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Effect of nitrogen, phosphorus and potassium on leaf nutrient status of high density apple cv. Silver Spur under temperate conditions of Kashmir

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Abstract
To study the effect of nutrients (N, P and K) on leaf nutrient status and their correlation with fruit quality and yield an experiment was conducted during the year 2015-2016 at the experimental field of Division of fruit Science Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar. The experimental site was located at 34.01^0 North latitude and 74.5^0 East longitude at an elevation of 1606 meters above mean sea level. The climate of experimental site was temperate type. The maximum temperature of the valley was 24.5^0 C and humidity of 43.9^0 C during the summer months. 30-40 healthy leaves free from insect damage, diseases and deficiency symptoms were collected at commercial harvesting stage during 2015 from mid portions of current season's shoots at chest height randomly from the four quadrants of plant as per the procedure given by Chapman (1964). The samples after processing and proper digestion were analyzed for different nutrients viz. N, P, K, Ca, Mg, S, Zn, Cu, Mn and Fe and the correlation between leaf nutrients and fruit quality and yield were determined. The experiment consisted of 10 treatments of different levels nitrogen, phosphorus and potassium. Results revealed that highest leaf nitrogen (2.19%) was recorded in T_4 treatment with 105 g N, 35 g P_2O_5 and 150 g K_2O. The highest leaf phosphorus (0.19%) was recorded in T_7 treatment with 85g N, 45g P_2O_5 and 150g K_2O. Highest leaf potassium (1.62%) in T_{10} treatment with 85g N, 35g P_2O_5 and 180g K_2O. Results indicated that treatments had non-significant effect on leaf calcium, magnesium and sulphur. However, the highest leaf calcium (1.76%) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O ; highest leaf magnesium (0.38%) was recorded with 105g N, 35g P_2O_5, 150g K_2O (T_4 treatment) and highest leaf sulphur (0.40%) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O. Maximum leaf zinc (31.3 mg kg^{-1}) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O. Leaf copper content differed significantly among all the treatments. Highest leaf copper (14.60 mg kg^{-1}) was recorded with 105g N, 35g P_2O_5, 150g K_2O (T_4 treatment). Leaf manganese content differed significantly among all the treatments. Highest leaf manganese (78.8 mg kg^{-1}) was recorded with 105g N, 35g P_2O_5, 150g K_2O (T_4 treatment). Highest leaf iron (126.6 mg kg^{-1}) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O. The relationship of leaf nutrient content with growth, fruit quality and yield revealed that the nitrogen content in leaves was positively and significantly correlated with tree height (r=0.897), annual shoot extension growth (r=0.801), tree girth (r=0.818), fruit length (r=0.809), fruit weight (r=0.775) and fruit yield (r=0.846). The relationship between leaf phosphorus with tree height, annual shoot extension growth, tree girth, fruit length, fruit diameter, fruit weight and fruit yield was positive but non-significant. The potassium content of leaf was positive and non-significant with tree height, annual shoot extension growth, tree girth, fruit length, fruit weight and fruit yield. Leaf calcium was positively and non-significantly correlated with tree height, annual shoot extension growth, tree girth, fruit size, fruit weight and fruit yield. Leaf magnesium content was positively and significantly correlated with tree height (r=0.830), annual shoot extension growth (r=0.923), tree girth (r=0.853), fruit length (r=0.835), fruit weight (r=0.810) and fruit yield (r=0.950). The sulphur content in leaves was positive and significantly correlated with tree height (r=0.721), annual shoot extension growth (r=0.718), tree girth (r=0.846), fruit length (r=0.692), fruit weight (r=0.865) and fruit yield (r=0.726). Leaf zinc was positively and significantly correlated with annual shoot extension growth (r=0.748), tree girth (r=0.648), fruit length (r=0.741) and fruit yield (r=0.732). The leaf copper content was positive and significantly correlated with tree height (r=0.778), annual shoot extension growth (r=0.662), fruit weight (r=0.801) and fruit yield (r=0.661). Leaf iron was positively and significantly correlated with tree height (r=0.705), annual shoot extension growth (r=0.763), trunk girth (r=0.791), fruit length (r=0.747), fruit weight (r=0.740) and fruit yield (r=0.737). The manganese content in leaves was positively and significantly correlated with trunk girth (r=0.642) and fruit diameter (r=0.707).

