Indian J. Hort. 68(1), March 2011: 39-43

Nutritional studies on strawberry under polyhouse

M. Feza Ahmad*, Ishtiyaq Ahmad Khan and Nawsheeba Wani
Quality Control cum Leaf Tissue Testing Laboratory, Division of Pomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar 191 121 (J&K)

ABSTRACT

An experiment comprising of four levels of nitrogen (0,100,150 and 200 kg ha^{-1}), three levels of potassium (0, 75 and 150 kg ha^{-1}) applied as T_1 (full dose one week after transplanting) and T_2 (1/2 dose one week after transplanting and remaining half at the time of fruit set) was conducted following RBD factorial design. Maximum plant height (24.19 cm), plant spread (659.04 cm^2) and number of fruits plant^{-1} (13.72) was observed when full dose of fertilizers was applied one week after transplanting, while the highest fruit weight (7.39 g) was obtained when fertilizer was applied in split doses. However, the time of fertilizer application did not show any significant effect on fruit yield plant^{-1} and quality characters of strawberry. The maximum plant height (27.25 cm), number of fruits/plant (14.79), fruit weight (8.11 g) and fruits/plant (120.09 g) was observed with 150 kg ha^{-1} N application. While the highest plant (23.70 cm), number of fruits/plant (13.93), fruit weight (7.58 g) and fruit yield/plant (106.68 g) was recorded with 150 kg ha^{-1} application of potassium. Both N and K applied each at 150 kg ha^{-1} significantly improved all qualitative attributes in strawberry fruit. An increase in the level of nitrogen and potassium increased the total leaf nitrogen and potassium nutrient content. Micronutrient content (Mn, Zn, Fe, and Cu) in leaves increased significantly with N application. However, potassium and time of fertilizer application did not show any significant impact on micronutrient contents.

Key words: Strawberry, growth, yield, leaf nutrient content.

INTRODUCTION

Strawberry (*Fragaria* × *ananasa* Dutch.) has been grown commercially in several parts of the world for many years but in India it was introduced in the early 1960s (Sharma and Sharma,18) and it has now acclimatized well in the various parts of India particularly in Maharashtra, Karnataka, Madhya Pradesh and some pockets of north India. This is essentially a temperate fruit crop hence its expansion in the Kashmir valley is gaining popularity owing to the fact that strawberry is commonly grown as an intercrop in the initial years of apple and pear orchards for utilization of space and light in order to get maximum remuneration per unit area (Ahmad, 2). There is a need to give special attention which forces to seek and employ more efficient production technique by devising a precise package of practices for this crop with special reference to fertilizer management. Studies on strawberry have shown the diversity of responses to changing N rates and time of application (Santos and Chandler, 17). Positive yield response to increasing rate of N up to about 150 kg /ha have been reported by Keefer *et al.* (12). Application of potassium has been reported to increase yield but higher rate can be deleterious by inducement of magnesium and calcium deficiencies (Guttredge *et al.*, 8). In India, meagre information is available on nutrient management of strawberry. Factors like soil fertility, irrigation practices, climatic conditions and cultivars used are influenced by the doses of fertilizer for specific regions. However, Joolka *et al.* (11) standardized nitrogen and phosphorous doses for Tioga strawberry under Solan conditions. Therefore, there is a need that optimum fertilizer doses with respect to strawberry be worked out for ensuring higher productivity with optimal input use efficiency for Kashmir valley.

MATERIALS AND METHODS

The investigation was carried out in the Division of Pomology, SKUAST-K, Shalimar for two seasons under polyhouse conditions. Earthen pots (30 cm dia) of 5 kg capacity containing well decomposed FYM and soil (4:6). Initial nutrient status of the pot mixture revealed that the soil was slightly acidic in pH (6.0), medium in organic carbon (0.6%), available N (244.0 kg ha^{-1}), K (155 kg ha^{-1}) and low in phosphorous (9.23 kg ha^{-1}), while the micronutrient status with regards to Fe, Zn, Mn and Cu were of 55.0, 10.25, 5.75 and 1.75 ppm respectively. One healthy and sound runner of strawberry cv. Confitura having 2-3 full (compound) open leaves was transplanted in the each experimental pot during the second week of October and pots were placed under polyhouse during first fortnight of November. The treatments consisted of four nitrogen levels (0, 100, 150 and 200 kg ha^{-1}) and three levels of potassium (0, 75 and 150 kg ha^{-1}) applied in the form of

