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Nutrient status of soils and carnation (*Dianthus caryophyllus* Linn.) Foliage under protected cultivation in the western Himachal Himalaya

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Abstract
A study was undertaken to obtain insight of soil nutrient status, under intensive carnation cultivation, of polyhouses located in low and mid hills of Himachal Pradesh. Studies reveal high soil organic carbon content (1.76-2.00 %) and available nitrogen, phosphorus and potassium ranged from 246.1 to 264.8, 49.5 to 61.9 and 587.1 to 682.5 kg ha^{-1}, respectively. With the exception of nitrogen at some locations, all the soils were high in primary nutrient content. The exchangeable calcium and magnesium were found to be adequate and sulphur content (15.21 to 16.99 mg kg^{-1}) was medium in the soils. Micronutrients Zn, Fe, Cu and Mn were medium to high in availability. Total N, P, K, Ca, Mg and S concentration in leaf were categorized as medium, medium, medium, high, high and low range, respectively. Foliage Zn, Cu, Fe, and Mn concentrations were found to be medium to high, high, medium to high and medium range, respectively. Thus, the crop is well supplied with the essential nutrients except sulphur.

Keywords: Protected cultivation, Carnation foliage, soil quality, Himachal Pradesh

1. Introduction
Soil quality can be a combined interpretation of soil nutrient content and the availability of the same to the crops growing in the particular soil. On the basis of elements' quantity and their requirement on the earth crust, essential elements have been classified in many ways such as macronutrients, i.e., N, P, K, Ca, and Mg, and micronutrients or trace nutrients which consist of B, Cl, Cu, Fe, Mo, Mn, Ni, Na, and Zn. Studies suggested that these elements enhance the growth and yields, besides performing different dynamic functions to protect the internal or external integrity of plant life (White and Brown 2010) [1]. Nutrient availability is one of the important factors influencing the plant growth and development (Caballero *et al*., 2007) [2]. However, increased cropping intensity had been found to accentuate changes such as rapid increase in degradation of soil physical condition, deterioration of nutrient status and changes in the number and composition of soil organisms (Ayoub, 1999) [3]. In India, the agricultural land availability is shrinking day by day due to ever increasing population, urbanization and industrialization. Therefore, it has almost become a compulsion to increase the per unit yield levels from the available land under agriculture which nevertheless, can be achieved by using modern technology such as cultivation in polyethylene-houses. Protected cultivation of flowers in the hill state of Himachal has come up in a big way, especially, in the low and mid hill zones. The present research was focused primarily on carnation crop, as among the various floricultural crops it is being raised widely under protected cultivation. Carnation (*Dianthus caryophyllus* L.) has high ornamental value and easy technology for production of cut flower (Madhuri *et al*., 2014) [4]. It is pertinent to add that intensive cultivation of flowers under polyhouse condition has however, lead to injudicious and excess use chemical inputs to produce more & more on a small piece of a land. It is, therefore, imperative to assess the soil and foliage nutrient status inside the polyhouses. The information generated will be of immense help in judicious management of soil quality. Keeping these factors in view the main objectives under taken in the present investigation were to study the impact of intensive management practices on essential nutrient availability in soil and their uptake by the standing crops.

Materials and Methods
In order to achieve the aforesaid objectives, the study was carried out in three districts namely Bilaspur, Solan and Sirmaur zoned in the west Himachal Himalaya.

