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Effect of conjoint bio-organic and inorganic nutrient sources on plant growth, leaf nutrient content and soil properties of peach (*Prunus persica*)

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ABSTRACT

The present investigation was carried out to find out the effect of conjoint organic and inorganic nutrient source on plant growth, leaf nutrient content and soil fertility status of peach (*Prunus persica* L. Batsch). The 9-years old trees of uniform size and vigour, planted at 4 × 2 m spacing were selected for the studies. The experiment was laid out in a randomized block design with 11 different conjoint treatment combinations. Maximum increase in plant height (26.69%), canopy diameter (18.01%), tree spread (15.46%), tree canopy volume (52.72%), annual shoot growth (52.32 cm) and leaf area (32.17 cm^2) were recorded in trees supplemented with 75% recommended dose of fertilizers (RDF) + vermicompost at 15 kg/tree treatment combination. Leaf N (2.46%), K (1.35%), Mg (0.57%), Cu (11.54 ppm), Fe (224.20 ppm) and Zn (26.14 ppm) were significantly increased in 75% RDF + vermicompost 15 kg/tree treatment application, whereas leaf Ca (1.67%) was higher in trees supplied with 50% recommended dose of fertilizers + vermicompost 30 kg/tree. Maximum available N (279.96 kg/ha) was recorded in treatment combination of 75% RDF + vermicompost 15 kg/tree, however, the conjoint application of nutrient supplemented with 50% RDF + vermicompost 30 kg /tree exhibited significantly higher organic carbon (1.96%), available P (73.39 kg/ha), bacterial count (43.99×10^{-7} cfu/g) and fungi (7.96×10^{-4} cfu/g) compared to control.

Key words: Cropping behaviour, Nutrient dynamics, Rhizosphere soil

Peach (*Prunus persica* L. Batsch) is an important fruit crop of temperate region of the world. It has wider climatic adaptability, grown commercially between 24º and 45º latitudes both above and below the equator. In India, it is commercial cultivation extends in Jammu and Kashmir, Himachal Pradesh and Uttarakhand and a limited scale in north-eastern states. Some low chilling cultivars are also grown in northern plains of Punjab, Haryana and Uttar Pradesh. The annual production of peach in the country is 112000 MT from an area of 18000 ha (Anonymous 2017). In Himachal Pradesh, it is one of the most important fruit crop in low and mid hills (700-1200 m above mean sea level) and occupies 5076 ha cultivated area with annual production of 8045 MT (Anonymous 2016).

Nutrient management is an important component of orchard management for improving production, productivity and quality of fruits. Fertilizers are one of the major orchard inputs and accounts for nearly one third of the cost of cultivation (Amenumey and Capel 2014). Application of chemical fertilizers tremendously boost fruit production but indiscriminate and continuous use of these fertilizers due to their ready availability and quick yield response, degrade soil health, pollute underground water and disturb the ecological balances. Due to the higher cost of chemical fertilizers and poor purchasing capacity of Indian farmers, organic manures have been used for their eco-friendly and beneficial effect on soil and plants. Organic manures along with inorganic fertilizers are effective means for improving soil physical properties (aggregation, structure and water holding capacity), fertility and microbial diversity (Zink and Allen 1998). Among the organic manures, vermicompost (Anitha and Prema 2003) and neem cake (Radwanski and Wickens 1981) are rich sources of nutrient elements, which improve soil physico-chemical properties, microbial action and plant growth regulating substances. The basic goal of integrated plant nutrition system is the maintenance of soil fertility to an optimum level for sustaining the desired crop productivity by optimizing the benefits from all possible sources of plant nutrients (Shah *et al.* 2014). Keeping in view the positive effects of integration of nutrient sources on soil health and plant growth, present studies were undertaken to find out the most suitable nutrient sources and their doses for integrated nutrient management in peach.