Keywords: Silver Spur, phosphorus and potassium

Introduction
Apple is an important temperate fruit which is grown widely in the state of Jammu and Kashmir

and is prominent in Kashmir division due to its wide adaptability to temperate conditions found in the region. Apple has a diverse climatic adaptation and most apple varieties require about 1500 hours of chilling below 7 ^{o}C to break the dormancy. Due to its chilling requirements, it grows best in relatively cooler climates than other deciduous fruits (Westwood and Chestnut, 1964) [29]. The average temperature should be around 21 to 24^{o}C during the growing period. Maximum yield and quality of crop can be achieved by nutrient management of the orchards. Nutritional elements that affect cropping consist of both major and minor elements. Major elements include nitrogen, phosphorous, potassium, calcium etc. The minor elements include boron, manganese, zinc, copper etc. Apple trees grown on seedling rootstock often tend to develop into large & vigorous trees making it difficult to manage them. Clonal rootstocks offer a viable solution to this problem, which have been used by the fruit growers in scientifically advanced countries for better management & quality fruit production. In most of the countries an increased interest is shown for planting high density and for this early developing dwarf and semi dwarf rootstocks are being used. The concept of high density orchards would definitely be an important step towards increasing the supply on existing land area to satisfy the world's increasing demand. Use of dwarf rootstock enables establishment of these close spaced orchards. Thus, the nature of plant-to-plant competition at spacing requires an analysis of the fertilizer treatments under high density conditions. Such analysis in the trend of mineral accumulations, maturity and quality, would help to resolve problems in production such as mineral-related disorders, fertilizer needs, maturity and quality of fruits and possible solution of these through the appropriate choices of rootstocks and fertilizer combinations. High density plantation refers to the accommodation of large number of trees per unit area and this type of plantation has already made a headway in our state. Therefore in order to maintain the high density orchard the present investigation was carried out in order to ensure the role of nutrients in enhancing the leaf content and their relationship with growth parameters and yield.

Materials and Methods

The investigation was conducted at the experimental field of Division of Fruit Science Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar during the year 2015. The experiment consisted of 10 treatments and 3 replications. The treatments comprised of four levels of nitrogen viz., 0, 65, 85 and 105 g N/tree and three levels of phosphorus viz., 0, 25 and 45 g P/tree and three levels of potassium viz., 0, 120 and 180 g K/tree. 30-40 healthy leaves free from insect damage, diseases and deficiency symptoms were collected at commercial harvesting stage during 2015 from mid portions of current season's shoots at chest height randomly from the four quadrants of plant as per the procedure given by Chapman (1964) [12]. After collection leaves were washed with tap water to remove dust and other unwanted material followed by dipping in dilute acid (0.1N HCl) and further washings were repeated with single and double distilled water. The samples were then air dried on filter papers and then oven dried at 60±5^{o}C for 24 hours (Chapman, 1964) [12]. The samples were further grounded in a stainless steel grinder and sieved through 1 mm sieve and stored in air tight polythene bags for chemical analysis. Nitrogen in leaf samples was determined by digesting the samples in concentrated sulphuric acid in presence of digestion mixture comprising of potassium sulphate, copper sulphate, iron sulphate and selenium powder in the ratio of 10.0 : 0.5 : 1.0 : 0.1. For the determination of phosphorus, potassium, calcium, magnesium, sulphur and micro-nutrient cations, the leaf samples were digested separately in di-acid mixture of nitric acid and perchloric acid in the ratio of 10:3. The digested material was diluted with double distilled water and filtered in 100 ml volumetric flask. In order to ensure complete transfer of digested material, about six washings were given with double distilled water and final volume was made to 100 ml for chemical analysis. After digestion the samples were analysed for various nutrients viz. Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Zinc, Copper, Iron and Manganese. The nitrogen determination was carried out by micro-kjeldahl's method as described by Jackson (1973) [20]. The phosphorus was determined by vanadomolybdo phosphoric acid yellow colour method given by Jackson (1973) [20]. The potassium was determined by flame photometric method as described by Jackson (1973) [20]. Calcium and magnesium were estimated by Versanate titration method as described by Jackson (1973) [20]. The sulphur was estimated by turbidity method given by Chesnin and Yien (1951) [13]. Zinc, copper, iron and manganese were estimated on atomic absorption spectrophotometer.

