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Effect of NPK and Zn on growth, flowering and bulb production in tulip under polyhouse conditions in Kashmir

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ABSTRACT

Healthy and uniform bulbs of tulip cv. 'Apeldoorn' were planted in two consecutive growing seasons under polyhouse conditions in FRBD design to study the effect of nutrient management on growth, flowering and bulb production in tulip in the Kashmir valley. Experimental treatments comprised of three levels of nitrogen (0,75 and 150 kg ha^{-1}) and two levels of phosphorus (0 and 50 kg ha^{-1}), potassium (0 and 50 kg / ha) and zinc (0 and 5 kg ha^{-1}). Except for bulb survival, nitrogen @ 75 kg ha^{-1} significantly improved all the parameters. However, further increase in dose of nitrogen (150 kg ha^{-1}) influenced only a few parameters like scape length, wrapper leaf area, vase life and bulblet weight per plant. Application of phosphorus, potassium and zinc also resulted in better growth, flower quality and bulb production. Application of different nutrients caused increased concentration of nutrients in leaf tissue, which resulted in better performance of the plant. Combined application of N, P, K and Zn @ 75, 50, 50 and 5 kg ha^{-1}, respectively, was found to be the most suitable dose for obtaining better growth, quality flower and bulb production.

Key words: Tulip, nutrition, flowering, bulb production, polyhouse

INTRODUCTION

Tulip (*Tulipa* spp.) is known throughout the temperate world and is considered an aristocrat of the pot, garden, a field or forest. It is the leading ornamental bulbous plant in the world and has gained popularity due to its beauty and economic value. Tulips are excellent for cut flower, garden display and pot culture. It is the top most flowering geophyte of the Netherlands and occupies the fourth position among the top ten cut flowers in the global floriculture trade. The largest area under any true bulb crop in the world is that of *Tulipa,* followed by *Narcissus, Iris, Hyacinthus* and *Lilium* (Rees, 1972). In India, tulips are grown chiefly in the state of Jammu and Kashmir. However, there is great scope of growing tulips for various purposes in temperate zones like Himachal Pradesh, Uttranchal and other, similar hilly regions of the country. Efforts on promoting commercial floriculture in our country have started and protected cultivation of cut flowers opens up newer avenues for quality production and export to earn valuable foreign exchange. Due to its high aesthetic appeal, tulips are in great demand, especially during Christmas, Valentine's Day, Mother's Day and other festive occasions. 'Apeldoorn' is one of the most suitable cultivars of tulip for cut flower production under polyhouse (Jhon and Khan, 2003). However, different aspects of production technology need to be developed for getting higher quality/yield of flower as well as bulb to fetch attractive returns. Work on different aspects of production technologies, viz., planting time (Jhon *et al*, 2004), growth environment (Jhon *et al*, 2005a) and suitable media (Jhon *et al*, 2005b) has been conducted. Nutrients play an important role in growth and development of any plant. However, information on this aspect in tulip is scanty. Therefore, the present investigation was carried out to study the effect of nutrients on growth, flower quality and bulb production in tulip cv. 'Apeldoorn' under polyhouse conditions.

MATERIAL AND METHODS

The experiment was conducted at the Division of Floriculture, Medicinal and Aromatic Plants, SKUAST (K), Shalimar (located at an altitude of 1585 m amsl) during two consecutive years, 2002 to 2004, under polyhouse conditions. A polyhouse with steel pipe framework clad with twin layer UV stabilized plastic sheet of 200 µm was used to create modified environment. 10 cm dead space

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Table 1. Effect of nutrients on growth, floral production and bulb production characters in tulip under polyhouse conditions

