NUTRITIONAL STATE AND YIELD REGRESSION BY FOLIAR NUTRIENTS IN APPLE ORCHARDS OF WESTERN HIMALAYAS

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Abstract: A nutritional survey was conducted in major apple growing belts of Western Himalayas *viz.* Jubbal-Kotkhai, Karsog, Kalpa, Kotgarh and Naggar areas of Himachal Pradesh (India) to study the nutritional wellbeing and effect of foliar nutrient concentrations on influencing yield. The foliar macro-nutrients, N, P, K, Ca, Mg in different locations were found in the range 1.71-2.31, 0.13-0.28, 1.18-1.82, 1.19-1.83 and 0.18-0.41 percent, respectively while the micro-nutrients Fe, Zn, Cu and Mg varied from 186.8-378.2, 17.67-61.01, 7.52-15.78 and 42.33-182.53 ppm. Multiple regressions have been calibrated for predicting apple yields at different locations and for low and high yielding (>150 kg/tree) trees where the models were found to have a high and significant predictability value. Using the data, fertilizer adjustment equations can be developed for prescribing optimum fertilizer doses for attaining high yields in the apple production areas in the Western Himalayas and indeed elsewhere with similar c1imatic and soil conditions.

Keywords: Nutrition, Apple, Essential nutrients, Regression plane, Sufficiency range

INTRODUCTION

Apple (*Malus x Domestica* Boorkh.) has immense nutritional value amongst fruits and is advised on daily basis in diet by dieticians. Owing to its chilling requirement, apple is cultivated in temperate regions of the world in an area of 4.8 million hectares with 76.7 MT production (FAO, 2015). In India, it is cultivated in high reaches of Himalayan region mainly in the states of Jammu & Kashmir, Himachal Pradesh, Uttaranchal and Arunachal Pradesh. In Himachal Pradesh it is a leading fruit crop cultivated on 107.7 thousand ha with 6.9 MT/ha productivity (NHB, 2014). The low productivity as compared to 15.9 MT/ha on world basis has been ascribed to various factors such as varietal, soil fertility, topography of land and incidence of pests and diseases. Providing adequate nutrition to fruit trees is the utmost concern among farmers for enhancing growth, yield and quality of apple which is mandatory for sustainable production. The fertilizer schedule should be holistic in nature because there are synergistic and antagonistic effects in relative availability of different essential nutrients from soil. Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection (Kimetu *et al.*, 2004). An increasing fertilizer price and growing awareness on environmental impact has increased interest in the optimal use of fertilizer for crop production. To enhance farm profitability under different soil-climate conditions, it is necessary to have information on optimum fertilizer doses for crops and it is important to provide to the farmer appropriate decision support tools that will allow them access to better fertilization (Robertson and Vitousek, 2009). Keeping this in view, the present survey was undertaken to study the nutritional wellbeing and effect of foliar nutrient concentrations on influencing yield in major apple growing areas and in the low and high yielding populations.

MATERIAL AND METHOD

The present studies were undertaken in major apple growing areas of Himachal Pradesh namely Jubbal-Kotkhai, Karsog, Kalpa, Kotgarh and Naggar which contributes to more than 80% of states production. Starking Delicious, which has a characteristic conical shape with deep red blush, is the main variety grown by farmers, hence was chosen for the study. At each location, five orchards (15-20 years old) were selected and in each orchard, twenty uniform and healthy trees were observed for two years. Leaf samples were collected from middle of terminal shoots of current year growth in the periphery of tree from 15th July to 15th August as suggested by Kenworthy (1964) and cleaning, drying, grinding and storage of samples was in accordance with Chapman (1964). Leaf samples were washed with deionized water, dried at 65°C, weighed and milled to 20 mesh for mineral analysis. Micro-Kjeldahl method was followed for estimation of total nitrogen and for estimation of other elements the samples were digested in di-acid (nitric and perchloric acid in the ratio 4:1). Phosphorus was estimated by vanado-molybdophosphoric yellow colour method using spectronic 21 while, potassium was estimated by flame photometric method. Calcium, magnesium, iron, manganese, copper and zinc content were determined by atomic absorption spectrophotometer

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ECIL model AAS 4129. The data of two years was pooled and analyzed in Randomized Block Design (RBD) with 5 replications (orchards) and 5 locations as treatments in accordance to Panse and Sukhatme (1985). Multiple regression planes were sought out taking fruit yield as dependant variable and nutrient concentration in leaf as independent variable.