Statistical Analysis

The treatment means were compared using critical difference. The relationship between the leaf contents with growth parameters and yield was carried as per procedures outlined by Gomez and Gomez (1984) [18].

Results and Discussion

Data as shown in Table 1 indicated that highest available nitrogen (311.6 kg ha^{-1}) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O and the lowest available nitrogen (306.9 kg ha^{-1}) was recorded in T_1 treatment with 0g N, 35g P_2O_5 and 150g K_2O. The treatments showed significant effect on available N. This may be due to increase in nitrogen supply, which render more nitrogen available to the plant and due to enhanced accumulation in leaves as a result of efficient translocation under high supply from roots to other parts (Walsh *et al.*, 1989) [28]. Leaf nitrogen status significantly increased with the increasing level of soil nitrogen. The increase in leaf nitrogen in response to soil application of this element has also been reported by Badyal (1980) [3] in "Santa Rosa" plum trees. Since nitrogen is highly mobile, its efficient translocation under abundant supply from root to the tree leaves could have added to its enhanced accumulation in the leaves (Smith, 1962) [27]. Highest leaf phosphorus (0.19%) (Table 1) was recorded in T_7 treatment with 85g N, 45g P_2O_5 and 150g K_2O and 150g K_2O and the lowest leaf phosphorus (0.13%) was recorded in T_1 treatment with 0g N, 35g P_2O_5 and 150g K_2O. The treatments showed significant effect on leaf phosphorus. The increase in phosphorus may be due to increased microbial activity leading to release of more phosphorus in soil which accordingly increased phosphorus level in leaves. These results are in agreement with Aroosa (2014) [2] and Kumar and Chandel (2004) [22]. Highest leaf potassium (1.62%) (Table 1) was recorded in T_{10} treatment with 85g N, 35g P_2O_5 and 180g K_2O and the lowest leaf potassium (1.42%) was recorded in T_8 treatment with 85g N, 35g P_2O_5 and 0g K_2O. Most of the treatments were at par statistically with respect to leaf potassium. This could be due to the fact that higher levels of soil potassium application create concentration gradient between potassium ion concentration inside the root and soil solution, which ultimately resulted in increased uptake of potassium by plant (Smith, 1962) [27].

Table 1: Effect of nitrogen, phosphorus & potassium on leaf nutrient contents of high density apple cv. Silver Spur

Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1	1.87	0.13	1.45
T_2	2.06	0.14	1.43
T_3	2.15	0.16	1.45
T_4	2.19	0.16	1.59
T_5	2.09	0.15	1.43
T_6	2.06	0.17	1.4
T_7	2.03	0.19	1.44
T_8	2.02	0.14	1.42
T_9	2.08	0.15	1.56
T_{10}	2.04	0.14	1.62
C.D($P \leq 0.05$)	0.02	0.01	0.03

Highest leaf calcium (1.76%) (Table 2) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O, while as, lowest leaf calcium (1.54%) was observed in T_{10} treatment with 85g N, 35g P_2O_5 and 180g K_2O. The treatments showed non-significant effect on leaf calcium. This may be due to synergistic effect of nitrogen on calcium. This is in accordance with the findings of El-Morshedy (1997) [17] and Bhutani and Bhatia (1986) [9]. Highest leaf magnesium (0.38%) (Table 2) was recorded with 105g N, 35g P_2O_5, 150g K_2O (T_4 treatment) and the lowest leaf magnesium (0.30%) was found with 0g N, 35g P_2O_5, 150g K_2O in T_1 treatment. The treatments had non-significant effect on leaf magnesium. This could be due to synergetic effect of nitrogen with magnesium. This was in accordance with the findings of Shahin *et al.* (2010) and Bhella and Wilcox (1989) [8]. Highest leaf sulphur (0.40%) (Table 2) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O and lowest leaf sulphur (0.34%) was recorded in T_1 treatment with 0g N, 35g P_2O_5 and 150g K_2O. Treatments had non-significant effect on leaf sulphur. This could be attributed to the role of S in protein synthesis in which it is used as an essential component of amino acids that lead to the general high performance of the crop including synthesis of all nitrogen containing compounds such as proteins, chlorophyll and nucleic acids. The sulphur content in leaves was directly related to supply and increase significantly as reported by Dhilley *et al.* (1958) [15] and Parups *et al.* (1958) [25].