Treatment	Bulb survival (%)		Stem thickness (mm)		Wrapper leaf area (cm^2)		Days to flowering		Scape length (cm)		Tepal diameter (mm)		Vase life (days)		No. of Bulbs / plant		Bulblet weight / plant (g)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
N (kg ha^{-1})																		
N_0 = 0	88.21	93.12	6.34	6.71	125.86	131.63	124.65	121.05	36.05	34.26	8.29	8.35	6.63	659	0.88	1.03	4.99	5.39
N_1 = 75	85.76	90.81	6.97	7.29	135.70	140.76	127.30	123.31	38.53	39.26	8.96	8.98	7.07	7.27	1.02	1.19	7.01	7.06
N_2 = 150	88.28	93.54	6.96	7.25	134.91	142.60	126.74	123.72	40.11	41.17	8.96	9.01	6.76	7.02	0.99	1.17	6.62	7.40
C.D (*P=0.05*)	NS	2.315	0.13	0.08	1.57	0.86	1.38	0.68	0.53	0.19	0.07	0.12	0.29	0.21	0.21	0.05	0.05	0.31
P (kg ha^{-1})																		
P= 0	86.48	91.15	6.52	6.88	129.80	135.47	127.18	123.55	36.99	36.47	8.59	8.59	6.59	6.65	0.89	1.05	5.66	6.21
P_1= 50	88.35	93.83	6.99	7.28	134.51	141.19	125.28	121.83	39.47	39.99	8.88	8.97	7.05	7.26	1.04	1.21	6.76	7.03
C.D (*P=0.05*)	NS	1.89	0.10	0.06	1.28	0.70	1.13	0.55	0.44	0.16	0.06	0.10	0.24	0.17	0.01	0.05	0.02	0.26
K (kg ha^{-1})																		
K_0= 0	86.89	92.05	6.65	7.01	131.39	136.55	128.44	124.16	37.01	37.21	8.63	8.71	6.44	6.76	0.95	1.12	6.12	6.40
K_1= 50	87.93	92.93	6.87	7.16	132.92	140.10	124.01	121.23	39.45	39.25	8.84	8.85	7.20	7.15	0.98	1.14	6.29	6.83
C.D (*P=0.05*)	NS	NS	0.10	0.06	1.28	0.70	1.13	0.55	0.44	0.16	0.06	0.10	0.24	0.17	0.01	NS	0.02	0.26
Zn (kg ha^{-1})																		
Z_0= 0	87.08	92.62	6.67	7.01	132.44	136.88	126.89	122.93	37.27	37.46	8.68	8.72	6.97	6.89	0.95	1.11	6.05	6.33
Z_1= 5	87.75	92.36	6.85	7.15	131.87	139.77	125.57	123.46	39.19	39.00	8.79	8.84	6.85	6.94	0.98	1.15	6.36	6.89
C.D (*P=0.05*)	NS	NS	0.10	0.06	NS	0.70	1.13	NS	0.44	0.16	0.06	0.10	NS	NS	0.01	NS	0.02	0.26

NS : Non - significant

was ensured between plastic layers. The polyhouse was additionally fitted with two high-pressure exhaust fans each on the east and west, whereas four ventilators each were provided on the north and south. Experimental treatments comprised three levels of nitrogen (0, 75 and 150 kg ha^{-1}) and two levels each of phosphorus (0 and 50 kg ha^{-1}), potassium (0 and 50 kg ha^{-1}) and zinc (0 and 5 kg ha^{-1}). Healthy and uniform bulbs of tulip cv. 'Apeldoorn' with 10 to 12 cm circumference were planted in beds of 0.54 m^2 size each year on 30th October as per the factorial RBD concept. There were two replications and eight representative plants constituted one replication unit. Growth media containing soil + Dal weed + sand in the ratio of 2:1:1 at pH 6.8 was used for growing the plants. Uniform cultural practices were followed throughout the experimentation. Observations were recorded on bulb survival (effective sprouting), stem thickness, wrapper leaf (lower most leaf) area, days to flower (days after planting), scape length, tepal diameter, vase life, bulb number and weight of bulblets per plant. Leaf N, P and K analysis was done as per the method of Jackson (1973). Data were statistically analyzed as per procedure given by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Different nutrients and their levels had significant effect on all the parameters studied (Table 1). Bulb survival was not affected by any individual treatment of nutrients during the first year (2002-03) of experimentation. However, it was found to be significantly influenced by increased doses of nitrogen and phosphorus during the second year (2003-04) of experimentation. The reason for the non-significant effect of nutrients on bulb survival may be absence of adequate root system at the initial stage of growth to absorb applied nutrients from soil. Non-significant effect of nutrient application on bulb survival has earlier been reported by Kumar and Singh (1998) in tuberose.