Bilaspur has an altitude of 610 m lying between North latitude 31°18′ & 31°55′ and East longitude 75°55′ & 76°28′. The annual average rainfall in the area is about 720 mm with about 55 average rainy days. Solan district lies between 30˚03′ to 32˚15′ North latitude and 76˚42′ to 77˚20′ East longitude and altitude ranging from 300-3000 m above mean sea level with a mean annual temperate of 13-18 ˚C and precipitation 1000-2500 mm. Sirmaur district lies in the Shivalik hills between 30˚22′30′′to 31˚01′20′′ North longitude and 77˚01′12′′ to 77˚49′40′′ East longitude and altitude ranging from 350-3650 m above mean sea level. Sirmaur falls under sub-humid sub-tropical zone, receives annual rainfall of 1000 mm and mean annual temperature 24˚C. These three districts have substantial variability in their soil, physiographic characters, land use pattern and cropping systems. An introductory survey of the areas was carried out for assortment of necessary information about cultivation practices, cropping patterns and problems prevailing in the polyhouses growing flowers. Farmers fertilize generally depending on their personal know-how and purchasing power mainly with urea, 12-32-16, 19-19-19, 12-12-12, farm yard manure and vermicompost. Ten polyhouses growing Carnation crops were selected at random from each district and soil samples were collected from inside the polyhouses. A total number of 30 soil samples (0 to 20 cm), were collected from different locations. All the samples were collected with the help of spade and auger. The soil samples were air dried, crushed in a wooden pestle and mortar, passed through 2 mm sieve and finally stored in plastic containers for the subsequent analysis. A total number of 30 leaf samples were also collected from the respective polyhouses by following standard procedure. The samples were washed with ordinary water and then with 0.1 N HCl followed by washing with distilled water followed by drying in the oven at 60 $\pm$ 5˚C for 72 hours. The dried samples were ground in stainless steel grinder and stored in paper bags for subsequent analysis.

Critical limit

The critical limits of the soil properties followed for categorizing soil nutrient status. The soil properties are presented in Tables 3, 4 and 5.

Table 1: Methods employed for estimating different soil physical, chemical and biological properties

Particular	Method employed	Reference(s)
pH	1:2 soil:water suspension	Jackson (1973)[5]
EC	1:2 soil:water suspension	Jackson (1973) [5]
Organic carbon	Wet combustion method	Walkley and Black (1934) [6]
Available N	Alkaline potassium permanganate method	Subbiah and Asija (1956) [7]
Available P	Olsen's method	Olsen *et al*. (1954) [8]
Available K	Ammonium acetate method	Merwin and Peech (1951) [9]
Available calcium	Ammonium acetate method	Merwin and Peech (1951) [9]
Available magnesium	Ammonium acetate method	Merwin and Peech (1951) [9]
Available sulfur (SO_4-S)	Turbidimetric method (0.15% $CaCl_2$)	Williams and Steinbergs (1959) [10]
DTPA Extractable Zinc, Iron, Manganese, Copper	Atomic Absorption Spectrophotometer (AAS)	Lindsay and Norvell (1978) [11]

Table 2: Methods used for estimating nutrient content of plant samples.

Particular	Method employed	Reference(s)
1. Nitrogen	Microkjeldhal distillation	A.O.A.C., (1970) [12]
2. Phosphorus	Vanado-molybdophosphoric yellow colour method	Jackson, (1973) [5]
3. Potassium, Calcium, Magnesium	Flame photometer	Jackson, (1967) [13]
4. Sulfur	Tubidimetric method	Jackson, (1967) [13]
5. Zinc, Manganese, Copper, Iron	Atomic absorption spectrophotometer (AAS)	Vogel, (1978) [14]

Table 3: Critical limits used for soil organic carbon and primary nutrients.

		Soil fertility Class			References
Sr. No.	Nutrient Element	Low	Medium	High	
1.	Organic carbon (%)	<0.5	0.5-1.5	>1.5	Bhandari and Tripathi, (1979) [15]
2.	Available N ($kgha^{-1}$)	< 280.0	280.0-560	> 560.0	FAI (1977) [16]
3.	Available P ($kgha^{-1}$)	< 10.0	10.0-24.6	>24.6	FAI (1977) [16]
4.	Available K ($kgha^{-1}$)	< 98.6	98.6-280.0	> 280.0	FAI (1977) [16]

Table 4: Critical limits considered for available secondary nutrients.