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

urea and muriate of potash, respectively as as T_1 = Full dose after one week of transplanting and T_2 = half-dose one week after transplanting and remaining half-dose at the time of fruit set, morphological characters *viz*., number of leaves per plant, plant height and plant spread were recorded as per the procedure. For estimation of fruit physico-chemical characteristics, ten stalks per replication was tagged at the time of fruit set and same fruits were collected at the time of commercial maturity (80-90% colour development) Parameters studied were number of fruits per plant, fruit length, width and fruit weight. Total soluble solids (TSS) were determined from freshly strained and thoroughly stirred juice using hand refractometer. Total sugars, total acidity and vitamin C were estimated by standard methods (AOAC, 1). Organoleptic ratings of fruits were determined by a panel of judges using 1-5 point scale. Fruits scoring 5 points were rated as excellent and those with 4, 3, 2 and 1 rated as very good, good, fair and poor in quality, respectively. Leaf samples were collected for leaf analysis as per the procedure outlined by Chapman (6). For macro- and micro-nutrient estimation, well ground leaf tissue was digested in di-acid mixture containing HNO_3 and $HClO_4$ (9: 4) for phosphorus, potassium and micro-nutrients (Jackson, 10). The phosphorous content was determined by using ammonium molybdate / ammonium metavanadate (Chapman and Pratt, 5) using double beam UV-vis spectrophotometer (ECIL, Hyderabad), while potassium was determined by using flame photometer (Jackson, 10) and micro-nutrients were estimated by using atomic absorption spectrophotometer (ECIL 4141, Hyderabad).

The experiment was laid out in randomized block design (factorial) with four replications and the data recorded were statistically analyzed as suggested by Gomez and Gomez (7) applying the least significant differences (LSD) at 5% for comparison among the treatment means.

RESULTS AND DISCUSSION

Data presented in Table 1 revealed that time of nitrogen and potassium application on vegetative growth parameters like plant height and spread significantly increased when nitrogen and potassium were applied as full dose during fall season (T_1) while the number of leaves/plant did not show any significant difference irrespective of fall and spring application of nitrogen and potassium. This might be due to the continuous growth of strawberry plants under the polyhouse during the initial growth stage and very less period was available for vegetative growth when fertilizer was applied in spring. The most important factors for not responding to spring fertilization might be due to low soil temperature in the spring that reduce nitrate uptake or it may be because of the fact that high concentrations of remobilized and cycling amino acids in the roots and / or a lack of necessary carbon skeletons for amino acid synthesis suppress nitrogen uptake (Strik *et al*., 19). However, the yield attributing characters like number of fruits/plant and fruit weight were significantly influenced by the fall and spring application. The maximum number of fruits/ plant (13.72) were recorded with T_1 as compared to T_2 (13.31). Similar results were also noticed by Quezada *et al.* (15) who have reported that the single fertilizer application was more beneficial for marketable fruit yield. However, the maximum fruit weight (7.39 g) was obtained when fertilizers were applied in split (T_2) than that of full dose of N and K applied just after transplanting (T_1). Time of fertilizer application did not influence the marketable yield/plant (Table 1), quality characters of fruits and consumers acceptability as in accordance with finding supported by Miner *et al.* (14).

