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Effect of integrated nutrient application on apple productivity and soil fertility in temperate zone of Himachal Pradesh

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ABSTRACT

Effect of integrated nutrient application on apple productivity and soil fertility in temperate zone of Himachal Pradesh was investigated during the years 2007 and 2008. Plant growth parameters viz terminal shoot growth, plant girth, height and spread; fruit characteristics viz fruit weight, length, breadth and yield; fruit quality parameters viz fruit pressure, total soluble solids, titratable acidity and total sugar; leaf nutrient content viz nitrogen, phosphorus and potassium and soil properties viz soil pH, OC content, available nitrogen, phosphorus and potassium were significantly affected by organic manures, bio-fertilizer and inorganic fertilizers treatments during both the years of experimentation. Maximum values of plant growth parameters, fruit characteristics, yield, leaf and soil nutrient contents were recorded under T_5 (IFFCO mixture + Urea + MOP + lime + FYM) treatment followed by T_1 (recommended doses) treatment and minimum values were recorded under control (T_6 - without fertilizers, manures and biofertilizers) treatment. Better quality fruits were also recorded in T_5 treatment.

Keywords: Organic manure; inorganic fertilizers; apple fruit quality; productivity; soil fertility

INTRODUCTION

A hill and mountainous state, Himachal Pradesh is vested with varied agro-climatic conditions and enjoys temperate climate. Among 38 types of fruits apple is the most dominant crop grown in the state. Currently apple is cultivated in an area of over one lakh hectare with a production of over 5.4 lakh tonnes. The crop generates nearly₹ 1,600 crores as a direct income to farmers and contributes nearly ₹ 20,000 crores indirectly. Though there has been many fold increase in area under apple during last two decades yet the productivity level in comparison to other developed countries is very low. The main reasons for low productivity are a) low inputs and imbalanced use of nutrients, b) poor management of soil and water

resources, c) inadequate management of major insect pests, mite, diseases and weeds, d) rainfed conditions and e) undulating topography and shallow soil depth.

Among these low inputs and imbalanced use of nutrients are of paramount concern. Orchardists mostly use fertilizers like CAN, urea, SSP and MOP for meeting out the nutritional requirements of apple orchards. The availability of these fertilizers in time is highly unregulated. The non availability of CAN in the state has led to a great concern for its search from other available sources. The soils have been found deficient in calcium, boron and zinc.

The integration of manures, biofertilizers, inorganic fertilizers and lime would not only pave way for overcoming the deficiencies of these vital nutrients in plants but also strengthen the integrated plant nutrient management programme. There is an urgent need to evaluate different nutrient systems currently being followed in apple to manage nutritional deficiencies along with appropriate combination of urea, IFFCO formulation, lime, SSP, MOP, vermicompost, farm yard manure and microbial culture to provide viable alternative for sustainable plant nutrient system on long term basis. Therefore investigations were conducted to evaluate the effect of manures, biofertilizers and inorganic fertilizers on apple productivity and soil fertility in temperate zone of Himachal Pradesh.

MATERIAL AND METHODS

The field experiment was undertaken in the experimental farm of Dr YS Parmar University of Horticulture and Forestry, Regional Horticultural Research Station, Mashobra, Shimla during the years 2007 and 2008. The physico-chemical properties of the soil were analysed before the start of experimentation and after crop harvest during both the years of study using standard procedures. The soil was silty clay loam in texture with pH 6.41 and organic carbon 1.28 per cent. The available N, P and K were 489.20, 19.10 and 284.40 kg ha^{-1} respectively. The experiment was laid out in randomized block design with different treatment combinations being replicated five times. The treatments were T_1- recommended dose (2200 g SSP, 1200 g MOP, 2800 g CAN and 100.00 kg FYM/ tree), T_2- IFFCO 12:32:16 mixture + urea + MOP + lime (1094 g 12:32:16 IFFCO mixture, 1237 g urea, 875 g MOP + 1.0 kg lime/tree), T_3- same as T_2 + vermicompost (5 kg/tree), T_4- same as T_2 + microbial culture (400g/tree), T_5- same as T_2 + farm yard manure (100 kg/tree) and T_6- control (without fertilizers, manures and biofertilizers). Actually N, P_2O_5 and K_2O/tree for T_1 to T_5 treatments were applied @ 700 g N, 350 g P_2O_5 and 700 g K_2O through single super phosphate (SSP), muriate of potash (MOP), urea, calcium ammonium nitrate (CAN) and IFFCO 12:32:16 mixture. The post harvest soil samples were drawn during 2007 and 2008 to study the changes in soil physico-chemical

properties under different treatments. Farm yard manure, SSP and MOP were applied during January in both the years of experimentation. Half dose of N through CAN was applied 2-3 weeks before flowering (last week of March) and remaining half N through CAN a month later (last week of April) under CAN applied treatment. Vermicompost, urea, IFFCO 12:32:16 mixture, microbial culture and lime were applied during last week of March.