Sr. No.	Secondary nutrients	Deficient	Sufficient	References
1.	Calcium(cmol (p^+)/ kg)	<1.5	>1.5	Tandon (1989) [17]
2.	Magnesium(cmol (p^+)/ kg)	<1.0	>1.0	Tandon (1989) [17]
3.	Sulfur (ppm)	<10	>10	Tandon (1991) [18]

Table 5: Critical limit for available micronutrient (Lindsay and Norvell, 1978) [11]

Availability	Micronutrients (mg kg^{-1})			
	Zn	Cu	Fe	Mn
Very low	0-0.5	0-0.1	0-2	0-0.5
Low	0.5-1	0.1-0.3	2-4	0.5-1.2
Medium	1-3	0.3-0.8	4-6	1.2-3.5
High	3-5	0.8-3	6-10	3.5-6
Very High	>5	>3	>10	>6

Table 6: Critical limits of nutrients for carnation leaves (Silva and Uchida, 2000) [19]

Sl. No.	Nutrient element	Concentration		
		Deficient	Sufficient	High
A. (%)				
1.	N	< 2.80	2.80–5.20	> 5.20
2.	P	< 0.19	0.19–0.80	> 0.80
3.	K	<1.17	1.17–6.00	>6.00
4.	Ca	< 1.00	1.00–2.00	> 2.00
5.	Mg	< 0.19	0.19–0.70	> 0.70
6.	S	< 0.25	0.25–0.80	> 0.80
B. (ppm)				
7.	Zn	< 20	20 – 60	>60
8.	Cu	< 6.0	6.0 - 10	>10
9.	Fe	< 50.0	50–200	>200.0
10.	Mn	< 33.0	33–302	> 302.0

Statistical analysis

The data were subjected to statistical analysis by adopting standard procedure (Gomez and Gomez, 1984) [20].

Results and Discussion:

Status of the available macro and micro nutrients in soil

Highest nitrogen content was found at Jukhala (332.40 kg ha^{-1}), Mahog-2 (344.9 kg ha kg ha^{-1}) and Dhamla (514.30 kg ha kg ha^{-1}) in polyhouse condition and lowest at Sakred-2 (181.80 kg ha kg ha^{-1}), Riwalsar-1 (172.40 kg ha-1) and Talon (109.70 kg ha-1) in district Bilaspur, Solan and Sirmaur (table 8) respectively. On an average, soils were noted to be deficient in available nitrogen content, might be due to the overuse of nitrogenous fertilizers which presumably induces the potential of nitrate leaching in intensive cultivation systems. Ju *et al*. (2006) [21] also ascribed that substantial mineral nitrogen leaching may take place down the soil profile in the polyhouses mainly due to excessive fertilizer and manure applications on the soil which exceeded the optimum crop requirement in protected cultivation systems leading to low available nitrogen content in the surface soil. Similar conclusions were also documented by Min *et al*. (2012) [22]. Under polyhouse condition highest available phosphorous content was recorded at Lanjhata-2 (154.56 kg ha^{-1}), Basal (152.32 kg ha^{-1}) and Kasar (159.04 kg ha^{-1}) areas and lowest at Noa (2.24 kg ha^{-1}), Riwalsar-2 (4.48 kg ha^{-1}) and Rajgarh (13.44 kg ha^{-1}) areas in district Bilaspur, Solan and Sirmaur, respectively. Very high phosphorus content under protected cultivation, may be attributed to intensive fertilization, a build-up effect and imbalance use of DAP, 12-32-16 inside the polyhouses. Xu *et al*. (2008) [23] also reported that readily available phosphorus accumulated the most, in the soil under polyhouse condition compared to those in open field condition due to nutrient accumulation exceeding the threshold levels. Under polyhouse condition highest available potassium content was recorded at Jukhala (1915.20 kg ha^{-1}), Patrar (1646.40 kg ha^{-1}) and Chakhal-1 (1321.60 kg ha^{-1}) areas and lowest at Nauni (219.52 kg ha^{-1}), Mahog-2, Riwalsar-2 (219.52 kg ha^{-1}) and Nohra (180.32 kg ha^{-1}) areas, in district Bilaspur, Solan and Sirmaur, respectively. Liu *et al*. (2001) [24] reported that in general, the content of available potassium in soils under protected cultivation were very high due to the intensive use of fertilizers in greenhouse soils. Similar conclusions were also reported by Cao *et al*. (2012) [25]. Furthermore, it has been observed that older polyhouses recorded higher content of available potassium. Zhohui *et al.* (2008) [26] also reported the similar trends. Among polyhouse soils, highest calcium content was found at Sakred-1 (19.60 cmol (p^+)/kg), Patrar (37.20 cmol (p^+)/kg) and Kotli (24.90 cmol (p^+)/kg) areas and lowest at Sakred-2 (5.25 cmol (p^+)/kg), Oachghat (6.20 cmol (p^+)/kg) and Kanogata (3.75 cmol (p^+)/kg) areas in district Bilaspur, Solan and Sirmaur, respectively. Similar range was also reported by (Minhas *et al*. 1997) [27] and Gupta and Tripathi (1996) [28]. Inside polyhouses, highest magnesium content was found at Sakred-1 (1.21 cmol (p^+)/kg), Patrar (1.13 cmol (p^+)/kg) and Kanogata (1.17 cmol (p^+)/kg) areas and lowest at Noa (0.86 cmol (p^+)/kg), Basal (0.91 cmol (p^+)/kg) and Dhamla (0.87 cmol (p^+)/kg) areas in district Bilaspur, Solan and Sirmaur, (table 8) respectively. Kaistha and Gupta (1993) [29] also reported the similar trends for exchangeable magnesium in Himachal Pradesh (0.1 to 4.2 cmol(p^+)/kg). So, the soils are moderately supplied with available magnesium as per critical limits (Table 4) suggested by Tandon (1989) [17]. Highest sulfur content was found at Nauni (35.00 mg kg^{-1}), and Oachghat (26.25 mg kg^{-1}) and Rajgarh (20.63 mg kg^{-1}) and lowest at Sakred-2 (7.00 mg kg^{-1}), Riwalsar-2 (6.94 mg kg^{-1}) and Dhamla (7.63 mg kg^{-1}) in district Bilaspur, Solan and Sirmour, respectively under polyhouse condition. This may be attributed to precise or limited application of sulphate fertilizers ($ZnSO_4$, $MgSO_4$ etc.) and sulfur based pesticides as the occurrence of insect infestation was considerably less under polyhouse condition. All the soil samples contained adequate available SO_4-S, according to critical limits (Table 4) as suggested by Tandon (1991) [18]. The DTPA-Zinc content ranged from 2.70 to 3.19 mg kg^{-1} with highest content (3.19 mg kg^{-1}) in Sirmaur and lowest (2.70 mg kg^{-1}) in Solan district (Table 5). According to suggested critical limits [11], soils were rated as medium to high in available zinc status. The soils were, adequately supplied with available iron according to the critical level (4.5 mg kg^{-1}) suggested by Lindsay and Norvell (1978) [11]. According to critical limits (Table 5) the soils are holding adequate level of DTPA extractable copper. The DTPA-Mn content ranged from 4.60 mg kg^{-1} to 9.83 mg kg^{-1} with highest in Sirmaur and lowest in Bilaspur. In the light of suggested critical limits [11], soils were rated as high to very high in their status. The high Mn content may be ascribed to the higher organic carbon content (Table 8) present in the soil, since in general the organic carbon has a positive relationship with available Mn. Similar consequences were documented by Tripathi *et al.* (1994) [30].

Macronutrient concentration in Carnation plants

N, P, and K concentration in the carnation leaves varied from 2.77 to 3.33, 0.25 to 0.32 and 2.63-3.37 per cent in different districts (locations) of Himachal Pradesh. According to critical limits (Table 6) all the plant samples for N, P and K falls under sufficient range. This may be due to the regular incorporation of organic matter (FYM, vermicompost etc.) and addition of CAN fertilizer through fertigation. Bhatia (2014) [31] and Dharma (2006) [32] also reported similar range of N, P and K concentration in carnation foliage. The concentration of Ca, Mg and S in the leaves of the crop ranged from 3.27 to 6.28, 0.18 to 0.49 and 0.08 to 0.14 per cent, respectively (Table 10). As per suggested critical limits (Table 6), it was noted that the plant samples for Ca and Mg fall in high range and low range for sulfur. This confirms that soil and plant analysis data are in the similar line for Ca and Mg, however, S does not seem to follow the same trend.