RESULT AND DISCUSSION

The overall range and mean of foliar nutrient concentrations and yield of apple orchards at different locations is presented in Table 1. In the present survey, the mean of foliar macro-nutrients N, P, K, Ca and Mg were recorded to be 1.99, 0.20, 1.57, 1.51 and 0.29 per cent while micro-nutrients Fe, Zn, Cu and Mn concentrations was 278.1, 38.21, 10.67 and 119.58 ppm, respectively. Maximum concentrations of leaf N, P, K, Ca, Mg, Fe, Zn, Cu and Mn were recorded at Jubbal-Kotkhai, Kalpa, Kotgarh, Naggar, Jubbal-Kotkhai, Karsog, Naggar, Naggar and Kotgarh, respectively. The locations varied significantly with respect to concentrations of K, Zn, Cu and Mn in the leaves of apple. When the orchards were diagnosed by Shear and Faust (1980) sufficiency ranges (Table 2), the leaf N status was found optimum in 100 % of the orchards because farmers apply enough nitrogenous fertilizers (Rana *et al.* 1984), 4 % of the orchards were deficient in P which has been attributed to fixation of phosphorus in the form of iron and aluminium phosphate resulting in poor availability (Sharma, 1994) while, 4 % of the orchards were deficient in K suggesting a need to incorporate of murate of potash in fertilizer schedule (Sharma *et al.*, 1982). Fifty two percent of the orchards were categorized as low in leaf Ca which confirms the earlier results (Bhandari and Sharma, 1981; Das, 1999) who argued that there is abundant leaching of $CaCO_3$ due to heavy rainfall and Ca has tendency of lesser translocation in plant system from soil, thus suggesting application of Ca based fertilizers and foliar sprays. Twenty eight and twelve per cent of the orchards were found to be in deficient and in excess for leaf Mg, respectively. Low Mg status has been explained by antagonistic effect of soil Ca on Mg uptake by plants (Singh, 1996), while slightly acidic soils present in some of the orchards favour high availability of Mg making it excessive (Yadav, 1967), moreover heavy crop load has also been reported to increase leaf Mg (Cain and Boynton, 1948). All the orchards were adequate in Fe and Zn because their availability has been reported to increase in slightly acidic soil reaction prevalent in these areas (Sharma and Bhandari, 1992). Twenty two per cent of the orchards had excess Cu concentration in leaves as there is abundant use of micronutrient fertilizers and Cu based pesticides (Singh, 1987). Manganese was found in excess in 16 % of the orchards as the soils of these areas are rich in Mn and there is considerable use of micronutrient fertilizers (Sharma, 1994; Das 1999).

Multiple regression planes (Table 3) show that 61.2, 57.33, 60.35, 54.43 and 68.11 per cent variability in yield was observed due to different essential nutrients involved in the plane at Jubbal-Kotkhai, Karsog, Kalpa, Kotgarh and Naggar, respectively. It can be inferred that apart from nutrient content, yield is being limited by other residual factors like moisture status of soil, management practices, pollination intensity and environment conditions. Availability of nutrients to the plant is affected by complex situations in the soil such as fixation, antagonism, synergism, volatilization, immobilization, mineralization etc. (Mamgain, 1990; Sharma, 1994; Das, 1999). The regression planes further reveal that leaf P, K, Mg and Fe content in leaf affected yield positively while Mn content affected yield negatively and significantly at all the locations.

