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Research Paper

Effect of soil application of nutrients on growth, yield and quality of apple (*Malus x domestica* Borkh.) cv. silver spur under high density plantation

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ABSTRACT

Field experiment was conducted in the Experimental Block of the Division of Fruit Science at Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar campus, Srinagar (J&K) during the years 2020 and 2021. Eight years old apple cultivar Silver Spur grafted on M.9 planted at a distance of 3 x 2 meter of uniform age, vigor and girth were used for the study. The experiment comprised of three levels of vermicompost (5, 7.5 and 10 kg) and four levels of nitrogen (75, 100, 125 and 150 g) + potassium (100, 150, 200 and 250 g) of twelve treatments combinations and the experiment was laid out in randomized complete block design with three replications. Observations were recorded on the growth (incremental plant height, plant spread, plant girth, annual extension growth and trunk cross sectional area), fruit yield, fruit weight and total sugars. Amongst the different treatment combinations under study V_3F_4 (Vermicompost @ 10 kg + N @ 150 g + K_2O @ 250g) proved to be superior in improving the growth, yield and quality of the Silver Spur apple.

Key words: Apple, growth, , nutrients, soil, vegetative, yield

Almost entire apple fruit plantation of the Union Territory of Jammu and Kashmir is still on seedling rootstock and on which plants attain huge size and become unmanageable, ultimately hampering the production and productivity. Clonal rootstocks offer a viable solution to this problem, which have been used by the fruit growers in scientifically advanced countries for better management and quality fruit production (Hooijdonk *et al.* 2006). Increased production can only be achieved by shifting from low density to high density orcharding. With the emerging trend of size controlling clonal rootstocks and spur type apple varieties, a lot of varieties are introduced by Union Territory of Jammu and Kashmir which are suitable for high density planting and government of Union Territory has also taken up an initiative on large scale to shift towards high density planting system for better yield and quality. High density apple plantation has gained popularity during recent times due to manifold increase in productivity (Robinson, 2003) and is precocious, easily manageable with higher yield potential, better quality fruits and higher returns per unit area.

Nutritional deficiency generally causes a reduction in the fruit yield and quality before visible symptoms develop. Nutrition of high density orchards had great importance in ensuring higher production from younger plantings (Bright, 2005). Nutritional elements that affect cropping consist of both major and minor elements. Nitrogen is one of the most important nutrients required by the plants as it is a major constituent of protein, nucleotides as well as chlorophyll (Mengel *et al.*, 2001) and has both direct and indirect effects on the regularity of cropping. Potassium is also one of the major essential nutrients and often described as the quality element which plays an important role in promoting synthesis of photosynthates and their transport to fruits, formation of starch and protein synthesis (Brunetto *et al.*, 2015). For higher yields and quality fruit, potassium is needed in higher levels. Therefore, nutrient management is very critical for optimum productivity of high

density apple as nutrients play an important role in enhancing good plant growth, yield and fruit quality as compared to the vigorous trees as high-density apple trees fruit earlier, have good yield potential and smaller root system. Keeping in view the above facts present study was conducted to determine the effect of nutrients on vegetative, yield and quality parameters of apple cv. Silver Spur/M9 under high density planting system.

MATERIALS AND METHODS

The present investigation was conducted in the Experimental Block of Division of Fruit Science at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar campus, Srinagar (J & K) during two consecutive years i.e. 2020 and 2021. Eight year old apple cultivar Silver Spur/M.9 planted at a distance of 3 x 2 meter of uniform age, vigor and girth were used for the study. The experiment comprised of twelve treatments viz., V_1F_1 (Vermicompost @ 5 Kg + N @ 75 g + K_2O @ 100g), V_1F_2 (Vermicompost @ 5 Kg + N @ 100 g + K_2O @ 150g), V_1F_3 (Vermicompost @ 5Kg + N @ 125 g + K_2O @ 200g), V_1F_4 (Vermicompost @ 5 Kg + N @ 150 g + K_2O @ 250g), V_2F_1 (Vermicompost @ 7.5 Kg + N @ 75 g + K_2O @ 100g), V_2F_2 (Vermicompost @ 7.5 Kg + N @ 100 g + K_2O @ 150g), V_2F_3 (Vermicompost @ 7.5 Kg + N @ 125 g + K_2O @ 200g), V_2F_4 (Vermicompost @ 7.5 Kg + N @ 150 g + K_2O @ 250g), V_3F_1 (Vermicompost @ 10 Kg + N @ 75 g + K_2O @ 100g), V_3F_2 (Vermicompost @ 10 Kg + N @ 100 g + K_2O @ 150g), V_3F_3 (Vermicompost @ 10 Kg + N @ 125 g + K_2O @ 200g) and V_3F_4 (Vermicompost @ 10 Kg + N @ 150 g + K_2O @ 250g) was laid out in randomized complete block design with three replications. Observations were recorded on vegetative growth parameters under each treatments and replication. Incremental plant height was recorded before the start and after the completion of the experiment with the help of a graduated staff and expressed in cm. Plant spread was measured with the help of measuring tape in two directions i.e. east-west and north-south at the end of growing season, averaged and expressed in metre. Plant girth was measured at 30 cm above the ground level before the start and after the completion of experiment with the help of measuring tape and was expressed in cm. Annual extension growth of the current season shoots was measured on four shoots selected randomly on each plant, averaged and expressed in cm. Trunk cross sectional area was measured fifteen centimeter above bud union and expressed as cm^2 using following formula.

$$\text{Area} = \frac{(\text{girth})^2}{4\pi}$$

Fruit yield per plant was recorded by weighing the total number of fruits per tree at the time of harvesting and expressed in kg. Fruit weight (g) was determined with the help of digital weighing machine. Total sugars (%) were determined as per the standard procedures (AOAC, 2000). Data generated from these investigations were appropriately computed, tabulated and statistically analyzed as per the procedure given by Snedecor and Cochran (1994). The level of significance was tested for different variable at 5 per cent level of significance.