MATERIALS AND METHODS

The present investigation was carried out in the Department of Fruit Science, Y S Parmar University of

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Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2015-16. The experiment was carried out on 9-year-old trees of peach cv. July Elberta raised on wild peach seedling rootstock. The trees of uniform vigour and size, spaced at 4 m × 2 m and trained to open centre system were selected. The experimental area is situated at an elevation of 1275 m above mean sea level with 30º52' N latitudes and 77º11' E longitudes. Annual rainfall is about 1000-1200 mm, major amount of which is received during the monsoon period (July to September). Summer is moderately hot during May-June, whereas winter is severe during December-January. The experiment was laid out in a randomized block design with 11 treatment combinations, viz. T_1-Recommended dose of fertilizers (RDF), T_2-75% RDF + wild apricot cake 2.5 kg/tree, T_3-50% RDF + wild apricot cake 5.0 kg/tree, T_4-75% RDF + neem cake 2.5 kg/tree, T_5 -50% RDF + neem cake 5.0 kg/tree, T_6-75% RDF + vermicompost 15 kg/tree, T_7-50% RDF + vermicompost 30 kg /tree, T_8-75% RDF + Jeevamrut (one application at full bloom), T_9-50% RDF + Jeevamrut (one application at full bloom), T_{10}-Jeevamrut (4 applications at monthly intervals starting from full bloom) and T_{11}-25% RDF + wild apricot cake 1.25 kg + neem cake 1.25 kg + vermicompost 15 kg + Jeevamrut (one application at full bloom), which were replicated thrice. Recommended dose of fertilizers (RDF) for peach is NPK at 500 : 250 : 700 g/tree + FYM at 40 kg/tree. Urea + calcium nitrate, single super phosphate and muriate of potash were used as sources of NPK, respectively. Jeevamrut was prepared by mixing 10 kg cow dung and 10 l of cow urine with the help of wooden stick in a plastic drum. To the well mixed cow dung and cow urine, 2 kg jaggery, 2 kg flour of gram and 1 kg live soil was added. Ingredients were again mixed properly and the volume was made to 200 l with fresh water. The mixture in the drum was then allowed to ferment and during the process of fermentation, solution was stirred clockwise regularly three times a day. Jeevamrut was processed for 7 days fermentation before use. Prepared stock solution was diluted 10 times with water and used for drenching. The height, spread and trunk diameter of each experimental tree was measured once before the start of the experiment and again after the termination of the growth at the end of season to find the increase in growth. Tree canopy volume was calculated from the height and spread measurements by using the formula (Westwood 1978), for the trees i) taller than its spread, the volume= $4/3\ \pi\ ab^2$, and ii) wider than its height, the volume = $4/3\ \pi a^2 b$, where, π=3.1428, a= 1/2 of major axis (height), b= 1/2 of minor axis (spread). Leaf area was recorded with Li-COR 3100 leaf area meter.

Leaf sample (leaf blade including petiole) from each experimental tree was collected during the first week of July from the middle of the current season's growth around the periphery of the tree. The leaf samples were washed under tap water followed by 0.1 N HCl and distilled water as suggested by Chapman (1964). The leaf samples were spread on filter paper sheets for surface drying and were subsequently put into paper bags which were kept in hot air oven at 65 ± 5°C for 48 hr for drying. The dried samples were crushed, ground and stored in butter paper bags for the estimation of various nutriment elements. The digestion of leaf sample for the estimation of nitrogen was carried out in concentrated H_2SO_4 in the presence of a digestion mixture, while for the estimation of P, K, Ca, Mg, Cu, Zn, Fe and Mn, the leaf samples were digested in diacid mixture prepared by mixing HNO_3 and $HClO_4$ in the ratio of 4:1. Total leaf N was determined by Foss Tecator Kjeltech 2300 analyzer. Leaf P was estimated by vanado molybdate phosphoric yellow colour method (Jackson 1973). Leaf K, Ca, Mg and micronutrient cations (Zn, Cu, Fe and Mn) were estimated on atomic absorption spectrophotometer.

Soil samples at 0-45 cm depth were collected from the drip line of each experimental tree with the help of screw type auger. The collected soil samples were dried in shade, grounded, sieved through 2 mm plastic sieve and stored in cloth bags. Soil pH and EC were determined in soil: water suspension (1:2.5) according to Jackson (1973). Organic carbon was determined by Walkley and Black's wet combustion method as outlined by Jackson (1973). Soil nitrogen was estimated by alkaline potassium permanganate method (Subbiah and Asija 1956), phosphorus by Stannous Chloride reduced ammonium molybdate method using Olsen's extractant (Olsen *et al*. 1954) and potassium was extracted with neutral normal ammonium acetate (Merwin and Peech 1951) and estimated on flame photometer. For soil microbial status, samples were collected from plant rhizosphere and screened through 2 mm sieve. The serial dilution technique was employed for isolation and identification of viable bacteria, actinomycetes and fungal count, preparing the media for desired microflora. The autoclaved and cooled (45ºC) medium was poured into sterile petri plates. Then medium was allowed to solidify. One gram of sieved (2 mm) soil was added to 9 ml sterile water blank and shaked for 15-20 min. Serial dilutions to 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7} were prepared. One milliliter of aliquots of various dilutions was added over cooled and solidified medium in petri plates. Plates were rotated for uniform distribution of spores and incubated at 28º C for 3-5 days. Population count of bacteria, actinomycetes and fungi were noted using dilution plate technique by employing nutrient agar medium, Ken Knight's agar medium and potato dextrose agar medium respectively, as suggested by Rangaswamy (1966).