Data on growth parameters viz terminal shoot growth, plant girth, height, spread, fruit characteristics like fruit weight, length and breadth and finally the yield were recorded at the harvesting stage of the apple crop. Plant spread was estimated with the help of measuring wooden rod by recording the maximum canopy spread in north-south and east-west directions. Total soluble solids (TSS) and fruit pressure were determined by Hand Refractometer and Fruit Pressure Tester respectively. Titrable acidity and total sugar content of fruits were estimated as per standard (Anon 1980). Nutrient (N, P and K) contents in leaf were determined by following the standard procedures.

RESULTS AND DISCUSSION

Effects of integrated nutrient supply treatments on growth of apple are presented in Table 1. Plant growth parameters viz terminal shoot growth, plant girth, height and spread were significantly affected by different integrated nutrient supply treatments during the years 2007 and 2008. Maximum terminal shoot growth, plant girth, height and spread in apple were recorded under T_5 (IFFCO 12:32:16 mixture + urea + MOP + lime + FYM) treatment followed by T_1 (Recommended dose) treatment and minimum values of terminal shoot growth, plant girth, height and spread in apple were recorded under T_6 (Control). The increase in plant height and girth might be due to improvement of physical properties of soil, higher nutrient uptake and increased activity of microorganisms which were manifested in the form of enhanced growth and higher carbohydrates production as explained by Kumar et al (2008) and Hassan et al (2001). These effects might also be due to the production of phytohormones produced by *Azospirillum* near root morphology and in turn influencing assimilation of nutrients. Available N, P and K status, organic carbon, microbial biomass and dehydrogenase activity increase due to application of inorganic fertilizers and organic manures help in increasing height and girth of the apple plants.

The fruit characteristics and yield of apple were significantly influenced by integrated nutrient supply treatments during the years 2007 and 2008 (Table 2). The yield and yield attributing characters (fruit characteristics) were mainly dependent on growth characters of the plant. The leaf growth characteristics decide the duration of the crop and also the grade of the bunch

with regard to their size and weight which finally result in production. Greater accumulation of dry matter confers greater ability to give higher yield. Fruit characteristics like fruit weight, length, breadth and yield of apple were recorded maximum under T_5 (IFFCO 12:32:16 mixture + urea + MOP + lime + FYM) treatment followed by T_1 (recommended dose) treatment and minimum under T_6 (control) treatment. The maximum values of fruit weight, length, breadth and yield under T_5 treatment were higher obviously due to the vigorous plant growth characters in this treatment. In treatments T_5 and T_1 increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates. Relatively higher amount of carbohydrates could have promoted the growth rate and in turn increased the fruit weight. This was in accordance with the results of Chezhigen et al (1999) in banana.

Fruit quality parameters (fruit pressure, total soluble solids, titrable acidity and total sugar contents) of apple were significantly affected by integrated nutrient supply treatments (Table 3). Total soluble solids (TSS) and total sugars were recorded maximum under T_5 (IFFCO 12:32:16 mixture + urea + MOP + lime + FYM) and T_1 (recommended dose) treatments whereas fruit pressure and titrable acidity were recorded minimum under T_5 and T_1 treatments. However in control (T_6) treatment TSS and sugars were recorded minimum whereas fruit pressure and titratable acidity were recorded maximum.

Since nitrogen nutrition is directly related with plant growth therefore its increased dose might have improved the plant growth especially leaf size. Increased leaf size might be responsible for improvement in the rate of photosynthesis and thereby faster growth of plants. The higher rate of nitrogen nutrition might promote vegetative growth at the cost of onset of reproductive stage. Potassium nutrition at higher rate might have improved the translocation of photosynthates from source to sink and ultimately yield. Improvement in fruit quality of banana due to nitrogen and potassium nutrition has also been observed by Ram and Prasad (1988), Natesh et al (1993), Pandey et al (2005) and Srinivas et al (2001). Increased total sugars in apple fruit due to accumulation of more photosynthates might be ascribed to uptake of more nitrogen and potassium in plant system. Similar findings have been reported by Kumar et al (2008).

Plant nutrient contents viz plant nitrogen, phosphorus and potassium were significantly influenced by different treatments of integrated nutrient supply system during both the years of experimentation (Table 4). Maximum plant nutrient contents were recorded under T_5 and T_1 treatments and minimum plant nitrogen, phosphorus and potassium

Table 1. Effect of integrated nutrient management on growth parameters of apple

Treatment	Terminal shoot growth (cm)		Plant girth (cm)		Plant height (m)		Plant spread (m)			
							NS		EW	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1	42.50	42.80	82.70	83.00	6.00	6.10	5.75	5.90	5.70	5.85
T_2	41.00	41.50	81.20	81.60	5.30	5.45	5.00	5.15	4.95	5.00
T_3	42.00	42.40	82.00	82.50	5.80	5.85	5.40	5.60	5.35	5.50
T_4	41.60	42.00	81.65	82.00	5.70	5.75	5.20	5.35	5.10	5.25
T_5	42.80	43.10	83.00	83.25	6.20	6.30	6.00	6.10	5.80	5.95
T_6	39.50	41.00	80.00	81.20	4.75	5.00	4.60	4.85	4.45	4.80
$CD_{0.05}$	0.53	0.69	0.86	0.48	0.42	0.26	0.40	0.30	0.26	0.44

