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Leaf nutrient status of pomegranate (*Punica granatum*) orchards in district Kullu of Himachal Pradesh

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Abstract
The investigation entitled "Leaf nutrient status of pomegranate (*Punica granatum*) orchards in district Kullu of Himachal Pradesh" was carried during 2015-2016. Based on uniformity in respect of tree age and vigour, thirty orchards of "Bhagwa" cultivar were selected and leaf sampling was done from the twigs of current season growth at 8th leaf from the apex with 50 leaves per sample. The results indicated that leaf N, P and K contents in the pomegranate orchards exhibited a range of 1.12 to 2.80, 0.22 to 0.44 and 0.45 to 2.51 per cent with mean values of 1.96, 0.29 and 0.83 per cent, respectively. The macro nutrients were in sufficient to high range except K and S. The leaf micro nutrient status was sufficient to high except Zn and B, which were low and deficient in 90 and 40 per cent of the orchards, respectively. The K content in growing plants was significantly and positively correlated with Mg and Fe. Thus, the concentration of mineral elements is needed to be studied in tissue as it has a controlling influence on growth, vigour and fruitfulness of plant.

Keywords: pomegranate, leaf tissue, macronutrient, micronutrient and correlation

Introduction
Pomegranate (*Punica granatum* L.) belongs to family Punicaceae. It is native of Iran, Afghanistan and Baluchistan. It is one of the premier fruit crops of India due to its demand for internal market and export potential. The states where commercial cultivation is taken up are Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Haryana, Tamil Nadu and Himachal Pradesh. Pomegranate is performing well in mid- hill areas of district Kullu of Himachal Pradesh and farmers are fetching good returns. But the average productivity of this fruit crop in the state is far below the national average. The main reasons for low productivity are lack of assured availability of irrigation water, rainfed agriculture, sub-optimal and imbalanced use of fertilizer nutrients, improper management of soil and water resources, inadequate crop management practices, weed control and plant protection measures. Amongst these, sub-optimal and imbalanced uses of fertilizer nutrients and improper management of soil are claimed to be the prime causes of low productivity of pomegranate. Assessment of nutritional needs of fruit crops assume significance for growers and planners as crop growth and quality are adversely affected under nutrient deficient conditions. Nutrient management is one of the largest shares of cost with its impact on potential yield and crop quality (Bhat *et al.*, 2017) [2]. Plant analysis is used to confirm the suspected deficiencies and toxicities of nutrients and also to assess the efficiency of fertilizer treatments. Plant being the best indicator of soil nutrient supply under a given environment and leaf being a centre of nutrition of plant, therefore, forms basis of the foliar analysis. Hence, plant analysis is necessary as it is complementary to soil analysis The area under pomegranate cultivation in Kullu district of Himachal Pradesh is increasing year after year due to diversification, therefore, it is imperative to have an information on the nutritional status of the newly established orchards so that the effective and fortified utilization of costly inputs could be made, which will help in getting the higher yield of good quality fruits.

Material and Methods
A survey was conducted to assess the leaf nutrient contents of thirty pomegranate orchards in district Kullu of Himachal Pradesh. The "Bhagwa variety" of pomegranate was selected for study.

Representative leaf samples comprising of 50-60 leaves (8th leaf pair from the growing tip of non-fruiting secondary branches of tree node) were collected from 4-5 randomly selected trees in each selected orchard as per the sampling time suggested by Bhargava and Chadha (1988) [1]. The leaf samples were washed with ordinary water and then with 0.1 N HCl followed by washing with distilled water. After washing, the samples were spread on filter paper for air drying and were subsequently put in paper bags for drying in hot air oven at 60 ± 5°C for 72 hours (Kenworthy, 1964) [9]. The dried samples were grounded in a stainless steel blender and stored in butter paper bags for chemical analysis.