RESULTS AND DISCUSSION

Vegetative growth characteristics

The perusal of data presented in Table 1 reveals that different integrated nutrient management treatments had significantly influenced tree height, trunk diameter, tree spread, canopy volume, annual shoot growth and leaf area of peach. Trees subjected to 75% RDF + vermicompost 15 kg/tree (T_6) exhibited maximum annual increase in tree height (26.69, which was statistically at par with 75% RDF + neem cake 2.5 kg/tree (T_4) and 50% RDF + vermicompost

Table 1 Effect of conjoint nutrient sources on vegetative growth traits of peach cv. July Elberta

Treatment	Per cent increase				ASEG (cm)	Leaf area (cm^2)
	Plant height	Tree diameter	Tree spread	TCV		
T_1	20.76	14.23	15.26	52.43	44.94	31.94
T_2	20.04	16.23	13.81	50.99	45.74	30.86
T_3	20.25	14.89	11.13	51.78	44.67	32.03
T_4	23.36	16.27	10.98	51.62	51.59	30.76
T_5	20.45	13.76	11.09	51.71	46.01	29.55
T_6	26.69	18.01	15.46	52.72	52.32	32.17
T_7	23.28	17.64	14.67	50.33	50.76	31.24
T_8	21.50	13.57	11.16	47.27	46.98	31.07
T_9	22.42	11.48	12.61	49.48	45.29	30.97
T_{10}	18.11	10.31	10.98	41.87	43.38	29.04
T_{11}	20.76	14.13	14.30	47.31	46.59	30.01
CD (P=0.05)	4.19	4.18	2.21	4.48	3.38	1.82

TCV, Tree canopy volume; ASEG, Annual shoot extension growth

30 kg/tree (T_7) treatments but significantly higher to all other treatments under study. Similarly, maximum increase in trunk diameter (18.01%) was recorded in T_6. This treatment was closely followed by T_7 and both these treatments had significant increase in trunk diameter than 50% RDF + one application of jeevamrut (T_9) and 4 applications of jeevamrut at monthly intervals (T_{10}). Trees that received 75% RDF + vermicompost 15 kg/tree (T_6) had highest increase in tree spread (15.46%), followed by RDF (T_1). Both of these treatments had significant effect on increase in tree spread except 75% RDF + wild apricot cake 2.5 kg/tree (T_2), T_7 and 25% RDF + wild apricot cake 1.25 kg + neem cake 1.25 kg + vermicompost 15 kg + jeevamrut (T_{11}). Highest increase in canopy volume (52.72%) was also recorded in trees treated with 75% RDF + vermicompost 15 kg/tree (T_6) followed by T_1. However, least annual increase in tree height, trunk diameter, and tree spread and canopy volume was found in T_{10}.

Maximum annual shoot growth (52.32 cm) was attained by the trees in T_6 which was statistically at par with T_4 and T_7. Similarly, trees under T_6 exhibited highest leaf area (32.17 cm^2), followed by T_1 and T_3. These treatments had significantly higher leaf area than T_5, T_{10} and T_{11}. Whereas, minimum annual shoot growth and leaf area was observed in T_{10}. The increase in tree height, trunk diameter, tree spread, tree volume and higher annual shoot growth as well as leaf area with the integrated application of chemical fertilizers and vermicompost may be attributed to improvement in soil physical properties and microbial activity, which increased the availability of nutrients to the plants in the presence of organic amendments like vermicompost. Improved soil physical conditions create more favorable condition for plant growth and supplying the trees with the nutrient elements (Helail *et al*. 2003). Thus better soil conditions coupled with higher nutrient elements availability may have contributed to higher growth and vigour of the trees under inorganic fertilizers and vermicompost. Gautam *et al.* (2012) also had recorded maximum plant height, spread and volume in mango with 500, 250, 250 g NPK/tree, respectively + 50 kg FYM + 10 kg vermicompost. Ghosh *et al.* (2012) also observed maximum growth of plants in respect of plant height, stem girth and canopy volume with the application of FYM and vermicompost along with inorganic fertilizers in pomegranate plants.