Stem thickness was found to be significantly influenced by addition of different levels of nitrogen, phosphorus, potassium and zinc in both the years. Similarly, wrapper leaf area also differed markedly with these nutrient treatments, except with zinc during the first year of experiment. Similar results on vegetative growth with nitrogen have also been reported by Rani *et al* (2005) in *Lilium*. Increased plant growth with nitrogen application

Table 2. Interaction effect of various nutrients on growth, flower quality and bulb production in tulip

Treatment (kg ha^{-1})	Wrapper leaf area (cm^2)		Days to flowering (DAP)		Scape length (cm)		Vase life (days)		No. of bulbs/plant		Bulblet weight/plant (g)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
$N_0 P_0 K_0 Z_0$	123.26	129.36	126.83	123.38	34.63	31.64	6.08	6.12	0.88	1.00	3.80	4.25
$N_0 P_0 K_0 Z_5$	121.27	130.50	124.08	121.50	35.00	34.23	6.17	6.25	0.82	1.00	3.75	4.20
$N_0 P_0 K_{50} Z_0$	127.46	131.15	123.00	120.50	37.50	34.68	6.83	6.75	0.76	0.95	4.37	4.45
$N_0 P_0 K_{50} Z_5$	126.95	132.58	125.58	122.00	36.50	33.22	6.83	6.62	0.76	0.92	4.62	6.30
$N_0 P_{50} K_0 Z_0$	128.85	130.35	124.00	121.25	33.88	30.66	6.58	6.50	0.88	1.00	4.62	4.75
$N_0 P_{50} K_0 Z_5$	128.18	131.56	125.50	122.25	36.63	36.45	6.08	6.12	1.08	1.17	6.37	6.55
$N_0 P_{50} K_{50} Z_0$	126.85	133.50	124.58	119.50	35.75	35.75	7.08	7.12	0.88	1.05	5.87	6.01
$N_0 P_{50} K_{50} Z_5$	123.76	134.00	123.58	118.00	38.50	37.46	7.33	7.25	1.01	1.18	6.50	6.60
$N_{75} P_0 K_0 Z_0$	130.24	135.00	134.17	120.50	35.00	36.21	6.58	7.12	0.88	1.00	6.37	6.50
$N_{75} P_0 K_0 Z_5$	132.11	137.20	130.00	126.50	36.25	35.83	6.67	6.75	0.94	1.11	6.37	6.52
$N_{75} P_0 K_{50} Z_0$	136.48	136.30	124.17	121.75	37.50	37.11	6.83	6.50	0.94	1.11	6.25	6.45
$N_{75} P_0 K_{50} Z_5$	131.17	142.15	126.08	124.50	37.50	37.96	6.92	7.00	0.94	1.09	6.62	6.75
$N_{75} P_{50} K_0 Z_0$	137.20	141.65	131.83	128.00	38.50	39.46	6.75	7.25	1.07	1.28	7.12	7.25
$N_{75} P_{50} K_0 Z_5$	141.59	143.95	129.75	125.25	39.25	42.35	6.75	7.25	1.07	1.25	7.87	7.78
$N_{75} P_{50} K_{50} Z_0$	136.98	143.50	121.42	120.50	40.00	41.69	7.92	8.00	1.13	1.31	7.37	7.48
$N_{75} P_{50} K_{50} Z_5$	139.83	146.35	121.00	119.50	44.25	43.48	8.17	8.25	1.19	1.37	8.12	7.75
$N_{150} P_0 K_0 Z_0$	130.40	131.95	132.50	129.00	37.00	39.23	6.00	7.50	0.94	1.10	7.12	7.05
$N_{150} P_0 K_0 Z_5$	127.46	135.80	128.00	125.25	36.63	37.14	6.25	6.25	0.88	1.06	6.87	7.25
$N_{150} P_0 K_{50} Z_0$	135.65	141.25	126.25	125.00	37.50	38.50	6.92	6.50	0.88	1.05	5.62	7.20
$N_{150} P_0 K_{50} Z_5$	134.84	142.36	125.50	122.75	42.88	41.89	7.00	6.50	1.01	1.18	6.12	7.55
$N_{150} P_{50} K_0 Z_0$	137.63	144.00	129.42	125.25	38.50	40.46	6.67	6.75	1.07	1.30	6.87	7.20
$N_{150} P_{50} K_0 Z_5$	138.22	147.32	125.25	121.75	42.88	42.88	6.67	7.25	0.94	1.17	6.25	7.50
$N_{150} P_{50} K_{50} Z_0$	137.93	144.60	124.40	120.50	41.50	44.13	7.25	7.62	1.07	1.16	6.75	7.50
$N_{150} P_{50} K_{50} Z_5$	137.11	153.50	122.50	120.25	44.00	45.13	7.33	7.75	1.13	1.33	6.87	7.95
C.D *(P=0.05)*	NS	2.43	NS	1.91	1.51	0.54	NS	0.58	0.03	NS	0.07	0.88

