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Relationship of leaf nutrient content with fruit yield and quality of pear

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Abstract

In order to evaluate the effect of leaf nutrient content on fruit yield and quality parameters of pear cultivar "Bartlett" in Kashmir valley, a study was conducted, which showed that nitrogen, phosphorus, potassium and sulphur content in foliage revealed significant and positive relationship with fruit length, diameter, weight , volume, total soluble solids, total sugar and yield. The leaf calcium content exhibited significant and positive correlation only with fruit firmness, whereas leaf magnesium content indicated significant and negative relationship with total sugar. The zinc, copper, iron and manganese level in leaf showed significant and positive relationship with fruit length, diameter, volume, weight, total sugars, total soluble solids and yield. The study revealed that nutrients considerably effect the yield and quality attributes of pear.

Key words

Fruit quality, Leaf nutrients, Pear cultivar

Introduction

Among various factors of production, nutrition of pear has received a considerable attention in recent years, because of the role of various nutrients in quality production of fruits and also due to their relationship to physiological disorders and other effects particularly reduced respiration, delayed ripening and increased fruit firmness, thereby extending storage and shelf life of fruits. Deficiency of these nutrients result in decrease of fruit production and poor quality, while excess of nutrients also hamper quality production of fruits because of their antagonistic effects. Imbalance of nutrients causes several disorders which consequently affects the quality and yield of pear. The nutrients in soil and foliage have a considerable effect on yield and quality parameters of fruits because of their role in plant metabolism (Buchloh, 1974; Hansein and Ryugo, 1979; Nijjar, 1990 and Mitra *et al.*, 1991).

Growth and yield of fruit crops is governed by several factors and among those, plant nutrition is the most important factor, affecting growth and yield of all crops. Determination of nutritional requirement for maximum production of good quality fruits is an important aspect of nutrient management. Recent advances in the field of nutrition of various fruit crops have proved that leaf analysis is an excellent tool for diagnosing deficiencies and toxicity of various essential elements. Leaf is the main site of metabolism and optimum concentration of nutrients in leaves have relationship with yield and quality of fruits. Campeanu *et al.* (2009) reported that researchers should take into consideration the mineral nutrient status of leaves in order to get better quality of apple fruits. Leaf is considered as the main part of plant, where synthesis of various food constituents like carbohydrates, proteins, vitamins, fats etc. takes place and from there they are transported to other plant parts. Therefore, concentration of various nutrient elements in leaves is related to various quality attributes and yield of fruit crops, as they play an important role structural component, energy transformer, maintenance of cellular organization and enzyme activators. Bhargava and Chadha (1993) proposed leaf to be the best part for diagnosis of nutrient status of the plants. Most of the workers dealing with nutrition of perennial fruit trees have considered tissue analysis as a guide to assess nutritional requirement. This is due to the fact that this method allows comparison among various soil and

climatic factors in orchards (Robinson, 1980). Determining nutrient concentration has received special attention, since it can provide information on fruit quality based on previously known adequate and critical nutrient levels in leaves as reported by Marcelle (1984), Suzuki and Argenta (1994), Ernani *et al.* (2002) and Nachtigall and Dechen (2006). The importance of plant nutrition in yield enhancement and quality upgradation has been widely emphasized. All essential elements play a vital role in deciding growth and development of plant.

For a particular nutrient, there exists a relationship between its concentration in soil and leaf, as well as quality attributes of fruits. This serves as a guide to obtain maximum productivity of quality fruits. Awasthi *et al.* (1998) found a direct relationship between leaf nutrients with yield and quality of apple. Nutrient concentration in leaves seems to be the result of interaction between its genetic inheritance and the environment in which it grows which in turn has considerable impact on growth, yield and quality parameters of fruits. Sanchez-Alonso and Lachica (1987) observed that certain soil characters could be responsible for alternation in nutrient concentration in cherry leaves. Chaplin and Westwood (1980) and Ystaas (1990) observed significant difference in leaves for nitrogen, phosphorus, potassium, calcium, magnesium, zinc, copper, manganese and iron contents and reported that it is due to variation in nature of root system or due to structural differences in both root stock and scion. Since the nutritional aspect of pear has not received much attention so far and no study has been conducted to find out the effect of nutrients on yield and quality parameters of pear. Therefore, the present study was undertaken to find the relationship of nutrients in leaves with fruit yield and quality attributes of pear in Kashmir.

Materials and Methods

To conduct this study, 21 orchards of pear cultivar "Bartlett" were selected in pear growing areas of Kashmir. The trees were of uniform age group (15-20 years), vigour and growth. The leaf samples were collected from each orchard following the procedure outlined by Chapman (1964). The leaf samples were washed, dried, ground and digested for analysis. Nitrogen, phosphorus, potassium, calcium and magnesium were estimated by standard procedures outlined by Jackson (1973). Sulphur was determined by turbidity method (Chesnin and Yien, 1951) while, zinc, copper, iron and manganese were estimated on atomic absorption spectrophotometer. Fruit samples were collected as per the procedure of Waller (1980) and were washed and dried for analysis. Fruit length and diameter were measured with digital vernier calliper and fruit weight was recorded in a sensitive monopan balance, while, fruit volume was measured by water displacement method. Fruit firmness and total soluble solids (TSS) were measured with the help of Penetrometer and hand refractometer, respectively. Fruit yield was recorded and total sugar was determined as per the procedure given by A.O.A.C. (1990). Correlation co-efficient (r – values) was as per the procedure outlined by Gomez and Gomez (1984).

