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Effect of bio-organic and inorganic nutrient sources to improve leaf nutrient status in apricot

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ABSTRACT

The present study was carried out on 20-year-old 'New Castle' apricot (*Prunus armeniaca* L.) trees grown in Shiwalik hill range of north-western Himalayan region of India. The conjoint efficacy of bio-organics used along with chemical fertilizers for improving leaf nutrient content. Bio-organic nutrient sources namely, vermi-compost (VC), bio-fertilizer (BF), cow urine (CU) and two levels of NPK fertilizers, *i.e.* 75 and 50% of recommended dose were evaluated in 13 different treatment combinations. The conjoint treatment application of bio-fertilizer- 60 g tree^{-1}, vermi-compost- 30 kg tree^{-1}, cow urine -12.5% as foliar application and 50% NPK significantly improved total N, P, K, Ca, Mg, Fe, Cu, Zn and Mn contents of leaf and was significantly increased by 30.4, 109.5, 31.6, 33.5, 65.7, 34.6, 71.9, 47.5 and 31.3%, respectively over control (traditional orchard practice). The study inferred a saving of 50% of NPK fertilizers over the traditional orchard practice being followed in the region.

Key words: Vermi-compost, cow urine, bio-stabilization, leaf nutrients.

Apricot (*Prunus armeniaca* L.) is an important stone fruit of the mid-hills of Himachal Pradesh under Shiwalik hill range of north-western Himalayan region (NWHR) of India. The average annual productivity of apricot in India is 4.2 MT/ha, which is far less than an international level. Fertilizer is the most critical and costly input for sustaining crop production to ensure food security of the country. The imbalanced use of costly chemical fertilizers in apricot has led to decrease in nutrient uptake efficiency. Organics are effective alternatives and have the required potential to improve yield to save costly chemical fertilizers input. The epigeic earthworms recycle organic waste materials into enriched vermi-compost. Another important input, cow urine is a vital component in improving soil fertility, possesses an inherent property of acting not only as fertilizer but also as a mild biocide. Besides, bio-fertilizers are renewable source of low cost biological inputs and have been described as a viable component for integrated nutrient management to enhance crop production. Use of costly and scarce chemical fertilizers is much exorbitant to poor hill farmers of the region. The present studies was therefore, were conducted with the objective to evaluate the conjoint effect of bio-organics and chemical fertilizers on leaf nutrient content of apricot, as the information on these aspects is very scanty in the region.

