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Effect of Soil Amendments on Growth Characteristics of Apple (*Malus x domestica*) cv. Starking Delicious

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ABSTRACT: *In apple there is declining trend in productivity and plant health. The old apple orchards planted in the 1970-'80s need rejuvenation and replacement because ageing has severely affected the productivity of apple trees. To accomplish the requirement of apple saplings for replacement of old orchards, orchardist can meet their planting materials requirements by growing their own apple nursery as per need. The soil amendments of apple nursery fields help in the production of healthy and vigorous planting materials with residual effects also. Residual effect of the various soil amendments studied during the year 2010-11 was evident even one year (2012-13) after the application of the amendments. Maximum shoot length (38.94 cm) trunk girth (5.66 mm), root length (33.33 cm) and root volume (33.33 cc) were observed in treatment T_6 (application of bio control agent* Trichoderma viride*, soil amendments by* Vitex*/garlic leaves, soil heating and Bavistein @ 0.1%) as compared to the control treatment (T_{10}) viz. 20.69 cm, 3.63 mm, 13.67 cm and 23.33 cc respectively.*

Keywords*: Rejuvenation, Replacement, Soil amendments, Residual effect.*

INTODUCTION

Cultivation of apple has become main occupation and major source of economy to the farming community of Himachal Pradesh particularly in the temperate regions. The production and supply of healthy apple nursery is key factor in the establishment of healthy orchard. The nursery production can be carried out at lower elevation also at an altitude of 1200 m to 2500 m average mean sea level (AMSL). One year old seedlings after grafting with desired scion variety embrace the price tag of ₹ 30-70. Hence, it can be a good prospective for small farmers within limited input. The own production of apple nursery helps in the rejuvenation of old apple orchard and establishment of new apple orchard. It reduces the dependency on other agency for procurement of apple saplings. Apple cultivation requires 1,000-1,500 hours of chilling below 7°C during winter to break the rest period. Soil depth, drainage and pH determine the suitability of soil types. Loamy soils, rich in organic matter having a pH of 5.5-7.5 with gentle to moderate slope, proper drainage and good aeration are most suitable. The average summer temperature should be around 21-24°C during active growth period. In winter the average temperature should not exceed the chilling requirement i.e. below 7°C. The areas of rainfall of 100-125 cm throughout the growing season are favorable (Kishor *et al*., 2006).

Verma *et al*., 2009 investigated that the improvement in soil moisture availability, pH, organic carbon and nutrient status of the soil was significant under organic manure. Growth parameters, fruit characteristics and yield were recorded maximum with application of organic manure. Soil solarization for 12 weeks resulted in maximum reduction in the population of fungi, bacteria and actinomycetes, at 5, 10 and 15cm depths with 19.56, 35.00 and 40.00 per cent survival of *Dematophora necatrix* propagules at these depths, respectively (Sharma and Sharma, 2005). Hence, soil solarization carried out for longer durations can be utilized for soil borne disease management in temperate regions (Sharma *et al*., 2005). All the biocontrol agents significantly enhanced plant height, seedling diameter, root length and plant biomass as compared to uninoculated or pathogen-inoculated controls. Molin *et al*., (2011) in their study clearly indicated that EC relates with soil texture and moisture, and may represent an important and low

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price tool for collecting data and characterizing soil physical properties.

The objectives of present study firstly are to use easy, cost free and eco-friendly practices in nursery production for improving the production of healthy apple nurseries for establishment of orchards biodynamically. Secondly, recycling of organic waste of fields, energy input along with soil amendments to make nursery production practice familiar and recognizing its economic importance along with use of bio control agents to regulate soil health and the production of healthy and vigorous standard rootstocks for grafting with scion of desired variety.

MATERIALS AND METHODS

The present study was carried out at Churag, in Mandi district of Himachal Pradesh (India) situated at an elevation AMSL of 1740 m 31°20′ N latitude 77°08′ E longitudes during 2012-13.The present study which was aimed to analyze residual effect of soil amendments carried out during 2010-11 on growth characteristics viz. plant height, stem girth, root volume, root length and number of internodes of Starking delicious apples grafted on standard apple rootstocks (Fig. 1). The treatments were applied during growing season while growth parameters were recorded during dormancy period in winter. The overall details of the treatments at experimental field were as follow:

T_1 - Application of *Trichoderma viride* @ 100g/sqm

T_2 - Soil amendments i.e. *Vitex*/garlic leaves@1 kg/sqm

T_3 - Soil heating by burning straw/Soil solarization

T_4 - $T_1 + T_3$

T_5 - $T_1 + T_2 + T_3$

T_6 - $T_1 + T_2 + T_3 + T_8$ (if required)

T_7 - $T_1 + T_2$

T_8 - Application of chemicals

T_9 - Soil solarization (polythene sheet i.e. 25 μm thick)