Leaf nutrient concentration

It is clear from the data presented in Table 2 that integration of organic and inorganic fertilizers had significant effect on leaf macro and micro-nutrients content. The

Table 2 Leaf nutrient concentration influenced by conjoint nutrient sources in peach cv. July Elberta

Treatment	Macronutrient (%)			Mesonutrient (%)		Micronutrient (ppm)			
	N	P	K	Ca	Mg	Cu	Zn	Fe	Mn
T_1	2.42	0.27	1.33	1.65	0.52	11.51	24.34	219.61	56.93
T_2	2.34	0.26	1.17	1.62	0.45	10.59	25.92	214.95	56.70
T_3	2.34	0.24	1.22	1.64	0.50	11.44	24.31	221.56	54.60
T_4	2.35	0.22	1.18	1.61	0.48	10.61	23.77	216.96	54.03
T_5	2.43	0.28	1.20	1.63	0.52	11.28	25.21	200.85	54.96
T_6	2.46	0.27	1.35	1.66	0.57	11.54	26.14	224.20	58.11
T_7	2.41	0.30	1.30	1.67	0.54	11.47	23.96	223.04	57.00
T_8	2.37	0.24	1.14	1.57	0.44	10.40	22.51	207.67	54.73
T_9	2.13	0.25	1.07	1.59	0.47	10.59	22.40	204.70	55.33
T_{10}	2.09	0.22	1.05	1.54	0.43	10.44	23.17	204.37	52.62
T_{11}	2.39	0.26	1.18	1.62	0.47	11.33	21.24	213.26	53.14
CD (P=0.05)	0.05	NS	0.07	0.03	0.02	0.87	1.63	8.49	NS

NS, Non-significant

trees fertilized with T_6 treatment registered highest leaf N (2.46%), which was statistically at par with T_1, T_5 and T_7 but significantly higher than all other treatments. However, leaf P was not influenced significantly by conjoint application of organic and inorganic fertilizers. Highest leaf K (1.35%) was recorded in trees in T_6, which was statistically at par with T_1 and T_7 but significantly higher than all other treatments. Maximum leaf Ca (1.67%) was noticed in T_7 followed by T_6 and both these treatments were statistically at par with T_1 and T_3. Trees in T_6 had highest leaf Mg (0.57%) which was significantly higher compared to all other treatments. However, minimum leaf N, K, Ca and Mg contents were recorded in trees treated with T_{10}.

Maximum leaf Cu (11.54 ppm) was recorded in trees which received T_6 treatment, which was followed by T_1 (11.51 ppm). Both these treatments were statistically at par with T_3, T_5, T_7 and T_{11}. Trees subjected to T_6 had highest leaf Zn (26.14 ppm), which was statistically at par with T_2 and T_5. Similarly, highest leaf Fe (224.20 ppm) was recorded in T_6 followed by T_7. Both of these treatments had higher leaf Fe than those of T_5, T_8, T_9, T_{10} and T_{11}. However, leaf Mn was not influenced significantly by integrated application of organic and inorganic fertilizers. Minimum leaf Cu content was observed in T_8, leaf Zn in T_{11} and leaf Fe in T_5. Higher leaf nutrient content comprising integrated application of vermicompost and inorganic fertilizers may be ascribed due to higher mineralization coupled with microbial activity in the presence of vermicompost. Use of organic amendments, i.e. vermicompost facilitate better absorption and translocation of mineral nutrients by the plant system (Anitha and Prema 2003). Addition of organic manures along with inorganic fertilizers might have improved the soil aeration and moisture retention in root zone and improved root development thus increased leaf nutrient contents by increasing water and nutrients supply to the plant (Morselli *et al*. 2004). Singh *et al*. (2012) also observed significant increase in macro and micro-nutrient contents of apricot leaves with the application of vermicompost, cow urine and 50% NPK. Similar increase in concentration of leaf nutrients with the combined application of FYM along with 50% dose of inorganic fertilizers in sweet orange (Marathe *et al*. 2012) and guava (Goswami *et al*. 2012).