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The field experiment was conducted during 2005-07 on 'New Castle' apricot trees (20-year-old), planted at 6 m × 6 m apart. The study site was located at the Experimental Research Farm of Department of Fruit Science, Dr YSPUH&F, Nauni, Solan, Himachal Pradesh. The experimental orchard is situated at an elevation of 1,240 m above mean sea level between 30° 50' 45'' N and 77° 08'30" E longitude. The climate of the study site is sub-temperate, experiencing annual rainfall between 100 and 130 cm. The orchard soil was sandy in texture having pH 6.5, 0.61 dS m^{-1} electrical conductivity and 0.63% organic carbon. The water-holding capacity, bulk density and porosity at 15 cm depth of surface soil were 31.93, 1.29 and 47.77%, respectively. The initial available nitrogen, phosphorus and potassium content in the experimental soil were 308.94, 12.72 and 341.80 kg ha^{-1}, respectively. DTPA extractable micronutrient content in the form of iron, copper, zinc and manganese was 55.26, 2.49, 2.16 and 44.39 ppm, respectively. The experiment was laid out considering two levels of NPK fertilizers (75 and 50% of full recommended dose), bio-fertilizers (BF), vermi-compost (VC) and cow urine (CU) in different conjoint combinations. Nine different treatment combinations of bio-organic and inorganic nutrient sources were applied during two years of the study. Different inputs of bio-organic and inorganic nutrients, *i.e.* bio-fertilizers: 30 g tree^{-1} (BF_{30}); bio-fertilizers: 60 g tree^{-1} (BF_{60}); vermi-compost: 30 g tree^{-1} (VC_{30}), cow urine: 12.5%, spray of 10 liter tree^{-1}) ($CU_{12.5}$), cow urine: 25%, spray of 10 liter tree^{-1} (CU_{25}) as foliar application were applied in different conjoint combinations (T_1-T_8) along with a control (T_9) of recommended dose of fertilizer with following conjoint combinations: $BF_{30}VC_{30}CU_{25}NPK_{50}$ (T_1); $BF_{30}VC_{30}CU_{25}NPK_{75}$ (T_2); $BF_{30}VC_{30}CU_{12.5}$ NPK_{50} (T_3); $BF_{30}VC_{30}CU_{12.5}$ NPK_{75} (T_4); $BF_{60}VC_{30}CU_{25}NPK_{50}$ (T_5);$BF_{60}VC_{30}CU_{25}NPK_{75}$ (T_6); $BF_{60}VC_{30}CU_{12.5}NPK_{50}$ (T_7); $BF_{60}VC_{30}CU_{12.5}NPK_{75}$ (T_8) and control (recommended NPK fertilizers along with farmyard manure as used by the farmers) (T_9). The application of bio-fertilizers was done in the form of N_2-fixing diazotroph ($x10^7$ bacterial colony forming units per gram of *Azotobacter chroococcum* of strain A_{41}), phosphorus solubilizing bacteria ($x10^7$ cfu g^{-1} each of *Pseudomonas* and *Bacillus* spp.) and arbuscular mycorrhizal fungi (40,000 viable spores of *Glomus fasciculatum* per 50 g) were applied at 15 cm depth in the basin of each tree as band application, and followed by a light irrigation for further proliferation of the cultures. Agricultural residues, dry waste materials of tree leaves, mixed vegetable residues (organic waste) were inoculated with adult epigeic earthworms (*Eisenia foetida*) for the preparation of vermi-compost. Vermi-compost used in the experiment contained 2.12% N, 0.93% P_2O_5, 1.11% K_2O, 174.8 ppm Fe, 96.31 ppm Mn, 24.23 ppm Zn and 4.78 ppm Cu. Another input, i.e. cow urine contained 1.20% N, P_2O_5 in traces and 1.00% K. Cow urine was applied as foliar spray between 15 and 30 days of fruit set. FYM contained 0.50% N, 0.25% P, 0.40% K, 0.45% Fe, 0.0003% Cu, 0.004% Zn and 0.007% Mn. The dose of bio-organic sources was determined to compensate the full recommended dose of NPK to trees. Traditionally, the hill farmers are using recommended dose of fertilizer application as 40 kg FYM, 600 g N, 250 g P_2O_5 and 700 g K_2O to full bearing apricot trees >10-year-old of age. Full dose of FYM, P_2O_5 and K_2O were applied during the months of December-January before the onset of winters. Half dose of N was applied in 2nd fortnight of February and the remaining dose was applied during 1st fortnight of the month of May. The NPK fertilizers sources used were urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). Nitrogen was applied in two splits, i.e. 1st half during the 1st week of March before flowering and 2nd half after 30 days of the fruit set. Phosphatic and potassic fertilizers were applied along with farmyard manure/ vermi-compost as band application during December.

To estimate macro- and micro-nutrient contents of the foliage, the representative sample size of 50-fully expanded leaves along with petiole from the middle portion of the current season's shoot growth was collected during 1st fortnight of the month of July (Chapman, 2), washed with tap water followed by 0.1 N HCl and then finally with double distilled water. The digestion of leaf sample (1 g) for the estimation of total N was carried out in concentrated H_2SO_4 containing digestion mixture of potassium sulphate (400-parts), copper sulphate (20-parts), mercuric oxide (3-parts) and selenium powder (1-part). For the estimation of total P, K, Ca, Mg, Fe, Cu, Zn and Mn content, the samples (0.5 g) were digested in diacid (HNO_3: $HClO_4$) in the ratio of 4:1 (Piper, 9). Total N was determined on auto-analyzer Kjel Tech model Foss Tecator-2300 and P by vanado-molybdate-phosphoric yellow colour method. Total K, Ca, Mg, Fe, Cu, Zn and Mn contents were estimated on Perkin Elmer atomic absorption spectrophotometer. The experiment to observe the effect of conjoint combinations of bio-organic and inorganic nutrient sources was laid out in Randomized Block Design according to Panse and Sukhatme (8). All of the treatments were replicated thrice. The data obtained were subjected to further statistical analysis to evaluate the comparative efficacy among different treatment combinations applied. The significance of variation among the treatments was observed by applying 'F' test and thus critical difference was calculated at 5% level of probability.