T_{10}- Control

The soil samples were drawn from experimental fields consequently during same growth season (2012-13) to determine the soil characteristics viz. pH, EC, microbial population, organic carbon and matter and presented in Table 1. The determination of pH and electrical conductivity (EC) were made with a 'Lab Quest' with pH & EC probe. It was used to measure the electrical conductivity of a 1:2 soil: water suspension. The reagents used were distilled water and standardizing solution Sodium Chloride solution (500mg/L) with 1000 μS/cm EC for calibration as per manufacturer's instruction. The water is to have an electrical conductivity of < 1 μS/cm and have Co_2 concentration no more than atmosphere equilibrium (Rayment and Higginson, 1992). The soil samples were

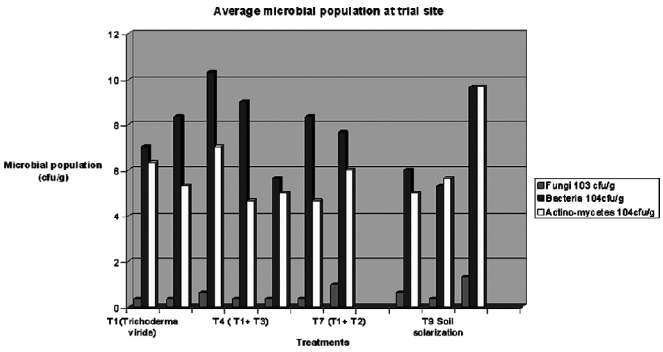

Figure 1: Pictorial presentation of microbial population in different treatments

Table 1
Status of microbial population, organic carbon/matter and electrical conductivity of soil of experimental nursery site, Churag block, Distt. Mandi (H.P).

		Av. Microbial Population					
Treatments	*pH*	*Fungi 10^3 cfu/g*	*Bacteria 10^4cfu/g*	*Actino-mycetes 10^4cfu/g*	*Organic carbon (%)*	*Organic matter (%)*	*Electrical conductivity in μs/cm Range (0-2000)*
T_1(*Trichoderma viride*)	6.89	1.33	7.00	6.33	1.15	1.98	485
T_2(Soil amendments)	6.79	0.33	8.33	5.33	1.07	1.84	428
T_3 (Soil burning)	6.68	0.66	10.33	7.00	0.98	1.68	462
T_4 (T_1+ T_3)	6.80	0.33	9.00	4.66	1.00	1.72	470
T_5 (T_1+T_2+T_3)	6.75	0.33	5.66	5.00	1.27	2.18	454
T_6 (T_1+T_2+T_3+T_8 (if required)	6.81	0.33	8.33	4.66	1.20	2.06	471
T_7 (T_1+ T_2)	6.78	1.00	7.66	6.00	1.23	2.12	405
T_8 Application of chemicals	6.48	0.66	6.00	5.00	1.13	1.94	395
T_9 Soil solarization	6.63	0.33	5.33	5.66	1.10	1.89	472
T_{10} Control	6.60	0.33	9.66	9.66	0.95	1.63	480

further analyzed for the estimation of organic carbon and organic matter collected from experimental nurseries. The chromic acid titration/ rapid digestion method was used for its estimation. Plant growth characteristics such as plant height, girth, leaf area, fresh and dry root weight were recorded for each treatment at experimental sites and presented in Table 2. The plants were selected randomly and plant height was recorded from stem base to the tip of the seedlings. Plant girth was measured with the help of vernier clipper and recorded in millimeter. Leaf area measurements were recorded with the help of leaf area meter and expressed in square centimeter. Ten leaves were taken from each treatment. Root weight was recorded after uprooting three plants at random from each treatment. The root portion was cut from the stem base, washed in tap water, air dried and fresh root weight was recorded in grams per plant. After that the roots were dried in oven at 50°C for 5-6 days till constant dry weight was achieved. The residual effect of the soil amendments on growth parameters under study was carried out during 2012-13 and emphasized on non-destructive method of analysis. The data so obtained for different characters was averaged and analyzed statistically.

Table 2
Effect of different treatments on plant growth characters at nursery trial site, Churag block of Distt. Mandi (H.P)

Treatment No.	*Seedling height (cm)*	*Av. fresh root weight (g)*	*Av. dry roots weight (g)*	*Av. leaf area (sq. cm)*	*Av. seedling girth (mm)*
T_1 *Trichoderma viride*	73.50	2.30	1.19	19.75	5.44
T_2 Soil amendment-*Vitex* leaves	91.80	3.80	1.52	22.08	6.77
T_3 Soil Heating-by burning stubbles	85.60	2.28	1.47	23.65	6.65
T_4 (T_1+ T_3)	88.19	1.97	0.85	25.94	6.68
T_5 (T_1+T_2+T_3)	107.10	1.69	0.75	23.99	7.18
T_6 (T_5+T_8 if required)	105.00	3.25	1.28	22.10	6.87
T_7 (T_1+ T_2)	98.10	2.06	0.93	21.99	6.67
T_8 (Bavistin @0.1%)	91.70	2.23	0.95	21.82	5.99
T_9 Soil solarization	94.50	2.07	0.84	20.30	6.07
T_{10} Control	95.40	1.27	0.53	23.71	5.93