Nitrogen @150 kg ha^{-1} gave significantly better results with regards to vegetative growth, yield and quality attributes over the control. Maximum number of leaves/plant (9.83), plant height (27.25) and plant spread (759.12 cm^2) were recorded with increased level of nitrogen up to 150 kg ha^{-1}. Further an addition of nitrogen significantly depressed morphological characters where number of leaves/plant (9.20), plant height (25.95) and plant spread (731.67 cm^2) were significantly reduced. Increasing rate of nitrogen enhanced the concentration of leaf aluminum and manganese, which caused deleterious effect on vegetative growth (Haynes and Goh, 9). Maximum number of fruits/plant (14.79) were recorded with 150 kg ha^{-1} N as compared to 75 kg N ha^{-1} (13.41) and 200 kg N ha^{-1} (14.00), recording an increase by 62 and 26% over the control and 75 kg N kg ha^{-1} respectively. Similar dose of nitrogen was also beneficial for increasing fruit weight by 30 and 14.54% over the control (Table 1) and nitrogen applied @ 75 kg ha^{-1} respectively. While nitrogen applied at the rate of 200 kg ha^{-1} had adverse effect on the number of fruits/ plant (14.00) as well as individual fruit weight (7.85 g). Yield/plant remained highest (120.09 g) with nitrogen applied @ 150 kg ha^{-1}. These results are in conformity with the findings of Joolka *et al.* (11) who observed an increase in the yield of strawberry with increasing dose of nitrogen up to 150 kg ha^{-1}. Highest TSS (8.93^{0}B), TSS: acid ratio (13.28) and total sugars (7.48%) were observed with N applied @150 kg ha^{-1}.However, acidity decreased significantly with increasing in dose of nitrogen. Maximum acidity (0.93%) was recorded in control as compared to nitrogen application. Data further revealed that the fruit acidity decreased with the dose of nitrogen increased. The fruit acidity at 100 kg

Table 1. Effect of nitrogen, potassium and their application time on vegetative, yield and qualitative attributes of strawberry.

Treatment	Vegetative growth attributes			Yield attributes			Qualitative attributes				
	No. of leaves	Plant height (cm)	Plant spread (cm^2)	No. of fruits/ plant	Fruit weight (g)	Yield/plant (g)	TSS (^0B)	Acidity (%)	TSS/acid ratio	Total sugars (%)	Organoleptic rating (1-5 scale)
Time of application											
T_1	8.68	24.19	659.04	13.72	7.25	100.40	8.5	0.77	11.33	7.20	3.32
T_2	8.43	23.41	641.79	13.31	7.39	99.33	8.49	0.76	11.37	7.19	3.34
$LSD_{0.05}$	NS	0.51	8.27	0.21	0.02	NS	NS	NS	NS	NS	NS
Nitrogen											
N_0	7.04	18.56	488.67	11.87	6.24	74.24	2.30	0.93	8.53	6.83	2.70
N_{100}kg/ha	8.16	23.44	622.44	13.41	7.08	95.11	8.45	0.81	10.32	7.19	3.15
N_{150}kg/ha	9.83	27.25	759.12	14.79	8.11	120.09	8.93	0.67	13.28	7.48	3.96
N_{200}kg/ha	9.20	25.95	731.67	14.00	7.85	110.02	8.65	0.66	13.27	7.28	3.53
$LSD_{0.05}$	0.46	0.73	11.70	0.29	0.02	0.23	0.024	0.007	0.170	0.016	0.086
Potash											
K_0 kg/ha	8.12	23.94	595.50	13.12	7.07	93.52	8.38	0.75	7.08	11.38	3.20
K_{75}kg/ha	8.72	23.69	637.31	13.50	7.30	99.39	8.50	0.76	7.20	11.45	3.34
K_{150}kg/ha	8.78	23.70	724.44	13.93	7.58	106.68	8.63	0.79	7.30	11.23	3.46
$LSD_{0.05}$	0.40	NS	10.13	0.25	0.02	1.93	0.021	0.005	0.014	0.14	0.07

N/ha was 0.81% which decreased to 0.67 and 0.66% at 150 and 200 Kg N / ha application respectively which indicates that the nitrogen application improved quality by increasing the TSS: acid ratio. Our findings are in close conformity with the findings of Martin del Molino and Roson (16). No significant difference in TSS: acid ratio was observed between 150 and 200 kg ha^{-1} N application while as organoleptic rating was better in fruits obtained with 150 kg ha^{-1} N (3.96 rating) than those from 200 kg N ha^{-1} (3.53).