For low and high yielding trees (Table 4) 29.50 and 22.51 per cent of variability in yield was observed due to different foliar nutrients. Leaf N, K, Mg, Fe, Zn and Cu showed positive and highly significant effects on yield in low productive trees, whereas in case of high productive trees, only P had a positive and highly significant effect while Cu exhibited negative and highly significant effect on yield. From these observations, it can be inferred that in low productive trees maximum number of nutrients are significantly and positively controlling the yield indicating that a unit increase in particular nutrient will lead to increase in yield as compared to high productive tree which already have enough supply of nutrients for better yield. The importance of leaf nutrient contents for increase in fruit yield stands by the fact that a certain level of vegetative and reproductive growth is essential for optimum production, which is only attainable by supply of nutrients in adequate amount and proportion (Campbell and Bould, 1970). The significant and negative association of some nutrients especially Cu and Mn indicate that these nutrients are present in adequate to high range and further maybe counteracting the effect of other nutrients towards yield, because of an imbalance in nutrient ratios (Mamgain, 1990).

Location/Orchard		Macronutrients (%)					Micronutrients (ppm)				Yield (kg/tree)
		N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	
Jubbal-Kotkhai											
	1	2.15	0.18	1.57	1.67	0.39	355.1	32.27	7.52	108.13	103.20

	2	1.98	0.23	1.66	1.42	0.33	319.5	23.54	9.53	115.78	107.80
	3	2.08	0.22	1.52	1.48	0.37	288.2	27.63	8.02	122.56	140.50
	4	2.20	0.19	1.41	1.54	0.41	248.4	33.41	10.15	143.82	112.50
	5	1.82	0.20	1.50	1.47	0.32	295.8	30.35	8.85	132.95	127.30
	Mean	2.05	0.20	1.53	1.52	0.36	301.4	29.44	8.81	124.65	118.26
Karsog											
	1	1.98	0.17	1.68	1.37	0.18	335.3	40.27	8.97	66.68	117.80
	2	2.11	0.13	1.78	1.26	0.23	378.2	47.38	11.57	89.73	97.30
	3	1.89	0.15	1.52	1.19	0.25	312.1	39.42	15.78	72.12	85.70
	4	1.77	0.19	1.37	1.36	0.22	288.6	51.11	12.09	42.33	106.50
	5	1.93	0.16	1.66	1.41	0.24	325.4	44.17	10.12	82.18	112.10
	Mean	1.94	0.16	1.60	1.32	0.22	327.9	44.47	11.71	70.61	103.90
Kalpa											
	1	1.73	0.25	1.34	1.58	0.23	220.3	22.21	8.12	98.13	113.50
	2	1.89	0.20	1.18	1.78	0.18	232.2	28.37	11.13	123.73	127.30
	3	1.95	0.28	1.56	1.33	0.26	205.3	17.67	9.52	135.44	82.50
	4	2.17	0.24	1.42	1.31	0.30	186.8	25.32	10.11	112.59	108.30
	5	1.78	0.25	1.29	1.52	0.21	256.4	28.42	9.88	88.92	102.10
	Mean	1.90	0.24	1.36	1.50	0.24	220.2	24.40	9.74	111.76	106.70
Kotgarh											
	1	2.02	0.18	1.82	1.79	0.31	220.8	38.10	11.82	112.18	138.10
	2	2.31	0.22	1.78	1.83	0.33	188.9	41.25	9.15	148.68	143.50
	3	2.05	0.21	1.67	1.55	0.28	245.3	44.21	12.13	182.53	101.40
	4	2.11	0.17	1.75	1.48	0.35	213.5	33.78	8.48	164.87	103.10
	5	1.71	0.19	1.48	1.41	0.29	232.3	28.89	10.13	135.92	127.80
	Mean	2.04	0.19	1.70	1.61	0.31	220.1	37.25	10.34	148.84	122.80
Naggar											
	1	2.17	0.20	1.69	1.57	0.29	319.3	54.92	14.12	101.22	113.40
	2	1.86	0.22	1.74	1.66	0.31	309.8	61.01	8.96	148.15	152.20
	3	2.11	0.26	1.81	1.72	0.32	373.2	46.18	15.12	168.12	146.00
	4	1.89	0.18	1.66	1.61	0.26	274.4	57.01	11.15	154.13	127.50
	5	2.08	0.20	1.41	1.48	0.31	327.5	58.24	14.50	138.48	104.50
	Mean	2.02	0.21	1.66	1.61	0.30	320.9	55.47	12.77	142.02	128.70
Overall Range		1.71-2.31	0.13-0.28	1.18-1.82	1.19-1.83	0.18-0.41	186.8-378.2	17.67-61.01	7.52-15.78	42.33-182.53	82.50-152.20
Overall Mean		1.99	0.20	1.57	1.51	0.29	278.1	38.21	10.67	119.58	116.10
$CD_{0.05}$ Location		0.03	0.008	0.03	0.02	0.01	5.38	0.47	0.34	1.23	4.76
$CD_{0.05}$ Location x Orchard		0.06	0.02	0.05	0.04	0.02	11.32	1.06	0.76	2.83	10.65