NS: Not significant

may be attributed to this nutrient's role in protein synthesis. It is also an important part of chlorophylls, which are involved in photosynthesis, and thus, in promoting plant growth. Phosphorus is also an important constituent of many essential compounds, and, is involved in various physiological processes including cell division, development of meristematic tissues, in photosynthesis, respiration, etc. (Marschner, 1986). Phosphorus also promotes root growth which, in turn, facilitates uptake of other nutrients and results in improved growth. Growth accelerating effects of potassium may be attributed to its role as an activator of many enzymes and a major contributor of plant osmotic relationship, essential for stomatal movement and cellular growth (Salisbury and Ross, 1986). Beneficial effects of zinc on physiological activities might be the reason for improved plant growth. It is an essential part of tryptophan, and thus, biosynthesis of auxin which is known to promote cell elongation and root initiation. Zinc is also an important constituent of several vital enzymes that play a significant role in carbohydrate synthesis (Marschner, 1986). Zinc also plays an important role in the uptake of phosphorus and calcium and in the availability of nitrogen (Shear, 1984).

Application of nitrogen caused significant increase in days taken to flower, whereas phosphorus, potassium and zinc resulted in significant decrease in days taken to flowering compared to the control in both the years. This finding is in accordance with the observation of earlier workers (Sharma and Singh, 2001; Rani *et al*, 2005). Higher doses of nitrogen may have caused excessive vegetative growth adversely affecting days taken to flower. In many species, days to flowering has been found to be closely associated with nitrogen and phosphorus, as excess nitrogen delays and abundant phosphorus hastens it. Contribution of potassium and zinc in reducing days to may be due to faster growth of the plant with application of these nutrients and early completion of the vegetative phase (Khan, 2000; Talukdar *et al*, 2003).

Scape length is an important quality parameter in maintaining the post harvest life of cut flowers, whereas, flower diameter is a parameter that influences aesthetic appeal in a quality conscious world. Application of different nutrients to soil individually exerted significant effects on both scape length and tepal diameter in both the years of experiment. Possible reasons for these effects might be better nutrient uptake facilitated by phosphorus and zinc and higher assimilation of food reserves through an enhanced assimilatory surface. Scape length and flower size have also been found to be positively correlated with nitrogen dose in tuberose (Kumar and Singh, 1998). Kumar and Arora (2000) reported higher spike length in gladiolus with zinc application.

Table 3. **Effect of N, P, K and Zn interactions on leaf N, P and K content in tulip under polyhouse conditions**

Treatment (kg ha^{-1})	Nutrient concentration (%)					
	Nitrogen		Phosphorus		Potassium	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
$N_0 P_0 K_0 Z_0$	3.18	3.19	0.160	0.190	3.60	2.60
$N_0 P_0 K_0 Z_5$	3.09	3.12	0.180	0.200	3.50	2.65
$N_0 P_0 K_{50} Z_0$	3.50	3.55	0.190	0.210	3.50	2.70
$N_0 P_0 K_{50} Z_5$	3.53	3.60	0.170	0.200	3.50	2.70
$N_0 P_{50} K_0 Z_0$	3.65	3.68	0.220	0.250	3.60	2.90
$N_0 P_{50} K_0 Z_5$	3.89	3.92	0.210	0.270	3.80	3.00
$N_0 P_{50} K_{50} Z_0$	3.65	3.71	0.250	0.250	4.10	3.20
$N_0 P_{50} K_{50} Z_5$	3.77	3.74	0.250	0.280	4.20	3.30
$N_{75} P_0 K_0 Z_0$	4.06	4.10	0.220	0.260	3.80	3.00
$N_{75} P_0 K_0 Z_5$	4.37	4.39	0.230	0.290	3.60	3.20
$N_{75} P_0 K_{50} Z_0$	4.09	4.11	0.196	0.210	3.90	3.30
$N_{75} P_0 K_{50} Z_5$	4.69	4.70	0.240	0.290	3.90	3.25
$N_{75} P_{50} K_0 Z_0$	4.97	4.99	0.253	0.280	3.50	3.10
$N_{75} P_{50} K_0 Z_5$	5.07	5.09	0.297	0.310	3.60	3.11
$N_{75} P_{50} K_{50} Z_0$	4.49	4.50	0.270	0.300	4.00	3.30
$N_{75} P_{50} K_{50} Z_5$	5.06	5.10	0.290	0.320	4.40	3.40
$N_{150} P_0 K_0 Z_0$	4.07	4.10	0.210	0.270	3.70	3.20
$N_{150} P_0 K_0 Z_5$	4.30	4.35	0.190	0.200	3.80	3.25
$N_{150} P_0 K_{50} Z_0$	4.86	4.90	0.187	0.220	3.70	3.15
$N_{150} P_0 K_{50} Z_5$	4.95	4.97	0.230	0.280	4.07	3.30
$N_{150} P_{50} K_0 Z_0$	4.90	4.95	0.197	0.260	3.80	3.20
$N_{150} P_{50} K_0 Z_5$	4.33	5.38	0.330	0.350	4.00	3.30
$N_{150} P_{50} K_{50} Z_0$	5.05	5.10	0.287	0.330	4.30	3.45
$N_{150} P_{50} K_{50} Z_5$	5.24	5.21	0.310	0.340	4.80	3.60
C.D *(P=0.05)*	NS	0.35	0.05	NS	NS	NS

