	111.584	2.60	1.76*
Zn/K	16.451	13.33	5.45**
Mn/K	37.953	8.95	13.20**
Cu/K	5.262	7.80	238.08**
B/K	11.436	10.34	1.19
Ca/Mg	4.371	14.28	7.33**
Fe/Ca	114.660	4.50	31.50**
Ca/Zn	6.060	15.46	5.29**
Ca/Mn	0.025	9.78	72.73**
Cu/Ca	5.350	9.13	5.98**
B/Ca	11.743	9.98	5.14**
Fe/Mg	500.818	13.33	1.60*
Zn/Mg	72.808	9.61	1.69*
Mg/Mn	0.006	9.56	18.56**
Cu/Mg	23.245	11.88	1.28
B/Mg	50.761	8.10	3.20**
Fe/Zn	6.917	15.00	2.24**
Fe/Mn	2.963	9.39	3.74**
Fe/Cu	2.585	8.47	1.35
Fe/B	9.858	10.28	0.55
Zn/Mn	0.434	12.05	13.3**
Cu/Zn	0.320	11.66	11.30**
B/Zn	0.701	10.21	2.51**
Cu/Mn	0.138	10.78	20.56**
B/Mn	0.301	7.37	61.52**
Cu/B	0.457	9.23	0.43

*, ** Significant at 5 and 1% levels

Macro-nutrients are expressed in per cent on dry weight basis, Micro-nutrients are expressed in ppm on dry weight basis

Table 2. Leaf nutrient status and DRIS indices for high yielding plum orchards.

Location/Orchard			N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B	Order of nutrient requirement	
													Limiting nutrients	Nutrient excess
Naggar	1	Content	2.50	0.16	2.23	1.80	0.46	268.70	27.93	77.10	9.10	29.70	Zn>B>Mg>Mn>P	Fe>N>K>Cu>Ca
		Indices	+10.48	-8.21	+6.71	-7.82	-21.56	+17.28	-36.26	-20.81	-4.71	-32.47		
	2	Content	2.76	0.20	2.50	1.98	0.49	255.50	26.67	84.20	8.10	23.57	B>Zn>Mg>Mn>Cu	Fe>N>K>P>Ca
		Indices	+11.47	+3.41	+8.42	-1.46	-22.60	+15.16	-27.12	-22.51	-3.92	-36.14		
	3	Content	2.40	0.21	3.03	2.32	0.64	264.30	25.93	97.00	9.06	27.33	B>Zn>Mn>Cu>Ca	Mg>Fe>K>N>P
		Indices	+9.00	+4.82	+9.16	+4.21	+20.42	+17.26	-25.26	-25.01	-4.12	-34.56		
	4	Content	2.33	0.11	2.80	2.43	0.42	253.60	28.47	98.20	7.30	30.60	Zn>Mn>Mg>P>Cu	Fe>K>B>Ca>N
		Indices	-0.52	-16.42	+6.92	+5.16	-21.47	+16.45	-30.12	-24.26	-8.46	+6.56		
	5	Content	2.40	0.13	2.93	2.67	0.65	272.80	30.57	88.10	10.03	28.53	Mn>P>B>K>Zn	Fe>Mg>N>Cu>Ca
		Indices	+12.46	-18.41	+2.90	+6.21	+18.12	+19.25	+4.56	-29.20	+6.42	+1.25		
Raison	1	Content	2.63	0.16	2.33	1.84	0.43	273.60	35.60	103.20	12.30	22.90	B>Mg>P>Mn>Ca	Fe>Cu>N>Zn>k
		Indices	+10.92	-8.46	+6.12	-1.52	-21.52	+19.00	+6.25	-2.16	+13.41	-37.00		
	2	Content	2.20	0.23	2.53	2.02	0.43	268.90	36.67	105.70	14.17	28.10	Mn>Mg>N>B>P	Cu>Fe>K>Zn>Ca
		Indices	-1.72	+4.98	+7.41	+5.72	-21.50	+16.26	+7.30	-30.21	+37.42	+4.28		
	3	Content	2.23	0.20	2.73	2.33	0.59	252.50	43.70	120.90	13.63	25.00	B>N>P>Mn>Ca	Cu>Mg>Fe>Zn>K
		Indices	-0.60	+2.46	+8.46	+6.48	+19.26	+15.41	+9.45	+4.56	+24.73	-30.51		
	4	Content	2.20	0.18	3.16	2.51	0.61	258.70	44.00	122.30	11.90	25.47	P>N>B>Mn>Ca	Mg>Fe>Cu>Zn>K
		Indices	-2.78	-9.42	+9.36	+6.12	+20.92	+13.24	+10.46	+4.91	+13.16	+2.56		
	5	Content	2.30	0.20	2.36	2.49	0.52	267.70	43.80	116.80	11.50	24.97	N>B>P>Mn>K	Mg>Fe>Cu>Zn>Ca
		Indices	-1.50	+2.46	+6.17	+6.46	+19.18	+18.26	+10.25	+3.26	+13.00	+0.57		

Macronutrients are expressed in per cent on dry weight basis
Micronutrients are expressed in ppm on dry weight basis