Results and Discussion

The soils were clay loam to silty clay loam in texture with normal electrical conductivity and calcium carbonate content. The pH of soil was slightly acidic to slightly alkaline and ranged from 6.10 to 7.76 with mean value of 6.75. The organic carbon was medium to high in soils and varied from 0.66 to 2.36 %, with mean value of 1.54 %. The available nitrogen ranged from 207.87 to 439.49 kg ha^{-1} with mean value of 353.25 kg ha^{-1} and its status was low to medium while available phosphorus was medium to high and varied from 21.06 to 41.66 kg ha^{-1} with mean value of 34.25 kg ha^{-1}. The available potassium was found in the range of 318.08 to 474.88 kg ha^{-1}, with mean value of 401.70 kg ha^{-1}. The soils were high in available potassium. The exchangeable calcium and magnesium ranged from 4390.40 to 4995.20 and 586.88 to 676.48 kg ha^{-1}, with mean value of 4766.92 and 638.51 kg ha^{-1}, respectively and both were high in soils under study. The available sulphur varied from 22.40 to 26.88 kg ha^{-1}, with mean value of 24.51 kg ha^{-1} and it was observed medium in soils. The DTPA-extractable zinc and copper was found in the range of 0.54 to 1.82 and 1.14 to 2.80 mg kg^{-1} with mean value of 1.28 and 2.00 mg kg^{-1}, respectively. The DTPA-extractable zinc was low to high while copper was medium to high. The DTPA extractable iron and manganese were found in the range of 29.60 to 76.00 and 25.40 to 54.40 mg kg^{-1} with mean value of 48.50 and 43.06 mg kg^{-1} and both the nutrients were observed high in the soils under study.

Leaf nitrogen, phosphorus and potassium content of pear ranged from 2.12 to 2.68, 0.140 to 0.198 and 1.62 to 1.97 %, with mean value of 2.42, 0.177 and 1.84 %, respectively. Calcium, magnesium and sulphur concentration in foliage of "Bartlett" cultivar of pear was found in the range of 1.68 to 1.86, 0.36 to 0.49 and 0.216 to 0.272 % with mean value of 1.79, 0.42 and 0.245 %, respectively. Zinc, copper, iron and manganese content in leaf varied from 24.0 to 58.3, 8.3 to 19.7, 8.4 to 199.3 and 72.0 to 128.3 ppm, with mean value of 42.86, 14.09, 126.84 and 102.46 ppm respectively. The concentration of all nutrients analysed were optimum to high in orchards except nitrogen and copper, which were low in 14 and 5 % orchards respectively.

Length and diameter of fruit varied from 61.43 to 84.15 and 46.75 to 58.76 mm respectively. Weight and volume of pear fruit ranged from 81.0 to 131.0 g and 69.2 to 111.0 cm^3, respectively, where as firmness and TSS ranged from 12.76 to 22.75 lb.p.s.i and 9.3 to 13.5 %. Total sugar in pear fruit ranged from 4.16 to 5.82 % and yield ranged from 72.0 to 132.0 kg $tree^{-1}$, in 21 orchards.

Leaf nitrogen exhibited positive and significant correlation with fruit length, diameter, weight, volume, TSS, total sugar and yield (Table 1). This may be due to the role of nitrogen as an essential constituent of cell and its effect on cell division and

Table 1 : Concentration of leaf nutrient in pear cultivar "Bartlett" in Kashmir

Nutrient	Unit	Range	Mean*	SD
Nitrogen	%	2.120 – 2.680	2.420	0.030
Phosphorus	%	0.140 – 0.198	0.177	0.003
Potassium	%	1.620 – 1.970	1.840	0.040
Calcium	%	1.680 – 1.860	1.790	0.010
Magnesium	%	0.360 – 0.490	0.420	0.010
Sulphur	%	0.216 – 0.272	0.245	0.001
Zinc	ppm	24.00 – 58.30	42.86	2.590
Copper	ppm	8.30 – 19.70	14.09	0.990
Iron	ppm	84.00 – 199.30	126.84	7.000
Manganese	ppm	72.00 – 128.30	102.46	6.190

* Mean of 21 samples

Table 2 : Quality parameters and yield of pear fruits

Parameters	Unit	Range	Mean*	SD
Length	mm	61.43-84.15	77.60	2.36
Diameter	mm	46.75-58.76	55.16	1.03
Weight	g	81.0-131.0	116.33	5.90
Volume	cm^3	69.2-111.0	97.16	4.54
Firmness	lb.p.s.i	12.76-22.75	19.71	0.61
TSS	%	9.3-13.5	12.09	0.43
Total sugar	%	4.16-5.82	5.29	0.11
Yield	Kg $tree^{-1}$	72.0-132.0	98.71	3.31