NS : Not significant

Addition of nitrogen, phosphorus and potassium caused significant increase in vase life in cut tulip in distilled water but zinc was unable to increase vase life in both the years of experiment. Increase in vase life due to nutrient treatment may be attributed to a healthy scape and leaves which may have more food reserves to be utilized during the vase period when the natural source of food is cut off from the plant consequent to harvest. A healthy scape may also facilitate better water uptake essential for maintaining turgor, and thus, freshness of cut flowers. High potassium level in the tissue may also have contributed directly to maintaining turgor and thus resulted in increased vase life.

Like growth and flowering, bulb production attributes were also influenced markedly by application of various nutrients. The number of bulbs per plant was significantly influenced by all the nutrients during the first

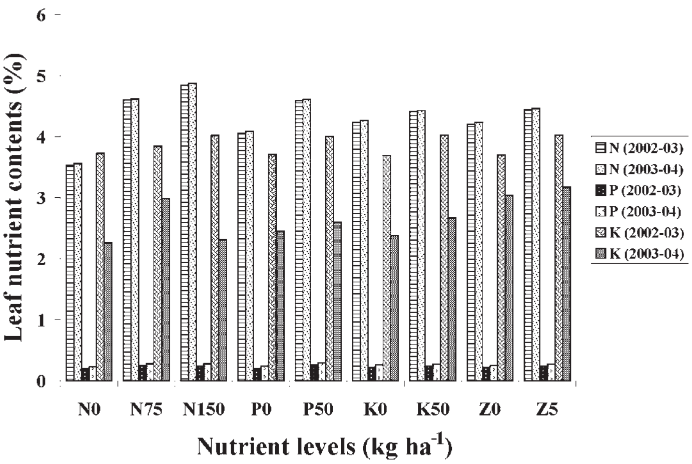

Fig 1. Effect of N, P, K and Zn application on leaf nutrient content in tulip

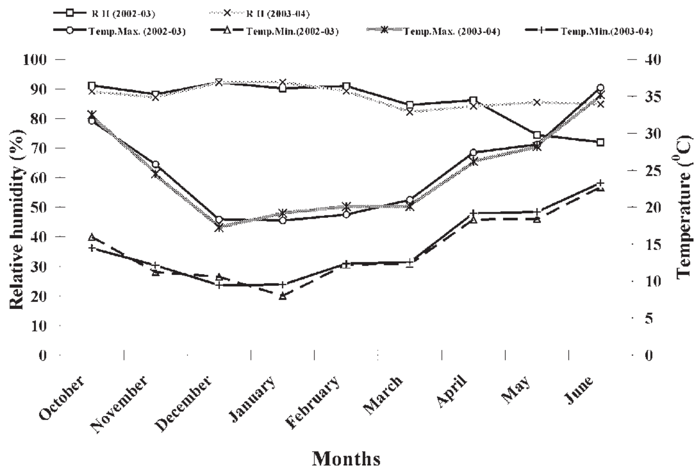

Fig 2. Month-wise relative humidity and temperature under polyhouse conditions

year while, during the second year, although nitrogen and phosphorus showed significant effects, potassium and zinc did not. All the nutrients had significant influence on the weight of bulblets per plant. Application of nitrogen and zinc has also been found to increase bulb production in tuberose (Kumar and Singh, 1998) and dahlia (Khan, 2000), respectively. A marked increase in both the number of bulbs and bulblet weight per plant may be attributed to better availability of phosphorus, which is required in particularly for bulb growth. Reduced bulb growth may be due to a limitation of source because most of the photosynthates tend to mobilize first towards the major sink i.e., flower. Therefore, an increased assimilatory power might have resulted in greater supply of photosynthates to the bulb, thus, increasing its production.

Combined application of nutrients did not show any marked impact on bulb survival per cent in both the years (Table 2). Interaction treatments also failed to exert any significant effect on stem thickness trials in both the years, while wrapper leaf area was significantly influenced during the 2nd year. Maximum wrapper leaf area (153.50 cm^2) was recorded with $N_{150}P_{50}K_{50}Z_5$ followed by $N_{150}P_{50}K_0Z_5$, while, minimum was observed in $N_0P_0K_0Z_0$ (129.36 cm^2). Like wrapper leaf area, days taken to flowering also showed significant influence when nutrients were applied in combination, but only during the 2nd year of trial. The minimum days taken to flower was 118.0 days in treatment $N_0P_{50}K_{50}Z_5$ followed by $N_{75}P_{50}K_{50}Z_5$ against the maximum (129.0) number of days