Soil properties

The perusal of data presented in Table 3 showed that application of organic and inorganic fertilizers had significantly influenced fertility and microbial status of peach orchard soil. Soil pH and electrical conductivity did not differ significantly among different combinations of organic and inorganic nutrient sources. Organic carbon (1.96%) was recorded maximum in soil in T_7, which was significantly higher than all other treatments under study. The presence of higher organic matter in the organic manures perhaps have accounted for higher organic carbon under vermicompost along with varing rates of RDF treatments. Marimuthu *et al*. (2001) also observed higher organic carbon content of soil with the integrated application of organic and inorganic fertilizers as compared to inorganic fertilizers only. Soil nitrogen (279.96 kg/ha) was recorded highest in tree basins that received T_6, which was statistically at par with T_1, T_3, T_7 and T_9 but significantly higher than all other treatments under study. Maximum available P (73.39 kg/ha) was recorded in T_7, which was significantly higher than all other treatments. However, available K could not influence significantly by integrated nutrient management treatments. Integration of organic manures with inorganic fertilizers may have created favorable conditions for microbial activity through improved soil physical properties which accelerated the rate of mineralization and led to more release of nutrients from native organic sources (Raina and

Table 3 Effect of conjoint nutrient sources on chemical and microbial properties of rhizosphere soil in peach cv. July Elberta

Treatment	pH	EC (dS/m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Microbial population (cfu/g)		
							Bacteria (× 10^7)	Fungi (× 10^4)	Actinomycetes (× 10^4)
T_1	7.45	0.193	1.64	279.16	56.70	431.44	37.21	6.96	12.70
T_2	7.41	0.163	1.79	278.65	52.56	375.13	38.96	7.62	13.21
T_3	7.32	0.192	1.68	279.82	61.62	425.60	39.88	7.70	12.96
T_4	7.31	0.174	1.66	278.73	53.40	394.40	41.94	7.06	13.14
T_5	7.43	0.128	1.76	278.83	57.56	422.53	43.19	7.66	13.33
T_6	7.37	0.181	1.91	279.96	65.79	425.60	43.58	7.76	12.85
T_7	7.10	0.142	1.96	279.90	73.39	448.00	43.99	7.96	13.29
T_8	7.33	0.124	1.65	279.02	65.57	356.00	42.37	7.47	13.11
T_9	7.32	0.163	1.66	279.03	64.19	344.10	42.71	7.42	13.56
T_{10}	7.34	0.114	1.69	277.43	65.27	328.53	43.89	7.70	13.73
T_{11}	7.11	0.160	1.71	277.94	52.75	323.82	40.59	7.52	13.68
CD (P=0.05)	NS	NS	0.04	0.93	3.90	NS	1.70	0.30	NS

NS, Non-significant; EC, electrical conductivity OC, organic carbon

Goswami 1988). The reaction of organic acids produced after decomposition of organic manures release unavailable P in the soil to available forms. Singh *et al*. (2012) also reported significant increase in buildup of available N and P in the soil with the application of organic manures and inorganic fertilizers.

Among different treatments, maximum bacterial count (43.99 cfu/g) was observed in T_7 followed by T_5, T_6, T_8, T_9 and T_{10}. Highest fungal population (7.96 cfu/g) was recorded in T_7. This superior treatment had significantly higher fungi population than T_1 and T_4. Minimum bacterial and fungi population were noticed in T_1. However, actinomycetes population was not influenced significantly by different integrated nutrient management treatments. The higher proportion of organic manures and lower proportion of chemical fertilizers in the combination increased microbial population of the soil. This increase in microbial population might be due to the fact that organic manures provide food and micro-environment to the microbes by releasing CO_2 during the process of decomposition in the soil which helps in multiplication and growth of microbes (Kumari and Kumari 2002). Moreover, organic manures act as an excellent substrate for soil microbes and increase the proportion of labile carbon and nitrogen, directly stimulating the population and activity of micro-organisms. The increase in microbial population in the presence of organic manures may also be attributed to greater availability of organic carbon and mineralized nutrients for their proliferation and further cellular development (Marathe *et al*. 2012). Mukherjee *et al.* (2000) also reported higher microbial population and enzymatic activity with application of vermicomost. Tiwari *et al.* (2001) also observed increased population of soil microbes like bacteria and fungi with the sole application of organic manures or in combination with the inorganic fertilizers.

Conclusions

Integration of organic manures and inorganic fertilizers for nutrient management in peach orchard significantly increased plant growth, leaf nutrients content and soil chemical well as microbial properties. Among the different integrated nutrient management treatments, application of 75% RDF + vermicompost 15 kg/tree was found most effective in improving the plant growth and nutritional status of plant and soil of peach orchards in mid hill conditions of Himachal Pradesh.

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