Table 2. Leaf nutrient status of apple orchards diagnosed by Shear and Faust (1980) sufficiency range standards

Nutrient	Nutritional level (per cent orchards)		
	Low	Adequate	Excess
N	-	100	-

P	4	96	-
K	4	96	-
Ca	52	48	-
Mg	28	60	12
Fe	-	100	-
Zn	-	100	-
Cu	-	76	24
Mn	-	84	16

Table 3. Regression equations of yield (Y) on leaf nutrient contents at different locations

Location	Regression plane	Coefficient of determination (R^2)
Jubbal - Kotkhai	Y = -562..47 +103.14N* +127.12P +50.13K* +103.11Ca* +304.83Mg* +0.19Fe +1.98Zn* -6.48Cu* -0.94Mn* (45.12) (98.13) (21.09) (51.15) (121.11) (0.13) (1.09) (1.78) (0.19)	61.32
Karsog	Y = -161.07 -44.57N +268.32P +72.12K* -68.13Ca* +326.03Mg* +0.29Fe* +0.70Zn -I.68Cu -I.27Mn* (36.91) (151.23) (26.89) (28.94) (143.18) (0.11) (1.35) (1.60) (0.72)	57.33
Kalpa	Y = -182.11 -31.42N +271.11P** +31.52K +59.18Ca +371.58Mg* +0.35Fe* +2.53Zn** +3.12Cu -1.0IMn* (26.52) (193.21) (26.42) (37.12) (152.53) (0.15) (1.17) (1.57) (0.39)	60.35
Kotgarh	Y = -672.51 +98.75N* + 78.19P +111.53K** +111.08Ca** +126.13Mg +0.31Fe* -0.41Zn -2.32Cu -1.37Mn** (32.39) (36.59) (30.85) (39.89) (91.33) (0.15) (0.99) (1.12) (0.27)	54.43
Naggar	Y = -813.07 +88.24N* +171.28P +110.49K** +117.88Ca** +117.08Mg +0.27Fe +2.35Zn* +1.86Cu -0.73Mn* (27.23) (112.18) (30.85) (39.89) (80.53) (0.12) (0.93) (1.61) (0.17)	68.11

Values in the parenthesis are standard errors
* Significant at 5% level of significance
** Significant at I % level of significance

Table 4. Regression equations of yield (Y) on leaf nutrient contents of low & high productive trees

Yield group	Regression plane	Coefficient of determination (%)
Low productive population (<150 kg/tree)	Y = -124..3 +27.23N** +72.13P +56.58K** -11.12Ca +162.53Mg** +0.31Fe** +0.56Zn** -1.62Cu** -0.18Mn** (10.13) (36.59) (7.11) (6.91) (33.12) (0.03) (0.17) (0.73) (0.04)	29.50
High productive population (>150 kg/tree)	Y = 73.01 -6.86N +21.86P** -4.13K +2.02Ca +52.71Mg +0.05Fe -1.01Zn* -2.13Cu** -0.23Mn* (14.13) (76.77) (15.56) (11.12) (61.63) (0.07) (0.45) (0.88) (0.08)	22.51

Values in the parenthesis are standard errors
* Significant at 5% level of significance
** Significant at I % level of significance

CONCLUSION

The present survey included the major quality apple producing areas of Western Himalayas and provides an insight into the nutritional health of orchards. The orchards and locations varied significantly with respect to foliar nutrient status and yield. Although most of the orchards were diagnosed were optimal in foliar status of essential nutrients but there is a need to concentrate on fertilization of secondary nutrients Ca and Mg either by foliar sprays or more soil soluble amendments. The regression equations developed in the study can be used to predict yields on the basis of nutrient concentrations and can also be used to advise fertilizer schedule for apple orchardists of the area.