RESULTS AND DISCUSSION

Soil moisture, pH, organic carbon and available N, P and K were recorded maximum under the application of commercial organic manure @ 20 kg tree^{-1} treatment and Farm yard manure @ 100 kg tree^{-1} . Better quality apple fruits were also obtained under the application of commercial organic manure @ 20 kg tree^{-1} and Farm yard manure @ 100 kg tree^{-1} during both the years of experimentation (Verma *et al.*, 2010). The growth parameters of apple saplings and soil characteristics viz. pH, electrical conductivity, organic carbon and organic matter were evaluated to find out best treatments at trial apple nursery site. The soil samples were analyzed for microbial population, pH, EC, organic carbon/ matter status during the application of treatments (Table 1).

1. pH

The pH of all samples ranged from 6.48(T_8) to 6.89(T_1). Increase in the pH value toward neutral i.e. pH 7 increase the plant height and girth value. The fresh root weight (3.80g) and dry root weight (1.52 g) had maximum value on pH 6.79 (T_2). The maximum leaf area (25.94 cm^2) was observed on pH 6.80 (T_4). Shoot growth increased with soil pH. The highest yield (boxes/tree) was obtained at pH 6.0-6.5 and the largest fruits were produced at pH 5.5-6.9. Low soil pH was associated with high concentrations of Mn in the leaves and fruit and a reduction in fruit red skin color (Raese 1995).

2. Electrical Conductivity (EC)

The electrical conductivity (0-2000µs/cm) was ranged from 395µs/cm (T8) to 485µs/cm (T_1). The maximum plant height and girth were observed on EC value 454.00µS/cm (T_5). The maximum value of fresh and dry root weight were observed on EC value 428.00µS/cm (T2).The maximum leaf area was observed on EC value 470.00µS/cm (T_4).

3. Organic Carbon/Matter contents

Organic matter and carbon ranged between 1.63 % (T_{10}) to 2.18% (T_5) and 0.95% (T_{10}) to 1.27% (T_5) respectively. The maximum plant height and girth were observed on OC value 1.27% and OM value 2.18% in T_5. The maximum fresh and dry root weight were observed on OC value 1.07% (T_2). The OM value for same was 1.84% (T_2). The maximum leaf area was observed on value OC 1.00% and OM 1.72% in T_4.

4. Microbial population

Microbial count showed that fungal population ranged between 0.33×10^3 (T_{10}) to 1.33×10^3 (T_1) and bacterial population ranges from 5.33×10^4 (T_9) to 10.33×10^4 (T_3). Similarly actinomycetes population ranged from 4.66×10^4 (T_4) to 9.66×10^4 (Control).The microbial population of bacteria, fungi and actinomycetes were maximum in T_3, T_1 and Control respectively. The minimum values for the same were observed in T_9, T_{10} and T_4 respectively.

5. Growth parameters

After observing the growth features of seedlings in the Table-2, the maximum average height was 107.10 cm in T_5 followed by T_6 (105.00 cm) and minimum average height was 73.50 cm (T_1). The seedling girth was ranged from 5.44mm (T_1) to 7.18 mm (T_5). The fresh root weight ranged from 1.27g (control) to 3.80 g (T_2) and dry weight ranged from 0.53g (control) to 1.52g (T_2). The application of biocontrol agent *Trichoderma viride* (TV) @100g/sqm mixed with FYM and its combined use with other soil amendments viz. *Vitex* leaves (VL) @1kg/sqm, soil heating by burning (SHB) i.e. TV+VL+SHB influenced the soil characteristics and growth parameters at experimental field.

The soil characteristics of above treatments gave maximum growth parameter values in T_2 and T_5. The fresh root weight (3.80g) and dry root weight (1.52g) had maximum value on pH 6.79 (T_2). The maximum leaf area (25.94 cm^2) was observed on pH 6.80 (T_4). The maximum plant height and girth were observed on EC value 454.00 µS/cm (T_5) and pH 6.75 (T_5). The maximum value of fresh and dry root weight were observed on EC value 428.00µS/cm (T_2).The maximum leaf area was observed on EC value 470.00 µS/cm (T_4).The maximum plant height and girth were observed on OC value 1.27% and OM value 2.18% in T_5. The maximum fresh and dry root weight were observed on OC value 1.07% (T_2). The OM value for same was 1.84% (T_2). The maximum leaf area was observed on value OC 1.00% and OM 1.72% in T_4. The microbial population of bacteria, fungi and actinomycetes were examined maximum in T_3, T_1 and Control respectively.