DTPA-extractable micronutrient concentration in Carnation plants

The concentration of Zn and Cu in the carnation foliage varied from 42.06 to 89.54 and 55.08 to 78.27 ppm, respectively (Table 11). In the light of critical limits given in table 3.7, it was observed that Zn and copper content fell in the high range. This shows that soil and plant analysis data are in the same line. The content of Fe and Mn in the leaves of carnation ranged from 108.19 to 234.05 ppm and 64.73 to 76.25 ppm, respectively (Table 11). Among different district, Bilaspur recorded highest (234.05ppm) iron content and lowest in the district Sirmaur (108.19 ppm). Whereas, manganese content was highest in Sirmaur district (76.25 ppm) and lowest in Bilaspur (64.73). Considering the critical limits (Table 6), the plants are well supplied with Fe and Mn.

Conclusion

The polyhouse soils of district Solan recorded highest content in majority of macronutrients followed by soils of Bilaspur and Sirmaur. Whereas, highest DTPA extractable micronutrient content was observed in Sirmaur soils followed by Bilaspur and Solan soils. Excluding nitrogen content at some locations, all the soils were high in primary nutrient content. Judicious application of fertilizers along with farmyard manure may further improve soil nutrient status and soil organic carbon content. The macronutrients concentration N, P, K, Ca, Mg and S in the foliage of carnation were categorized as medium, medium, medium, high, high and low range, respectively under the polyhouse condition. However, the concentration of micronutrient cations Zn, Cu, Fe, and Mn was found to be medium to high, high, medium to high and medium range, respectively. Thus, the crop is well supplied with the essential nutrients except sulphur.

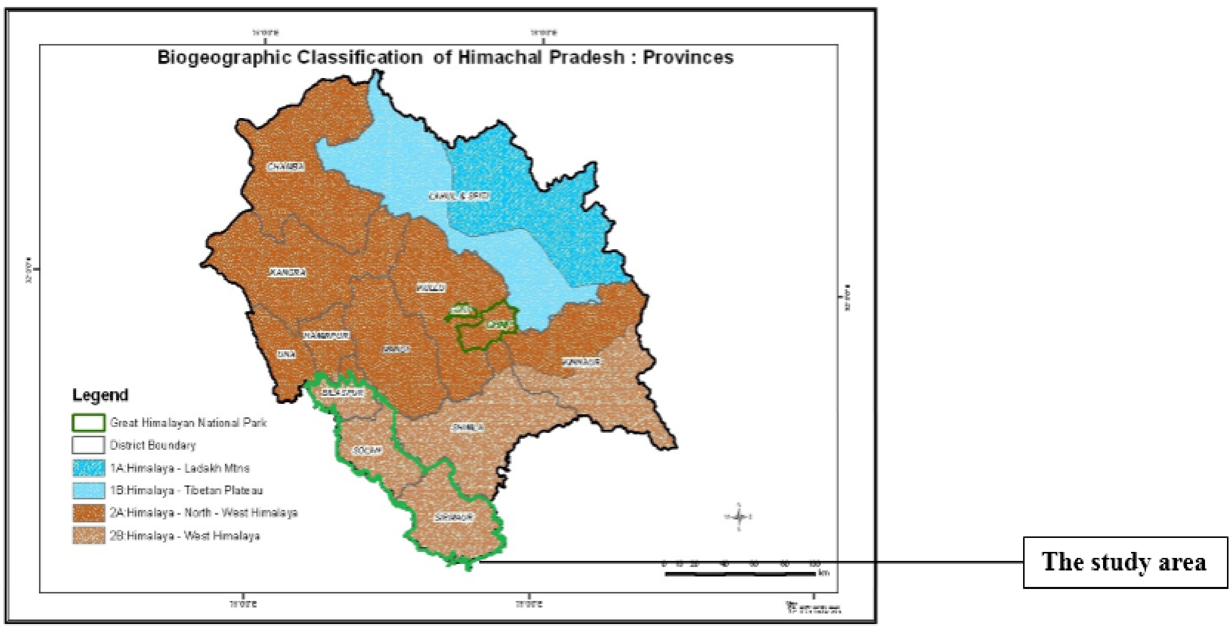

Fig 1: Biogeographic Classification of Himachal Pradesh: Provinces (Source: www.http://greathimalayannationalpark.com/maps/.com)

Fig 2: Carnation growing Polyhouse of certain locations

Table 7: Soil organic Carbon and available macronutrient content of the polyhouse soils in different locations of Bilaspur, Solan and Sirmaur districts.