The prepared leaf samples were digested in a diacid mixture of HNO_3: $HClO_4$ (4:1) for P, K, Ca, Mg, S, Fe, Cu, Zn and Mn and final volume was made to 100 ml (Jackson, 1973) [8]. Separate digestion was carried out for nitrogen estimation using concentrated H_2SO_4 and digestion mixture (Potassium sulphate 400 parts, copper sulphate 20 parts, mercuric oxide 3 parts, selenium powder 1 part) as suggested by Jackson (1973) [8]. The leaf samples were dry ashed at 550ºC in a muffle furnace for the estimation of boron. For molybdenum, leaf samples were digested with HNO_3 and $HClO_4$ as described by Purvis and Peterson (1956) [11]. The Mo in extract was estimated on ICPS. The macro and micronutrient contents in leaf tissue were determined by using standard procedures (Table 1). Simple correlation coefficients were computed to find out the extent of relationship between leaf nutrient contents by using SPSS v16.0.

Table 1: Methods followed for the analysis plant samples

Parameter	Method and Reference
N	Micro-kjeldhal method (Jackson, 1973) [8].
P	Vanado-molybdate yellow colour method (Jackson, 1973) [8]
K	Flame photometer method (Jackson, 1967) [7].
Ca	Flame photometer method (Jackson, 1967) [7].
Mg	Atomic absorption spectrophotometer method (Vogel, 1978) [14].
S	Turbidimetric method (Chesnin and Yien, 1950) [3].
Cu, Fe, Mn and Zn	Atomic absorption spectrophotometer method (Vogel, 1978) [14].
B	Azomethine-H method (Gupta, 1979) [6].
Mo	AB-DTPA method (Soltanpour *et al*., 1982) [13].

Results and Discussion

Macronutrient status of leaves

The data regarding leaf analysis of different pomegranate orchards for macronutrient status is presented in table 2.

The leaf N, P and K contents in the pomegranate orchards exhibited a range of 1.12 to 2.80, 0.22 to 0.44 and 0.45 to 2.51 per cent with mean values of 1.96, 0.29 and 0.83 per cent, respectively (Table 2). The CV for leaf N (23.43%), P (18.00%) and K (45.70%) contents indicates that, these varied spatially. Majority of samples were in sufficient range for N and P. Optimum N status in most of the pomegranate orchards may be due to regular use of nitrogenous fertilizers and use of organic manures by the orchardists. All the samples for leaf P fell under the high range. This may be ascribed due to high available P status of pomegranate orchard soils.

Table 2: Leaf macronutrient content in pomegranate orchards of Kullu district

Macronutrient	Range	Mean	S. E. (±)	C.V. (%)
N (%)	1.12 - 2.80	1.96	0.08	23.43
P (%)	0.22 - 0.44	0.29	0.01	18.00
K (%)	0.45 - 2.51	0.83	0.07	45.70
Ca (%)	0.82 - 2.44	1.71	0.07	23.43
Mg (%)	0.43 - 1.35	0.94	0.05	31.54
S (%)	0.05 - 0.43	0.19	0.02	50.91

About 13, 80 and 7 per cent samples for leaf K fell under low, medium and high categories, respectively (Figure 1). Eighty per cent of the analyzed samples were observed sufficient in leaf K status, may be ascribed due to vigorous extraction of nutrients by the roots from the soil layers. The leaf analysis data shows that pomegranate leaves are sufficient to high in N, high in P and low to sufficient in K. The results are supported by Gathala *et al*. (2004) [5] who reported 87 per cent pomegranate orchards to be intermediate in leaf K.

The leaf Ca, Mg and S content ranged from 0.82 to 2.44, 0.43 to 1.35 and 0.05 to 0.43 per cent with an average value of 1.71, 0.94 and 0.19 per cent, respectively (Table 2). The CV for leaf Ca (23.43%), Mg (31.54%) and S (50.91%) indicates that, these varied spatially. By perusal of data in Figure- 1, it can be inferred that 83 per cent samples were sufficient in Ca content, 100 per cent samples were high in Mg and 30 and 53 per cent samples were low and sufficient in S content, respectively. Raghupathi and Bhargava (1998) [12] also reported optimum content of leaf Ca and Mg in pomegranate orchards. They further reported pomegranate leaf S content to be low in 36 per cent of the orchards.