Leaf nitrogen content was significantly influenced by all conjoint treatments applied. Amongst, the conjoint treatment applications, the treatment T_8 ($B_{60}VC_{30}CU_{12.5}NPK_{75}$) resulted in maximum (2.92%) leaf N content followed by T_6 ($B_{60}VC_{30}U_{25}NPK_{75}$), T_7 ($B_{60}VC_{30}U_{12.5}NPK_{50}$) and T_4 ($BF_{30}VC_{30}CU_{12.5}NPK_{75}$) with corresponding value of 2.86, 2.77, 2.76%, whereas, minimum (2.24%) was recorded in T_9 (control) (Table 1). The treatment combination T_8 showed 30.4% higher leaf nitrogen content over control (recommended dose of application/ traditional practice). Higher N can also be attributed to the improvement in soil aeration, better soil moisture retention in root zone, increased microbial nitrogen fixation due to the conjoint application, and thus improved its availability to the plants. The addition of vermi-compost improves physical properties of soil, moisture retention in soil rhizosphere, improved root development by mycelial network of arbuscular mycorrhizal fungi, thus increased the water absorption and nutrients and thus improved the nutrient contents of leaf (Morselli *et al.*, 7; Gupta *et al.*, 5). The treatment combination T_7 resulted in maximum (0.44%) leaf P content followed by T_8 (0.39%) and T_6 (0.38%), whereas, minimum (0.32%) was recorded with treatment T_1 ($BF_{30}VC_{30}CU_{25}NPK_{50}$). Maximum P content was estimated in T_7 treatment is recorded 109.5% higher than control treatment. Phosphorous is applied to the soil in inorganic form get fixed up and is not readily available to the plant but released slowly due to microbial culture present in the soil,

Table 1. Influence of conjoint application of bio-organic and inorganic nutrient sources on macro-nutrient content in apricot.

Treatment	Treatment detail	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
No.		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
T_1	$BF_{30}VC_{30}CU_{25}NPK_{50}$	2.51	2.74	2.63	0.30	0.33	0.32	3.45	3.51	3.48	2.17	2.26	2.22	0.77	0.81	0.79
T_2	$BF_{30}VC_{30}CU_{25}NPK_{75}$	2.68	2.75	2.72	0.32	0.34	0.33	3.24	3.29	3.27	2.08	2.20	2.14	0.71	0.76	0.74
T_3	$BF_{30}VC_{30}CU_{12.5}NPK_{50}$	2.55	2.76	2.66	0.34	0.36	0.35	3.48	3.52	3.50	2.23	2.35	2.29	0.82	0.89	0.85
T_4	$BF_{30}VC_{30}CU_{12.5}NPK_{75}$	2.73	2.79	2.76	0.33	0.35	0.34	3.28	3.30	3.29	2.18	2.22	2.20	0.78	0.85	0.81
T_5	$BF_{60}VC_{30}CU_{25}NPK_{50}$	2.72	2.76	2.74	0.32	0.36	0.34	3.68	3.73	3.71	2.41	2.58	2.50	0.84	0.98	0.91
T_6	$BF_{60}VC_{30}CU_{25}NPK_{75}$	2.83	2.89	2.86	0.37	0.39	0.38	3.26	3.31	3.29	2.35	2.49	2.42	0.78	0.87	0.82
T_7	$BF_{60}VC_{30}CU_{12.5}NPK_{50}$	2.74	2.79	2.92	0.42	0.46	0.44	3.72	3.78	3.75	2.58	2.67	2.63	1.05	1.17	1.11
T_8	$BF_{60}VC_{30}CU_{12.5}NPK_{75}$	2.88	2.96	2.77	0.36	0.40	0.39	3.34	3.39	3.37	2.42	2.57	2.51	1.01	1.07	1.04
T_9	Control	2.22	2.26	2.24	0.18	0.23	0.21	2.81	2.88	2.85	1.92	2.01	1.97	0.63	0.71	0.67
	CD (P = 0.05)	0.13	0.16	0.14	0.06	0.06	0.04	0.14	0.15	0.21	0.08	0.06	0.06	0.07	0.08	0.08