	SOC (%)	N(kg ha^{-1})	P(kg ha^{-1})	K (kg ha^{-1})	Ca(cmol (p$^+$) kg^{-1})	Mg(cmol (p$^+$) kg^{-1})	S (mg kg^{-1})
Location	**Bilaspur**						
Sakred-1	2.64	266.56	78.40	884.80	19.60	1.21	19.31
Sakred-2	3.05	188.16	40.32	291.20	5.25	0.88	7.00
Jukhala	2.99	332.42	76.16	1915.2	6.40	0.90	21.88
Noa	1.08	323.01	2.24	414.40	8.90	0.86	25.94
Nauni	1.81	213.25	138.88	219.52	7.35	0.91	35.00
Patialog	2.01	232.06	154.56	728.00	14.30	1.02	19.69
Thandora	1.03	269.69	103.04	806.40	6.75	1.03	14.50
Lanjhata-1	0.31	181.88	64.96	806.40	6.10	0.97	9.75
Lanjhata-2	1.34	200.70	105.28	1041.6	5.55	1.04	25.06
Ghumarwin	2.84	297.92	42.56	492.80	7.35	0.99	16.25
MEAN	1.86	250.57	80.64	760.03	8.76	8.76	19.44
SD	0.97	55.42	46.5	487.33	4.61	4.61	8.20
CV	52.15	22.12	57.66	64.12	52.63	52.63	42.18
Solan							
Oachghat	2.37	294.78	132.16	604.80	6.20	0.97	26.25
Mahog-1	2.84	254.02	143.36	1400.0	7.90	1.01	22.81
Mahog-2	1.52	344.96	96.32	219.52	7.95	0.94	8.44
Budlayana	1.71	301.06	13.44	1321.6	16.50	1.03	22.81
Patrar	2.22	260.29	85.12	1646.4	37.70	1.13	11.19
Kathar	3.82	297.92	69.44	448.00	17.10	1.09	14.00
Sodi	1.45	225.79	150.08	414.40	14.40	0.94	12.82
Basal	1.75	222.66	152.32	414.40	16.35	0.91	14.13
Riwalsar-1	0.98	172.48	8.96	840.00	25.10	1.08	7.56
Riwalsar-2	1.08	307.33	4.48	219.52	21.55	1.00	6.94
MEAN	1.97	268.13	85.57	920.86	17.08	1.01	14.69
SD	0.87	50.98	59.77	943.02	9.45	0.07	6.93
CV	44.16	19.01	69.85	102.41	55.33	6.93	47.17
Sirmaur							
Kanogata	1.49	254.02	53.76	884.80	3.75	1.17	19.31
Paviana	2.65	313.60	96.32	1198.4	16.79	0.94	11.06
Chakhal-1	3.34	213.25	141.12	1321.6	23.05	0.94	16.25
Chakhal-2	2.79	285.38	64.96	918.40	8.95	0.91	11.94
Kasar	1.96	266.56	159.04	683.20	16.00	1.14	10.56
Kotli	3.77	241.47	26.88	1120.0	24.90	1.01	14.75
Talon	0.51	109.76	38.08	728.00	7.40	0.93	11.56
Dhamla	3.87	514.30	20.16	649.60	12.10	0.87	7.63
Rajgarh	2.38	275.15	13.44	336.00	14.85	0.93	20.63
Nohra	2.22	301.06	49.28	180.32	14.65	0.90	12.56
MEAN	2.50	277.45	66.3	802.03	14.24	0.97	13.63
SD	1.04	101.23	14.28	364.4	6.59	0.10	4.08
CV	41.6	36.49	75.96	45.43	46.28	10.31	29.93

Table 8: DTPA extractable micronutrient content of the soils in different locations of Bilaspur, Solan and Sirmaur districts.