Residual Effect of Soil Treatments on Growth of cv. Starking Delicious apple grafts

Residual effect of the various soil amendments studied during the course of study was evident even one year (2012-13.Table 3) after the application of amendments. Maximum shoot length (38.94 cm) trunk girth (5.66 mm), root length (33.33 cm) and root volume (33.33 cc) were observed in treatment T6 as compared to the control treatment (T_{10}) figures, viz. 20.69 cm, 3.63 mm, 13.67 cm and 23.33 cc respectively. With respect to number of internodes treatment T_7 (44.00) exhibited the maximum number of internodes. Treatment T_6 exhibited 43.33 internodes which were statistically at par with the T_7 treatment. The control treatment exhibited minimum value for all the traits except for the number of internodes and root volume.

Table 3
Residual Effect of Soil Treatments on Growth of cv. Starking Delicious apple

Treatments	*Shoot length (cm)*	*Trunk girth (mm)*	*No. of internodes*	*Root length (cm)*	*Root volume (cc)*
T_1	34.86	3.94	40.67	22.67	15.00
T_2	29.47	4.05	36.33	18.33	15.00
T_3	25.78	4.01	37.67	22.67	10.00
T_4	28.28	4.52	36.67	21.00	15.00
T_5	28.78	4.64	38.00	26.67	18.33
T_6	38.94	5.66	43.33	33.33	33.33
T_7	32.89	5.20	44.00	30.67	29.00
T_8	21.78	3.83	28.00	20.00	15.00
T_9	16.89	3.59	19.67	23.33	18.33
T_{10}	20.69	3.63	25.33	13.67	23.33
C.D. (0.05)	3.40	0.30	3.01	N.S.	4.79

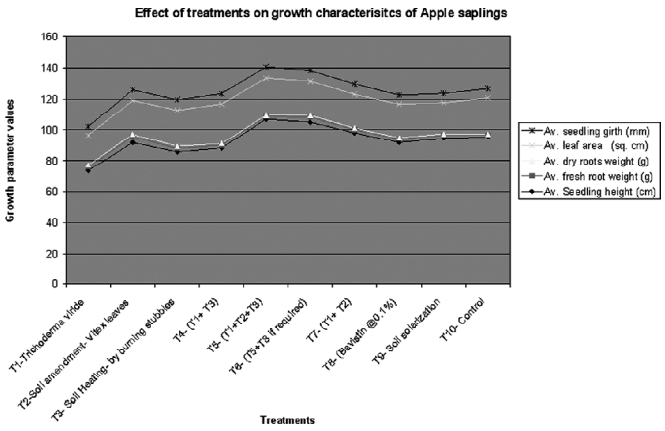

Figure 2: Effect of soil amendments on growth characterisitcs

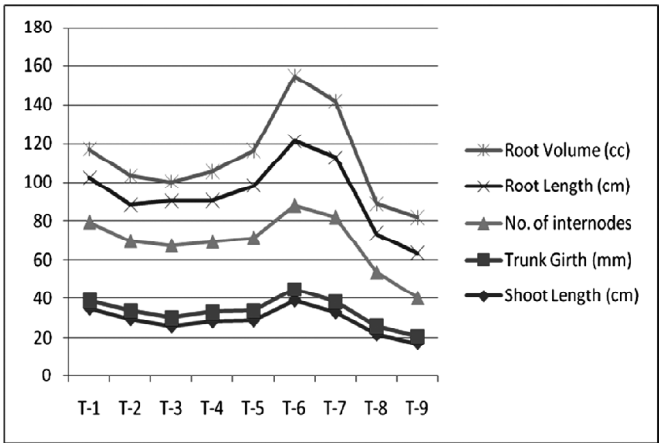

Figure 4: Residual effect of soil amendments on growth characteristics

The survival percentage of apple sapling in above treatments was 80% in treatment 5 followed by 71% in treatment 9 and minimum survival percentage was in control i.e 35% only after studying the residual impacts of soil amendments. The effect of soil

amendments and its residual effects on growth characteristics are presented in Figure 2 & 3 respectively.

CONCLUSION

The application of biocontrol agents and use of chopped leaves of medicinal plants viz. *Vitex nigundoo* along with soil heating by burning overcome the drawbacks of conventional method of apple nursery production and ensure organic nursery production with vigorous saplings. The less input along with organic waste recycling in the cultivation of apple nursery impact growth parameters of apple sapling. The application of soil amendments regulate the population of soil micro flora and increase the organic carbon or matter contents also. The residual impacts of these soil amendments were effective for consecutive year with satisfactory survival percentage of apple saplings. These soil amendments ensure enhanced resistance against soil borne diseases of apple nursery.

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