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Location/Orchard			N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B	Order of nutrient requirement	
													Limiting nutrients	Nutrient excess
Nagabagh	1	Content	2.60	0.17	2.36	1.93	0.55	248.10	33.20	117.90	11.03	30.93	Fe>Ca>P>Mn>Zn	Mg>Cu >N>K>B
		Indices	+11.00	+1.42	+6.42	-1.94	+19.46	-3.51	+5.26	+3.96	+12.17	+5.61		
	2	Content	2.83	0.23	2.80	1.92	0.38	259.00	37.93	123.80	11.10	27.50	Mg>Ca>B>Mn>P	Fe>N>Cu>K>Zn
		Indices	+12.16	+5.00	+7.46	-1.90	-30.48	+14.21	+6.18	+4.27	+12.00	+2.46		
	3	Content	2.40	0.16	2.66	2.60	0.54	248.50	34.53	117.00	11.30	24.93	B>Fe>N>P>Mn	Mg>Cu>Ca>K>Zn
		Indices	-2.42	+1.46	+6.42	+7.42	+19.46	-4.26	+5.21	+3.71	+13.12	-34.26		
	4	Content	2.36	0.16	2.96	2.30	0.49	249.30	36.23	127.40	13.67	29.27	Mg>Fe>N>P>B>	Cu>K>Zn>Ca>Mn
		Indices	-2.51	-0.41	+8.46	+6.36	-20.21	-3.46	+8.21	+5.26	+14.67	+2.59		
	5	Content	2.43	0.21	3.10	2.50	0.50	245.70	39.50	125.50	11.10	31.47	Zn>Fe>N>P>Mn	Mg>Cu>K>Ca>Mn
		Indices	-1.50	+3.16	+9.36	+6.98	+14.56	-2.46	-24.21	+5.12	+10.52	+5.26		
Gahar	1	Content	2.63	0.16	2.83	1.93	0.55	268.00	32.93	117.40	8.00	28.77	P>Cu>Ca>B>Zn	Mg>Fe>N>Fe>Mn
		Indices	+11.18	-5.26	+6.47	-1.92	+18.27	+16.75	+4.19	+4.59	-4.17	+1.28		
	2	Content	2.43	0.21	2.83	2.06	0.64	272.10	38.10	116.40	8.60	28.27	Cu>N>B>P>Ca	Mg>Fe>Zn>K>Mm
		Indices	-1.56	+2.61	+7.78	+4.62	+20.12	+17.21	+9.51	+5.26	-5.16	+1.30		
	3	Content	2.73	0.20	2.90	1.99	0.54	273.40	34.97	83.60	9.03	25.70	B>Mn>Cu>Ca>P	Fe>Mg>N>K>Zn
		Indices	+11.42	+2.16	+7.46	-1.85	+14.56	+18.00	+5.24	-24.16	-5.21	-30.16		
	4	Content	2.53	0.21	2.80	2.53	0.53	277.10	36.03	137.00	8.26	24.97	B>Cu>P>Ca>Zn	Mg>Fe>N>K>Mn
		Indices	+9.42	+3.21	+8.42	+6.42	+14.92	+17.28	+6.53	+7.21	-4.46	-36.42		
	5	Content	2.33	0.14	2.50	2.57	0.54	269.30	38.90	127.20	7.96	24.63		Mg>Fe>Ca>k>Zn
		Indices	-0.36	-0.17	+6.23	+6.42	+18.45	+17.17	+6.21	+6.15	-5.46	-30.14	B>Cu>N>P>Mn	

Macro-nutrients are expressed in per cent on dry weight basis
Micro-nutrients are expressed in ppm on dry weight basis

Contd...

Table 2 Contd...

Location/Orchard			N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B	Order of nutrient requirement	
													Limiting nutrients	Nutrient excess
Badah	1	Content	2.33	0.16	2.50	2.67	0.56	253.60	28.77	54.50	7.26	27.10	Zn>Mn>Cu>N>P	Mg>Fe>Ca>K>B
		Indices	-2.30	-0.46	+6.45	+7.47	+19.98	-2.46	-31.16	-27.16	-5.92	+1.46		
	2	Content	2.76	0.20	2.86	2.04	0.50	248.80	26.07	59.97	7.50	26.20	Zn>B>Mn>Cu>Fe	Mg>N>K>Ca>P
		Indices	+12.00	+1.49	+7.42	+4.56	+18.26	-4.56	-30.14	-25.21	-6.00	-26.27		
	3	Content	2.40	0.21	2.63	2.32	0.39	25.70	32.07	52.20	8.26	29.17	Mg>Mn>P>Cu>N	Fe>K>Ca>Zn>B
		Indices	-1.56	-8.25	+6.82	+6.42	-35.26	+15.15	+4.56	-29.41	-2.54	+2.45		
	4	Content	2.43	0.23	2.40	2.17	0.59	274.30	29.90	65.30	8.36	26.60	Zn>Mn>N>Cu>B	Mg>Fe>K>Ca>P
		Indices	-2.47	+4.17	+7.46	+4.71	+20.12	+18.26	-30.26	-28.51	-2.61	+1.25		
	5	Content	2.26	0.17	2.53	2.64	0.52	267.90	27.87	65.27	10.23	25.37	B>Mn>Zn>P>N	Fe>Mg>Ca>Cu>K
		Indices	-0.18	-0.46	+6.92	+7.52	+19.54	+16.21	-11.24	-29.46	-4.41	-30.45		

Macro-nutrients are expressed in per cent on dry weight basis
Micro-nutrients are expressed in ppm on dry weight basis

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