in $N_{150}P_0K_0Z_0$. Combined treatments of nutrients also altered the scape length significantly in both the years but did not exert any marked influence on tepal diameter. Maximum scape length was recorded in $N_{75}P_{50}K_{50}Z_5$ (44.25 cm) and $N_{150}P_{50}K_{50}Z_5$ (45.13 cm), whereas, the minimum scape length was seen with $N_0P_{50}K_0Z_0$ (33.88 cm and 30.66 cm) in first and second year, respectively. Interaction effects of these nutrients on vase life were non-significant during the first year, whereas, there it differed significantly during the subsequent year with maximum in $N_{75}P_{50}K_{50}Z_5$ (8.25 days) followed by $N_{75}P_{50}K_{50}Z_0$ (8.00 days) and minimum in $N_0P_0K_0Z_0$ (6.12 days). Combination of different nutrient treatments affected the number of bulbs per plant during the first year of trial but did not show any marked variation in the subsequent year. Treatment $N_{75}P_{50}K_{50}Z_5$ recorded the highest number of bulbs per plant, (1.19) followed by $N_{75}P_{50}K_{50}Z_0$, while, it was minimum (0.88) in $N_0P_0K_0Z_0$. However, both years of experiment recorded a significant increase in bulblet weight per plant due to combined effects of nutrients. The maximum bulblet weight per plant observed was 8.12 g ($N_{75}P_{50}K_{50}Z_5$) and 7.95 g ($N_{150}P_{50}K_{50}Z_5$), and, of 3.75 g and 4.20 g ($N_0P_0K_0Z_5$) during the first and second year of experiment, respectively.

Nutrient analysis in leaf (Fig 1) revealed that addition of nitrogen to soil significantly increased leaf nitrogen content in both the years of experiment. However, significant increase in phosphorus in the first year and potassium level during the second year was observed. Addition of phosphorus resulted in a marked increase in leaf nitrogen, phosphorus and potassium content which indicated that phosphorus was helpful in increasing uptake of other nutrients from the soil. Phosphorus promotes root growth, which in turn, facilitates improved uptake of other nutrients (Marschner, 1986). Potassium application to the soil also increased leaf nitrogen content significantly during the first year of trial whereas increase in leaf nitrogen due to potassium application in the subsequent year was not significant. Increase in leaf potassium content due to application of potassium in the soil is obvious because of greater availability and uptake. Combined application of nutrients exerted significant variation in leaf nitrogen and phosphorus content during the 2nd and 1st year, respectively, whereas potassium content of leaf remained unaffected (Table 3).

Slight variations in the results of both years' study may be attributed to the differences in relative humidity and temperatures during the growing periods of crops in both years (Fig 2).

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