Table 2: Effect of nitrogen, phosphorus and potassium on leaf nutrient contents of high density apple cv. Silver Spur

Treatment	Calcium (%)	Magnesium (%)	Sulphur (%)
T_1	1.69	0.3	0.34
T_2	1.72	0.31	0.36
T_3	1.73	0.36	0.38
T_4	1.76	0.38	0.4
T_5	1.71	0.32	0.37
T_6	1.69	0.33	0.35
T_7	1.65	0.34	0.36
T_8	1.63	0.32	0.37
T_9	1.6	0.33	0.35
T_{10}	1.54	0.33	0.35
C.D($P \leq 0.05$)	NS	NS	NS

Highest leaf zinc (31.3%) (Table 3) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O and the lowest leaf zinc (21.1%) was recorded in T_1 treatment with 0g N, 35g P_2O_5 and 150g K_2O. The treatments revealed significant effect on leaf zinc content. This could be due to high microbial activity leading to more decomposition of soil organic matter and hence results in increased release of nutrients including micronutrients like zinc (Kamble and Kathmale, 2015) [21]. Highest leaf copper (14.60%) (Table 3) was recorded with 105g N, 35g P_2O_5, 150g K_2O (T_4 treatment) and lowest leaf copper (9.27%) was recorded with 0g N, 35g P_2O_5, and 150g K_2O (T_1 treatment). Leaf copper content differed significantly among all the treatments. This could be due to the favourable soil reaction and high organic matter decomposition due to addition of nitrogen, phosphorus and potassium that forms soluble complexes and makes copper subsequently available to plants (Bhandari and Sharma, 1981) [6]. Highest leaf manganese (78.8%) (Table 3) was recorded with 105g N, 35g P_2O_5, 150g K_2O (T_4 treatment) and lowest leaf manganese (67.7%) was recorded with 0g N, 35g P_2O_5 and 150g K_2O (T_1 treatment). Leaf manganese content differed statistically among all the treatments. This could be due to the favourable soil reaction and adequate organic matter decomposition due to addition of nitrogen, phosphorus and potassium that forms soluble complexes and makes manganese subsequently available to plants (Bhandari and Sharma, 1981) [6]. This may also be attributed to the soil-acidifying effect of phosphorus, which increases the manganese uptake. This is in agreement with the findings of Jackson and Carter (1975). Highest leaf iron (126.6%) (Table 3) was recorded in T_4 treatment with 105g N, 35g P_2O_5 and 150g K_2O and the lowest leaf iron (121.0%) was recorded in T_1 treatment with 0g N, 35g P_2O_5 and 150g K_2O. Treatments differed significantly with leaf iron. This could be due to synergistic effect of nitrogen with iron and release of iron during high decomposition of soil organic matter. Similar results were observed by Malvi (2011) [23], while working on apple.

Table 3: Effect of nitrogen, phosphorus and potassium on micro-nutrient contents of high density apple cv. Silver Spur

Treatment	Zinc (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)
T_1	21.1	9.27	121	67.7
T_2	30.4	10.09	123.6	75.6
T_3	30.6	12	124.2	74
T_4	31.3	14.6	126.6	78.8
T_5	23.4	13.06	122.6	74
T_6	27.9	11.03	122.2	72.4
T_7	25.9	13.03	123.8	70.6
T_8	25.2	11.09	122.5	73.6
T_9	27.7	13	121.4	68.3
T_{10}	26.9	12.06	122.7	68.7
C.D($P \leq 0.05$)	0.23	0.88	0.95	1.51