BF_{30}, Bio-fertilizers-30 g tree^{-1}; BF_{60}, Bio-fertilizers, 60 g tree^{-1}; VC_{30}, vermi-compost-30 kg tree^{-1}; CU_{25}, cow urine-25% in water; $CU_{12.5}$, cow urine-12.5% in water as foliar spray

Table 2. Influence of conjoint application of bio-organic and inorganic nutrient sources on micro-nutrient content of apricot leaf.

Treatment	Treatment detail	Fe (ppm)			Cu (ppm)			Zn (ppm)			Mn (ppm)		
No.		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
T_1	$BF_{30}VC_{30}CU_{25}NPK_{50}$	126.53	122.75	126.53	14.91	16.13	15.52	65.20	67.62	66.41	60.29	62.07	61.18
T_2	$BF_{30}VC_{30}CU_{25}NPK_{75}$	122.74	118.59	122.74	13.69	14.54	14.11	63.94	66.40	65.17	58.08	59.80	58.94
T_3	$BF_{30}VC_{30}CU_{12.5}NPK_{50}$	131.56	130.35	131.56	17.34	17.96	17.65	66.72	69.85	68.29	61.23	63.28	62.25
T_4	$BF_{30}VC_{30}CU_{12.5}NPK_{75}$	129.84	127.42	129.84	15.72	16.42	16.07	65.79	68.74	67.27	59.16	61.05	60.11
T_5	$BF_{60}VC_{30}CU_{25}NPK_{50}$	131.96	129.30	131.96	16.84	17.77	17.30	71.13	71.48	71.30	67.05	70.69	68.87
T_6	$BF_{60}VC_{30}CU_{25}NPK_{75}$	127.13	125.52	127.13	14.37	15.48	14.93	68.11	69.83	68.97	66.25	68.85	67.55
T_7	$BF_{60}VC_{30}CU_{12.5}NPK_{50}$	140.21	137.54	140.21	18.74	21.91	20.33	78.55	80.47	79.51	68.75	74.41	71.58
T_8	$BF_{60}VC_{30}CU_{12.5}NPK_{75}$	135.87	132.33	135.87	16.54	19.32	17.93	73.07	74.60	73.84	67.32	71.67	69.49
T_9	Control	104.13	102.16	104.13	11.09	12.55	11.82	52.79	55.03	53.91	54.18	54.86	54.52
	CD (P = 0.05)	1.81	1.98	1.59	0.61	0.71	0.65	4.56	3.24	3.46	2.05	1.81	1.90