Increasing potassium rate up to 150 kg ha^{-1} indicated a positive response of K on vegetative growth. Maximum number of leaves and plant spread were recorded with 150 kg ha^{-1} K application. Further, it is evident from the data that the various doses of potassium did influence all yield attributing characteristics. The maximum number of fruits/plant, fruit length, and fruit width were recorded with highest dose of K application (150 kg ha^{-1}). Fruit weight and yield/plant were also increased with the enhanced potassium upto 150 kg ha^{-1} K as conformed with the findings of Albregts *et al.* (3) where in total fruit yield linearly related with rate of potassium upto 170 kg/ha. Potassium application also had significant influence on the quality attribute of strawberry TSS (8.62^{0}B) and total sugars (7.30%) recorded with potassium application @ 150 kg ha^{-1}. The quality component most affected by the potassium application is the titrable acidity of the fruit which increased with the increased potassium concentration in the leaf. Organoleptic rating recorded indicated that the highest rating was observed with 150 kg ha^{-1} potassium application.

The time of nitrogen and potassium application had a significant influence on leaf nutrient content (Table 2) The fall and spring fertilizer application did not influence the leaf P, K and micro-nutrients content (Zn, Cu, Mn and Fe). Leaf N content in strawberry increased with the increase in nitrogen dose and maximum leaf N content (2.45%) was observed with 200 kg/ha N application as reported by (Roson and Martin del Molino (16), whereas the graded dose of nitrogen did not alter the leaf P and K content but significantly influenced the micronutrient content in strawberry leaves in contrary to this no effect of nitrogen application on leaf K was observed as reported by Haynes and Goh (9). Zinc content in strawberry leaf varied from 17.79 to 36.75 ppm and maximum concentration was found with the higher dose of nitrogen (200 kg N ha^{-1}). While the maximum leaf Mn, Cu and Fe was obtained with 150 kg ha^{-1} N followed by 200 kg ha^{-1} N application and minimum in control. The finding of Haynes and Goh (9), and Koszanski *et al.* (13) supports our results. Application of the various doses of potassium had no significant effect on leaf levels of P, Zn, Cu, Fe and Mn content though they were in the sufficient range. However potassium application significantly increased leaf N and K content (Table 2). Bojic *et al.* (4) also did not observe significant effect on leaf micro-elements with the application of P and K. Leaf K content increased with increasing the dose of potassium and highest leaf K (1.25%) was obtained with 150 kg ha^{-1} K than that of control (0.85%). Roson and Martin del Molino (16) reported that increasing K doses increased the leaf potassium content. Time of

Table 2. Effect of nitrogen, potassium and their application time on macro- and micro-nutrient contents in strawberry.

Treatment	Macro-nutrient (%)			Micro-nutrient (ppm)			
	N	P	K	Zn	Cu	Fe	Mn
Time of application							
T_1	2.25	0.22	1.04	26.45	6.12	126.19	40.66
T_2	2.22	0.22	1.03	26.50	6.00	126.60	41.27
$LSD_{0.05}$	0.01	NS	NS	NS	NS	NS	NS
Nitrogen							
N_0	1.89	0.21	1.04	17.79	22.83	2.62	73.75
N_{100} kg/ha	2.20	0.22	1.04	24.87	37.62	6.25	124.37
N_{150} kg/ha	2.40	0.22	1.02	36.50	55.58	7.70	152.75
N_{200} kg/ha	2.45	0.21	1.04	36.75	57.83	7.66	154.71
$LSD_{0.05}$	0.025	NS	NS	0.97	1.13	0.47	1.01
Potash							
K_0 kg/ha	2.25	0.22	0.85	26.68	5.96	126.53	41.18
K_{75}kg/ha	2.24	0.22	1.01	26.12	6.06	126.69	40.81
K_{150}kg/ha	2.21	0.21	1.25	26.62	6.15	125.97	40.90
$LSD_{0.05}$	0.02	NS	0.015	NS	NS	NS	NS

fertilizer application also had no effect on macro and micronutrient content except leaf N, which may be because of the fact that application of nitrogen just after planting had positive effect on the vegetative growth and development during initial period of growth leading to higher nitrogen content in leaf. Thus, it is concluded that the application of nitrogen and potassium @ 150 kg ha^{-1} is very effective for enhancing strawberry yield, fruit quality and consumers acceptability.