REFERENCES

Bhandari, A. R. and Sharma, V. S. (1981). Macronutrient status of apple orchards of Shimla district. *Indian Journal of Horticulture*. 38: 10-22.

Cain, J. C. and Boynton, D. (1948). Some effects of season, fruit crop and nitrogen fertilization on the mineral composition of McIntosh apple leaves. *Proceedings of the American Society for Horticultural Science.* 51: 13-21.

Campbell, A. R. and Bould, C. (1970). Virus, fertilizer and rootstock effects on growth and precocity of young apple trees. *Journal of Horticulture Science*. 45: 75-85.

Chapman, H. D. (1964). Suggested foliar sampling and handling techniques determining the nutrient status of some field, horticultural and plantation crops. *Indian Journal of Horticulture.* 21: 97-119.

Das, B. (1999). Nutrient indexing and preliminary DRIS norms for apple. Ph. D. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Solan (India).

FAO. (2015). Available at http://www.faostat.fao.

Kenworthy, A. L. (1964). Fruits, nuts and plantation crops, deciduous and evergreen, a guide for collecting foliar samples for nutrient element analysis. Hort. Department.Michigan State University. pp.1-36.

Kimetu, M.; Mugendi, D. N.; Palm, C. A.; Mutuo, P. K.; Gachengo, C. N.; Nandwa, S. and Kungu, B. (2004). African network on soil biology and fertility (http://www.ciat.cgiar.org/#afnecbook). pp. 207- 224.

Mamgain, S. (1990). Path analysis of correlations between fruit yield and other related yield components in apple. Ph.D. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Solan (India).

NHB. (2014). National Horticulture Database. p. 30.

Panse, V.G. and Sukhatme, P.V. (1985). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, India.

Rana, R. S.; Sharma, R. P. and Azad, K. C. (1984). Nutritional status of apple orchards in Himachal Pradesh. *Indian Journal of Horticulture*. 41 (3/4): 244-250.

Robertson, G. P. and Vitousek, P. M. (2009). Nitrogen in agriculture: balancing the cost of an essential resource. *Annu.Rev.Env.Resour*. 34: 97–125.

Sharma, C. R.; Dhuria, H. S. and Gautam, D. R. (1982). A survey of nutrient status of apple orchards in Kullu district of Himachal Pradesh. *Haryana Journal of Horticultural Science*. 11(1/2): 21-26.

Sharma, U. and Bhandari, A. R. (1992). Survey of nutrient status of apple orchards in Himachal Pradesh. *Indian Journal of Horticulture*. 49(3): 234-241.

Sharma, U. (1994). Studies on the nutrient status in the soil and trees of apple orchards in Chamba district of Himachal Pradesh. Ph.D. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Solan (India).

Shear, C. B. and Faust, M. (1980). Nutritional ranges in deciduous tree fruits and nuts. *Horticultural Reviews.* 2: 142- 163.

Singh, N. (1987). Leaf nutrient status of apple, grape and almond orchards of Kinnaur district of Himachal Pradesh and its relationship with physic-chemical characteristics of soil. Ph. D. Thesis, HPKVV, Palampur (India).

Singh, N. P. (1996). Studies on the Diagnosis and Recommendation Integrated System (DRIS) norms for apple (*Malus x Domestica* Borkh.) cv. Starking Delicious in Himachal Pradesh. Ph. D. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Solan (India).

Yadav, D. K. (1967). Comparative study of the physical and chemical properties and nutrient status of Himachal Pradesh and Nilgiri soils. M. Sc. Thesis, ACRI, Coimbatore (T. N.).

Table 1: Foliar nutrient status of apple orchards at different locations.