The correlation between leaf nutrient content with growth parameters and yield (Table 4) revealed that nitrogen content in leaves was positively and significantly correlated with tree height, annual shoot extension growth, trunk girth, fruit length, fruit weight and fruit yield. This may be attributed to the fact that nitrogen plays an active role in cell division and cell elongation thus improves the growth parameters and yield. These results are in agreement with the findings of Kumar and Chandel (2004) [22]. The relationship between leaf phosphorus with tree height, annual shoot extension growth, trunk girth, fruit length, fruit diameter, fruit weight and fruit yield was positive and non-significant. This could be attributed to the role of phosphorus as an essential constituent of cell and its organelles and in plant metabolism. These are in line with the findings of Kumar and Chandel (2004) [22]. The potassium content of leaf was positive but non-significant with tree height, annual shoot extension growth, trunk girth, fruit length, fruit diameter, fruit weight and fruit yield. This is because of its role in plant metabolism and enzyme system of plants. Similar results were found by Afzal *et al.* (2015) [1]. Leaf calcium was positive but non-significantly correlated with tree height, annual shoot extension growth, trunk girth, fruit length, fruit diameter, fruit weight and fruit yield. It could be due to role of calcium as structural component of cell and enzyme activity (Bhat *et al.,* 2009) [9]. Leaf magnesium content was positively and significantly correlated with tree height, annual shoot extension growth, trunk girth, fruit length, fruit weight and fruit yield. It may be because of the role of magnesium in chlorophyll and many physiological and biochemical processes. It is also an essential element for plant growth and development (Cakmak and Kirkby, 2008) [11]. The sulphur content in leaves was positively and significantly correlated with tree height, annual shoot extension growth, trunk girth, fruit length, fruit weight and fruit yield. This could be attributed to the role of sulphur in activation of enzymes, constituent of amino acids etc. and in cell division thereby improving the growth and yield (Mansour *et al.,* 2008) [24]. Leaf zinc was positively and significantly correlated with annual shoot extension growth, trunk girth, fruit length and fruit yield. This could be due to its role in plant metabolism especially as activator of enzyme system leading to quality production and since zinc is essential co-factor for number of enzymes like peptidase, protienase, enolase and is required for formation of amino acids tryptophan which consists of hormone indole acetic acid (IAA) and is essential for cell elongation. (Barker and Pilbeam, 2007) [4]. Leaf iron was positively and significantly correlated with tree height, annual shoot extension growth, tree girth, fruit length, fruit weight and fruit yield. Iron plays a key role in carbohydrate metabolism and fruit quality (Dongre *et al.,* 2000) [16]. Iron has an important role in photosynthesis that causes higher photosynthetic rate thereby improving the quality parameters and yield (Houimli, 2015 and Davarpanah *et al.,* 2013) [19, 14]. Leaf copper content was positive and significantly correlated with tree height, annual shoot extension growth, fruit weight and fruit yield. The possible reason could be that copper is essential for photosynthesis due to its involvement in the electron transport chain (Bergmann, 1992) [5]. Copper rich plants have higher enzyme activities resulting in higher carbon fixation rates. This results in more carbohydrates for plant growth and development, which increases the yield (Brown *et al.,* 1994) [10]. The manganese content in leaves was positively and significantly correlated with trunk girth and fruit diameter. This result might be owing to the role of manganese in the oxygen evolving step of photosynthesis and membrane function as well as serving as an important activator of numerous enzymes in the cell, thereby increasing cell size and hence increases in diameter (Wiedenhoeft, 2006) [30].

Table 4: Coefficient of correlation between leaf nutrients and growth, yield and quality parameters of high density apple cv. Silver Spur

Nutrients	Tree height	Annual shoot extension growth	Trunk girth	Fruit length	Fruit diameter	Fruit weight	Fruit yield
N	0.897*	0.801*	0.818*	0.809*	0.568	0.775*	0.846*
P	0.585	0.467	0.096	0.217	0.515	0.112	0.37
K	0.253	0.432	0.463	0.547	0.279	0.57	0.473
Ca	0.124	0.119	0.323	0.094	0.471	0.27	0.317
Mg	0.830*	0.923*	0.853*	0.835*	0.566	0.810*	0.950*
S	0.721*	0.718*	0.846*	0.692*	0.6	0.865*	0.726*
Zn	0.441	0.748*	0.648*	0.741*	0.502	0.522	0.732*
Cu	0.778*	0.662*	0.567	0.593	0.273	0.801*	0.661*
Fe	0.705*	0.763*	0.791*	0.747*	0.565	0.740*	0.737*
Mn	0.557	0.492	0.642*	0.504	0.707*	0.61	0.501

*Significant at 5% level

Conclusion

It may be concluded that nutrients play a crucial role in the development of fruit crops and with the increase in the application of nutrients to soil plant nutrient content increases subsequently. Most of the leaf nutrient contents had significant effect on growth parameters and yield.

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