BF_{30}, Bio-fertilizers-30 g tree^{-1}; BF_{60}, Bio-fertilizers, 60 g tree^{-1}; VC_{30}, vermi-compost-30 kg tree^{-1}; CU_{25}, cow urine-25% in water; $CU_{12.5}$, cow urine-12.5% in water as foliar spray solubilized the fixed phosphorus and makes it easily and readily available to the plant (Sundara *et al.*, 14). Moreover, arbuscular mycorrhizal fungi would have helped in better P uptake due to synergistic effect (Balakrishnan *et al.*, 1). The greater absorption of phosphate by arbuscular mycorrhizal fungi is because of its superior efficacy towards uptake from labile form of soil phosphates (Gianinnazi-Peerson *et al.*, 4). The treatment combination of T_7 resulted in maximum (3.75%) leaf K content followed by T_5 ($BF_{60}VC_{30}CU_{25}NPK_{50}$), T_3 ($BF_{30}VC_{30}CU_{12.5}NPK_{50}$) and T_1 recorded corresponding values of 3.71, 3.50 and 3.48, respectively, whereas, minimum (2.81%) was recorded in T_2 ($BF_{30}VC_{30}CU_{25}NPK_{75}$) treatment. Similarly, maximum (1.11%) leaf Mg content was also recorded in T_7 also treatment combination followed by T_8 (1.04 %) and T_5 (0.91%). *Azotobacter chroococcum* secretes plant growth regulators in the soil rhizosphere, which have lowered pH soil and thereby making K easily available to the plant. The increased and steady availability of nutrients from vermi-compost have resulted in increased uptake of nutrients by plants (Rajkhowa *et al.*, 11). Chaudhary *et al.* (3) observed an increase of N, P and K content due to combined application of vermi-compost and farmyard manure. Hangarge *et al.* (6) reported higher N, P and K content with the application of vermi-compost and cow dung slurry. Besides, phosphorus is synergistic with calcium and that might be responsible for higher uptake of calcium with increasing phosphorus levels. Interestingly, when P was applied with phosphorous solubilizing microbial culture, the uptake of leaf Mg content increased possibly due to the improvement in soil conditions as well as mineralization of salts, making them readily available to the plant system.

The perusal of data given in Table 2 revealed that leaf Fe content was influenced significantly by different treatments. Maximum (140.21 ppm) leaf Fe content was recorded in T_7 followed by T_8, T_5 and T_3 treatment combinations with corresponding value of 135.87, 131.96, 131.56 ppm, whereas minimum (122.74 ppm) was recorded in T_2. The treatment combination of T_7 showed 34.6% increase of leaf Fe content over control. The treatment combination (T_7) also resulted in maximum (20.33 ppm) leaf Cu content followed by T_8 (17.93 ppm) and T_3 (17.65 ppm), whereas, minimum (14.11 ppm) was recorded with conjoint application of treatment T_2. Similarly, maximum (79.51 ppm) leaf Zn content was found in T_7 and showed 47.49% increase over control. Similarly, maximum of 71.58 ppm leaf Mn content was found in T_7 followed by T_8, T_5 with corresponding values of 69.49 and 68.87 ppm, whereas, minimum (54.52 ppm) was recorded in control. However, 31.3% increase over control was found in T_7. The increase in leaf Fe and Zn content due to the enhancement in concentration of these elements in soil profile on addition of organic manures, vermi-compost and bio-fertilizer along with inorganic fertilizers (Prakash *et al.*, 10; Sen, 12). Webber and Singh (16) observed that the incorporation of cow manure when supplemented with organic manures and inorganic fertilizers enhanced Zn availability. Besides, AM fungi increases root colonization, which in turn increased the surface area for absorption. Direct mycorrhizal effects on mineral nutrient may be limited to these nutrient ions, which have poor mobility and are present in low concentrations. In other studies, it is inferred that in the soil solution (like Zn and Cu) and the application of AM fungi converted complex and insoluble form of nutrients to soluble form to make them easily available to plant system and synergistic effect among these nutrient cations (Balakrishnan *et al.*, 1). Vasanthi and Kumarswamy (15) reported that Fe and Cu status was significantly higher in the treatments received vermi-compost due to mineralization of P and K present in organic form and release from native source (Singh *et al.*, 13).

This study therefore, investigated the combined effect of conjoint bio-organic and inorganic nutrient sources on improving the leaf nutrient content of apricot. The results showed that conjoint application of 60 g of bio-fertilizers (*Pseudomonas*, *Bacillus*, *A. chroococcum* and AM fungi), 30 kg of vermi-compost and spray of 12.5% of cow urine as foliar application along with 50% NPK fertilizers had significantly improved total N, P, K, Ca, Mg, Fe, Cu, Zn and Mn content of leaf with corresponding increase by 30.4, 109.5, 31.6, 33.5, 65.7, 34.6, 71.9, 47.5 and 31.3%, respectively over recommended orchard fertilizer application.

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