REFERENCES

1. A.O.A.C. 1998. *Official Methods of Analysis*. Association of Official Analytical Chemists, Washington, D.C.
2. Ahmad, M.F. 2009. Effect of planting density on growth and yield of strawberry. *Indian J. Hort.* **66:** 132-34.
3. Albregts, E.E., Howard, C.M. and Chandler, C.K. 1991. Effect of high N rates on fruiting strawberry. *Proc. Soil Crop Sci. Soc. Fla.* **50**: 1134-36.
4. Bojic, M., Jankovic, R., Stanojevic, V. and Rakicevic, M. 1999. Effect of different rate of P and K fertilizers on microelement contents in the leaves of strawberry cv. Senga Sengana. *Jugoslovensko Vocarstvo*, **33**: 35-41.
5. Chapman, H.D. and Pratt, P.F. 1961. *Method of Analysis for Soil, Plant and Water*. Division of Agricultural Sciences, University of California, Berkley, USA, 61 p.
6. Chapman, H.D. 1964. Suggested foliar sampling and handling techniques for better determining the nutrient status of field and horticultural and plantation crops. *Indian J. Hort.* **21**: 77-119.
7. Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* (2nd Edn.), John Wiley and Sons Inc., New York.
8. Guttridge, C.G., Hughes, R.F., Stinchcombe, G.R. and George, W.W. 1978. Nutrient effects on tipburn of strawberry. *Expl. Hort*. **30**: 36-41.
9. Haynes, R.J. and Goh, K.M. 1987. Effect of nitrogen and potassium application on strawberry growth, yield and quality. *Comm. Soil Sci. Plant Anal.* **18**: 457-71.
10. Jackon, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd; N. Delhi, pp. 32.
11. Joolka, N.K., Badiyala, S.D. and Lakhanpal, S.C. 1986. Effect of N and P doses on the yield and quality of strawberry. **In**: *Advances in Research on Temperate Fruits.* T.R. Chadha, V.P, Bhutani and G.L. Kaul (Eds.). Dr Y.S. Parmar University of Hort. & Forestry, Solan, H.P.
12. Keefer, R.F., Hickman, C.E. and Adams, R.E. 1978. The response of strawberry yields to fumigation and nitrogen fertilization. *HortSci*. **13**: 52-52
13. Koszanski, Z. and Rumasz-Rudnicka, E. 2008. Reaction of raspberry on varied nitrogen fertilization and drip irrigation. *Inzynieria Roinicza,* **4**: 415-22.
14. Miner, G.S., Poling, E.B., Carroll, D.E. and Nelson, L.A. 1997. Influence of fall nitrogen and spring nitrogen-potassium application on yield and quality of "Chandler" strawberry. *J. Amer. Soc. Hort. Sci.* **122**: 290-95.
15. Quezada, C., Celerino, I. and Lemus, L. 2007. Effect of nitrogen fertilization on yield and quality of raspberries (*Rubus idaeus* L.) under two fertigation programs. *Revista de Ciencia del Suelo y Nutricion Vegetal*. **7**: 1-15.
16. Roson, R.J.A and Martin del-Molino, I.M. 1980. Influence of N and K on strawberry plants in sand culture. I. Effect on mineral composition. *Anales-de-edafologia-y-Agrobiol.* **38**: 1743-56.
17. Santos, B.M. and Chandler, C.K. 2009. Influence of nitrogen fertilization rates on the performance of strawberry cultivars. *Int. J. Fruit Sci.* **9**: 126-35.
18. Sharma, V.P. and Sharma, R.R. 2004. *The Strawberry*. ICAR, New Delhi.
19. Strik, B., Ighetti, T. and Buller, G. 2004. Influence of date, timing and method of nitrogen fertilizer application on uptake and use of fertilizer nitrogen, growth and yield of June bearing strawberry. *J. Amer. Soc. Hort. Sci.* **129**: 165-74.

Received: March, 2010; Revised: December 2010;
Accepted : January, 2011