NS = North South
EW = East West

Table 2. Effect of integrated nutrient management on fruit characteristics and yield of apple

Treatment	Fruit weight (g)		Fruit length (cm)		Fruit breadth (cm)		Fruit yield (kg/tree)	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1	220.10	216.10	8.20	7.60	8.20	8.10	68.30	66.90
T_2	218.90	214.05	7.20	7.00	7.20	7.15	67.00	65.80
T_3	219.40	215.20	8.00	7.45	8.00	7.90	68.00	66.35
T_4	219.20	215.00	7.60	7.20	7.80	7.60	67.20	66.00
T_5	221.40	218.40	8.70	8.00	8.80	8.40	68.50	67.20
T_6	215.00	213.50	6.30	6.10	6.40	6.25	66.10	65.00
$CD_{0.05}$	1.12	1.65	0.35	0.61	0.55	0.46	0.83	0.40

Table 3. Effect of integrated nutrient management on fruit quality parameters of apple

Treatment	Fruit pressure ($lb/inch^2$)		Total soluble solids (^{0}Brix)		Titratable acidity (%)		Total sugars (%)	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1	18.10	18.00	13.0	12.9	0.14	0.12	9.85	9.80
T_2	19.60	19.30	12.5	12.4	0.19	0.18	9.20	9.10
T_3	18.90	18.80	12.9	12.8	0.15	0.13	9.65	9.50
T_4	19.20	19.10	12.7	12.6	0.17	0.16	9.40	9.20
T_5	17.50	17.40	13.8	13.4	0.11	0.09	10.50	10.20
T_6	19.70	19.50	12.1	12.0	0.21	0.20	9.10	9.00
$CD_{0.05}$	0.48	0.35	0.46	0.40	0.03	0.04	0.23	0.40

Table 4. Effect of integrated nutrient management on leaf nutrient content of apple

Treatment	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	2007	2008	2007	2008	2007	2008
T_1	3.00	3.05	0.24	0.25	1.75	1.80
T_2	2.60	2.65	0.16	0.16	1.52	1.56
T_3	2.80	2.90	0.19	0.21	1.70	1.75
T_4	2.65	2.75	0.17	0.18	1.63	1.67
T_5	3.10	3.15	0.26	0.28	1.80	1.85
T_6	2.35	2.45	0.13	0.14	1.35	1.42
$CD_{0.05}$	0.13	0.13	0.06	0.06	0.12	0.13

Table 5. Effect of integrated nutrient management on soil properties in apple orchard

Treatment	Soil pH		Organic carbon content (%)		Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1	6.70	6.75	1.30	1.32	479.10	481.40	18.80	18.90	270.80	274.20
T_2	6.45	6.52	1.15	1.20	467.50	470.50	17.55	17.85	260.00	262.50
T_3	6.60	6.65	1.28	1.30	472.00	475.40	18.50	18.65	265.20	268.40
T_4	6.55	6.60	1.20	1.25	470.10	473.20	18.00	18.25	264.30	265.80
T_5	6.75	6.80	1.35	1.37	480.20	482.20	19.50	19.80	278.40	280.40
T_6	6.25	6.30	1.10	1.14	460.30	464.80	16.50	16.80	256.60	258.80
$CD_{0.05}$	0.13	0.19	0.10	0.09	4.13	0.69	0.55	0.51	0.90	0.72

contents were recorded under T_6 (control) treatment. These findings are in close conformity with the earlier findings of Naik and Haribabu (2007) and Dutta et al (2010).

Soil physico-chemical properties like soil pH, organic carbon (OC) content, available nitrogen, phosphorus and potassium contents in apple orchard after harvest of fruits during the years 2007 and 2008 were significantly affected by different treatments (Table 5). Soil pH, OC, N, P and K contents were recorded maximum under T_5 and T_1 treatments and minimum under T_6 (control) treatment. Dutta et al (2010) and Prasad et al (2010) reported that the application of different nutrients through inorganic fertilizers, manures and biofertilizers increased the soil nitrogen, phosphorus and potassium contents. The higher nutrient status of soil due to organic manaure might be because of slow release of nutrients from organic manures and better uptake of nutrients by plants which in turn increases the leaf mineral content of apple. Application of FYM was better in terms of carbon buildup and sustained release of nitrogen to the crops (Goel et al 1999, Singh et al 2000, Datta and Singh 2010).

The present investigations revealed that the treatments T_5 (IFFCO 12:32:16 mixture + MOP + lime + FYM) and T_1 (recommended dose– SSP + MOP + CAN + FYM) performed equally very good in terms of response on plant growth parameters, fruit characteristics, yield and quality parameters of apple fruits. Higher contents of plant as well as soil nutrients were also recorded under these treatments. Therefore integrated application of organic manure and inorganic fertilizers may be a better option for enhancing yield and fruit quality of apples in the state.

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