Location	Zn(mg kg^{-1})	Fe(mg kg^{-1})	Cu(mg kg^{-1})	Mn(mg kg^{-1})
Bilaspur				
Sakred-1	2.55	0.98	7.13	3.12
Sakred-2	4.32	6.66	6.25	6.25
Jukhala	4.38	7.01	11.72	7.13
Noa	2.92	7.84	4.63	1.94
Nauni	2.53	5.80	0.31	2.04
Patialog	2.08	11.37	2.93	6.32
Thandora	3.76	4.41	13.99	12.34
Lanjhata-1	3.34	10.73	6.23	6.45
Lanjhata-2	3.59	0.34	9.39	3.42
Ghumarwin	3.77	3.45	9.90	8.84
MEAN	3.32	4.68	7.25	5.79
SD	0.78	4.94	4.12	3.28
CV	23.49	105.56	56.83	56.65
Solan				
Oachghat	4.15	6.12	11.69	4.74
Mahog-1	2.97	1.19	1.98	9.38
Mahog-2	4.57	18.65	5.34	22.14
Budlayana	2.42	2.48	1.89	14.76
Patrar	3.82	5.48	4.19	5.17

Kathar	2.94	6.02	0.81	3.93
Sodi	2.30	4.62	0.96	6.05
Basal	2.31	17.58	0.61	5.61
Riwalsar-1	1.37	7.51	0.10	1.44
Riwalsar-2	2.90	8.09	0.02	4.29
MEAN	2.98	7.78	2.76	7.75
SD	0.97	5.84	3.59	6.22
CV	32.55	75.06	130.07	80.26
Sirmaur				
Kanogata	3.92	3.34	4.56	12.44
Paviana	4.15	8.59	2.57	4.13
Chakhal-1	3.99	15.64	2.61	10.76
Chakhal-2	4.11	9.87	8.05	13.65
Kasar	2.20	7.19	5.64	10.32
Kotli	4.18	4.51	0.55	12.38
Talon	1.89	1.52	0.04	14.01
Dhamla	3.64	8.37	2.73	12.27
Rajgarh	4.07	11.48	1.85	11.23
Nohra	2.21	23.26	1.85	1.40
MEAN	3.44	9.38	3.44	10.26
SD	0.94	6.37	2.52	4.16
CV	27.33	67.91	73.26	40.55

Table 9: Primary nutrient concentrations in foliage of different locations.

	Nitrogen (%)			Phosphorous (%)			Potassium (%)		
Locations	**Bilaspur**	**Solan**	**Sirmaur**	**Bilaspur**	**Solan**	**Sirmaur**	**Bilaspur**	**Solan**	**Sirmaur**
Mean	2.77	3.33	2.89	0.30	0.25	0.32	2.63	3.37	3.36
$CD_{0.05}$	0.1	0.1	0.1	0.08	0.08	0.08	0.12	0.12	0.12

Table 10: Secondary nutrient concentrations in foliage of different locations.

	Calcium (%)			Magnesium (%)			Sulphur (%)		
Locations	**Bilaspur**	**Solan**	**Sirmaur**	**Bilaspur**	**Solan**	**Sirmaur**	**Bilaspur**	**Solan**	**Sirmaur**
Mean	3.27	6.28	4.66	0.18	0.49	0.29	0.10	0.14	0.08
$CD_{0.05}$	0.47	0.47	0.47	NS	0.12	0.12	0.13	NS	NS

Table 11: DTPA extractable micronutrients concentration in foliage of different locations.

Sites	Zn (ppm)			Fe (ppm)			Cu (ppm)			Mn (ppm)		
	Bilaspur	**Solan**	**Sirmaur**	**Bilaspur**	**Solan**	**Sirmaur**	**Bilaspur**	**Solan**	**Sirmaur**	**Bilaspur**	**Solan**	**Sirmaur**
Mean	89.54	73.12	42.06	234.05	211.93	108.19	72.32	78.27	55.08	64.73	69.26	76.25
$CD_{0.05}$	7.24	7.24	7.24	5.10	5.10	5.10	9.10	9.10	9.10	12.19	12.19	12.19

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