Sufficient Ca in the plants may be ascribed to its adequate supply in the soil. Slight acidity in soils and also, high soil Mg content, favours high availability of Mg to the pomegranate plants. Lower content of leaf S in some orchards may be due to high Mo content in soils. Because of similarity in charge and size, MoO_4^{2-} ion exerts a decreasing effect on uptake of SO_4^{2-} ion by the plants (Das, 2011) [4].

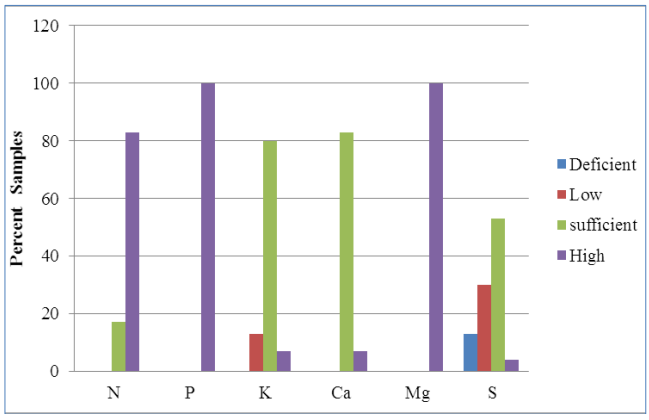

Fig 1: Per cent leaf samples in different categories for macronutrients

Micronutrient status of leaves

The data presented in Table 3 portrays that leaf Cu, Fe and Mn ranged between 20.10 to 84.60, 195.20 to 268.60 and 31.50 to 126.60 per cent with mean value of 52.49, 236.93

and 70.86 per cent, respectively. Leaf Cu, Fe and Mn showed spatial variation with CV of 42.54, 6.23 and 34.05 per cent, respectively. The leaf samples of pomegranate were sufficient in Cu (53 %) and Mn (80 %) and for Fe, 7 per cent leaf samples were lying in medium category and remaining 93 per cent in high category (Figure- 2). The plants might get high amount of Cu due to foliar application of copper containing fungicides. The sufficient levels of leaf Fe and Mn could be due to the fact that soils in these orchards were also high in these nutrients. Navale (2007) [10] also reported high leaf Cu and Fe content in pomegranate orchards in Western Maharashtra.

Table 3: Leaf micronutrient content in pomegranate orchards of Kullu district

Micronutrient	Range	Mean	S. E. (±)	C.V. (%)
Cu (ppm)	20.10 - 84.60	52.49	4.08	42.54
Fe (ppm)	195.20 - 268.60	236.93	2.69	6.23
Mn (ppm)	31.50 - 126.60	70.86	4.41	34.05
Zn (ppm)	11.10 - 92.10	38.59	3.88	55.10
B (ppm)	18.70 - 38.10	28.70	0.94	18.01
Mo (ppm)	0.24 - 0.49	0.38	0.01	18.69

The leaf Zn content ranged from 11.10 to 92.10 ppm with a mean value of 38.59 ppm (Table 3). The CV of 55.10 per cent for leaf Zn indicates that, it varied spatially. The data reveals that 90, 3 and 7 per cent of the samples were in low, sufficient and high categories, respectively (Figure- 2). Most of the analyzed samples (90 per cent) were found low in leaf Zn content which may be due to the removal of Zn by the plants in the absence of adequate replenishment. Lower levels of leaf Zn have also been reported by Gathala *et al.* (2004) [5] for the pomegranate orchards in Jaipur district of Rajasthan.