* Mean of 21 samples

Table 3 : Correlation coefficient values between leaf nutrient content and fruit yield and quality parameters of pear fruit

Nutrient	Length	Diameter	Weight	Volume	Firmness	TSS	Total sugar	Yield
Nitrogen	0.874*	0.872*	0.846*	0.892*	0.347	0.872*	0.875*	0.914*
Phosphorus	0.901*	0.911*	0.849*	0.842*	0.428	0.838*	0.938*	0.714*
Potassium	0.660*	0.640*	0.632*	0.594*	-0.118	0.692*	0.602*	0.812*
Calcium	0.197	0.212	0.180	0.231	0.841*	0.095	0.328	-0.812*
Magnesium	-0.358	-0.424	-0.329	-0.306	-0.216	-0.424	-0.516*	-0.377
Sulphur	0.807*	0.856*	0.763*	0.826*	0.353	0.769*	0.911*	0.657*
Zinc	0.889*	0.891*	0.886*	0.908*	0.361	0.719*	0.943*	0.744*
Copper	0.857*	0.869*	0.863*	0.886*	0.281	0.921*	0.845*	0.882
Iron	0.686*	0.759*	0.695*	0.736*	0.343	0.804*	0.770*	0.780*
Manganese	0.730*	0.729*	0.737*	0.705*	0.005	0.828*	0.687*	0.821*

* Significant at 5% level

cell elongation leading to growth and development of large leaf area, stimulation of buds, flower initiation, fruit set with significant increase in yield and improvement in quality attributes through photosynthetic activity. This is supported with the findings observed by Kumar *et al.* (2007). A significant and positive relationship of leaf phosphorus was observed with fruit length, diameter, volume, weight, TSS, total sugar and yield. This could be attributed to its role as an essential constituent of cell and its components, in plant metabolism and in energy transfer. These results are in conformity with the finding of Kumar *et al.* (2007) and Singh *et al.* (2005). Leaf potassium level revealed positive and significant relationship with fruit length, diameter, weight, volume, TSS, total sugars and yield (Table 3). This may be due to its role in plant metabolism and is known as quality nutrient because of its effect on fruit qualities through activation of enzymes, regulating cell hydration, in water economy etc. These results are in line with the findings of Kumar *et al.* (2007). Leaf calcium indicated positive and significant correlation with fruit firmness only. This can be due to its role in the synthesis of pectic substances which provide strength to cell wall and thereby enhance fruit firmness. Calcium acts as cofactor of enzymes and is essential for cellular organization and is component of chromosomes. Similar

observations were also reported by Kumar *et al.* (2007). A significant and negative relationship was observed between leaf magnesium and total sugar of fruits, which may be due to Mg/K+Ca ratio. Leaf sulphur level showed positive and significant correlation with fruit length, diameter, weight, volume, TSS, total sugar and yield. This could be due to its role in plant metabolism for enhancing biosynthesis of organic food and in cell division. It is main constituent of several amino acids, vitamins and is involved in activation of enzyme acting in dark reactions of photosynthesis. This is in confirmation with the findings of Mostafa and Abd El-Kader (2006) and Mansour *et al.* (2008).

Leaf zinc exhibited positive and significant relationship with fruit length, diameter, weight, volume, TSS, total sugar and yield. This could be due to its role in metabolism of plants especially, as an activator of enzymes and precursor of auxins. It also functions in enzyme activation which play important role in protein synthesis and carbohydrate metabolism. These results are in confirmation with the findings of Singh *et al.* (2007) and Babu and Yadav (2005). A positive and significant correlation of leaf copper was found with fruit length, diameter, weight, volume, TSS, total sugar and yield. This can be due to its role in plant metabolism. Copper plays important role in synthesis of proteins, coenzyme in various reactions, lignification and electron transfer. This is supported with the findings of Singh *et al.* (2007). Iron content in foliage of pear exhibited positive and significant relationship with fruit length, diameter, weight, volume, TSS, total sugar and yield. This can be due to its role in plant metabolim. These findings are in line with the results of Jeyabaskaran and Pandey (2008) and Veleais *et al.* (1998). Leaf manganese level in pear revealed significant and positive relationship with fruit length, diameter, weight, volume, TSS, total sugar and yield. This can be due to its involvement in physiological processes of plants, leading to quality production. It is essential for enzyme activation involved in respiration, nitrogen fixation, protein synthesis, carbohydrate synthesis and synthesis of chlorophyll. This is supported by Babu and Yadav (2005) and Singh *et al.* (2005). All other relationships were observed to be in significant.

Plant nutrition is one of the key factors influencing yield and quality of crop plants. The importance of plant nutrition in yield enhancement and quality upgradation has been widely emphasized. Each essential element plays a vital role in growth and development of plants. There exists a relationship between essential nutrients and quality attributes as well as fruit yield, which serves as a guide to obtain maximum productivity of quality fruits. Awasthi *et al.* (1998) reported a direct relationship of leaf nutrients with yield and quality of apple. Thus, it can be concluded that leaf nutrients have pronounced effect on fruit yield and quality parameters of pear.

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