In pomegranate orchards of Kullu district, the leaf B content varied from 18.70 to 38.10 ppm with mean value of 28.70 ppm (Table 3). The CV of 18.01 per cent for leaf B content indicates that, it varied spatially. About 40 per cent samples were found deficient and 60 per cent samples were found sufficient in their leaf B content (Figure- 2). Deficient leaf B has also been reported by Gathala *et al.* (2004) [5] in the pomegranate orchards of Rajasthan. Deficient leaf B was observed because of its lower content in the soils. The leaf Mo content varied from 0.24 to 0.49 ppm with mean value of 0.38 ppm (Table 3). Leaf Mo showed spatial variation with CV of 18.69 per cent. All the analyzed leaf samples were found to be sufficient in available molybdenum which might due to its sufficient content in soils.

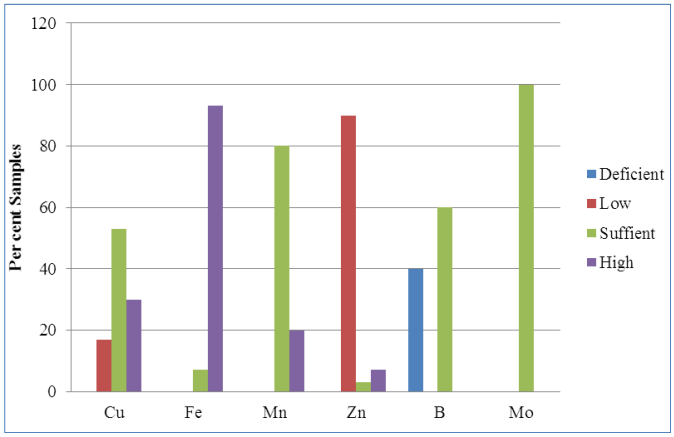

Fig 2: Per cent leaf samples in different categories for micronutrients

Correlation amongst various nutrients in pomegranate leaves

Correlation coefficients were worked out between the various leaf nutrient contents of pomegranate orchards (Table 4). The potassium content in growing plants had significant and positive correlations with Mg and Fe (r = 0.38*) whereas it had non-significant correlations with nutrients like P, S, Cu, Mn, Zn and Mo. The Ca content in growing plants had significant and positive correlation with Fe (r= 0.56**). The S content was significantly and positively correlated with Mn (r= 0.59**). There was significant and negative correlation between leaf S and Mo (r= -0.40*).

Table 4: Correlation amongst various nutrients in pomegranate leaves

	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn	B	Mo
N	1											
P	-0.36	1										
K	0.16	-0.12	1									
Ca	0.23	-0.25	0.34	1								
Mg	-0.02	-0.10	0.38*	0.05	1							
S	0.07	0.05	0.11	0.03	0.06	1						
Cu	-0.13	-0.13	0.19	-0.24	0.33	0.07	1					
Fe	-0.05	0.21	0.38*	0.56**	-0.11	0.26	-0.04	1				
Mn	0.25	-0.32	0.13	0.33	0.02	0.59**	0.07	0.16	1			
Zn	0.27	0.09	0.20	0.17	0.20	0.34	-0.09	0.18	0.18	1		
B	-0.12	-0.28	-0.08	-0.03	0.11	0.03	0.01	-0.25	-0.10	0.11	1	
Mo	0.23	0.01	0.31	0.30	-0.07	-0.40*	-0.29	0.20	-0.25	-0.06	0.01	1

Conclusion

From the above study it can be concluded that majority of the orchards were adequate in leaf Ca and Mg. Whereas, 13, 30, 17 and 90 per cent of the samples fell in low category for K, S, Cu and Zn, respectively. Leaf B was deficient in 40 per cent of the samples. The analyzed leaf samples were sufficient to high in all the nutrients, except for Zn and B, which were low in most of the orchards. These nutrient elements (N, Zn & B) need to be taken care of and application of these would improve the plant nutrition level and hence, growth and productivity. To get potential and quality produce, proper fertilization to orchards reported deficient in various nutrients is recommended.

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