RESULTS AND DISCUSSION

Significant results were obtained among all the treatments with respect to vegetative characters. The data presented in Table 1 reveal that incremental plant height and plant spread of apple cv. Silver Spur was significantly influenced by the soil application of vermin-compost and fertilizers during both the year of study. Among different doses of vermin-compost maximum increment in plant height (42.47 and 44.09 cm) was obtained with vermin-compost @ 10 kg which was statistically higher among all other doses of vermin-compost whereas minimum increment in plant height (38.03 and 39.85 cm) was recorded with the application of vermin-compost @ 5 kg. With respect to fertilizer doses highest increment in plant height (44.19 and 45.93 cm) was measured with the application of N @ 150g + K_2O @ 250g which was statistically higher among all other treatments and lowest increment in plant height (36.17 and 38.23 cm) was measured in F_1 i.e. N @ 75g + K_2O @ 100g. Interaction studies of vermin-compost and fertilizers also showed significant results for increment in plant height and maximum increment in plant height (46.94 and 48.10 cm) was recorded in treatment combination V_3F_4 i.e. vermin-compost @ 10 kg + N @ 150g + K_2O @ 250g whereas the lowest (34.20 and 36.30 cm) was found in V_1F_1 i.e. vermin-compost @ 5kg + N @ 75g + K_2O @ 100g during the first and second year of investigation, respectively. Maximum plant spread (1.37 and 1.49 m) was recorded with the soil application of vermin-compost @ 10 kg which was statistically higher among all other vermin-compost treatments during the year 2020 and 2021, respectively whereas minimum plant spread (1.16 and 1.26 m, respectively) was measured with 5 kg vermin-compost. Maximum plant spread (1.38 and 1.48 m) was recorded with the application of N @ 150g + K_2O @ 250g which was statistically higher in the first year whereas it was

statistically at par with N @ 125g + K_2O @ 200g (1.42 m) however minimum plant spread (1.16 and 1.26 cm) was recorded with the application of N @ 75g + K_2O @ 100g. Significant results were obtained during both the year of study among the interaction studies of vermin-compost and fertilizers, highest plant spread (1.48 and 1.60 m) was measured in treatment combination of V_3F_4 i.e. vermin-compost @ 10 kg + N @ 150g + K_2O @ 250g which was statistically at par with V_3F_3 i.e. vermin-compost @ 10 Kg + N @ 125 g + K_2O @ 200g (1.42 and 1.54 m) however lowest (1.05 and 1.15 m) was found in V_1F_1 i.e. vermin-compost @ 5kg + N @ 75g + K_2O @ 100g during the first and second year of investigation, respectively. Increase in growth parameters with higher dose of vermin-compost 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 (Kumar *et al.*, 2008). Present findings are in agreement with those of Suman (2011) and Fayaz *et al*. (2021) in apple. High nutrients rate is directly responsible for growth of the apple plants and can be attributed to the fact that among major nutrients, potassium act as an activator of enzymes involved in synthesis of certain peptide bonds during protein synthesis and plays an important role in photosynthesis and translocation of carbohydrates (Milosevic *et al.*, 2019).

Table 1: Effect of soil application of nutrients on incremental plant height and plant spread of apple cv. silver spur

Fertilizer dose	Incremental plant height (cm)								Plant spread (m)							
	2020				2021				2020				2021			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
F_1	34.20	36.10	38.23	36.17	36.30	38.30	40.10	38.23	1.05	1.17	1.25	1.16	1.15	1.27	1.36	1.26
F_2	36.40	38.61	40.81	38.60	38.50	40.54	42.30	40.44	1.14	1.19	1.35	1.23	1.23	1.29	1.46	1.32
F_3	39.63	41.32	43.92	41.62	41.23	43.40	45.89	43.50	1.18	1.31	1.42	1.30	1.30	1.41	1.54	1.42
F_4	41.89	43.76	46.94	44.19	43.37	46.33	48.10	45.93	1.28	1.37	1.48	1.38	1.38	1.47	1.60	1.48
Mean	38.03	39.94	42.47		39.85	42.14	44.09		1.16	1.26	1.37		1.26	1.36	1.49	
$CD_{0.05}$																
Fertilizer (F)	0.28				0.51				0.04				0.09			
Vermicomposting (V)	0.24				0.44				0.04				0.08			
F x V	0.49				0.88				0.07				0.10			

Plant girth was significantly influenced by the application of vermin-compost and fertilizers during both the year of study and data presented in Table 2 depicts that maximum plant girth (25.20 and 25.47 cm, respectively) was recorded with the application of vermin-compost @ 10 kg which was statistically higher among all other treatments however minimum (24.26 and 24.48 cm, respectively) was observed in 5 kg vermin-compost. During both the year of study, highest plant girth (25.14 and 25.63 cm) was recorded with N @ 150g + K_2O @ 250g which was statistically at par with N @ 125g + K_2O @ 200g (24.94 and 25.22 cm) however minimum (24.28 and 24.34 cm) was recorded with the application of N @ 75g + K_2O @ 100g. Vermin-compost and fertilizers interaction showed significant results during both the year of study and maximum plant girth (25.42 and 25.91 cm) was recorded with the treatment combination of vermin-compost @ 10 kg + N @ 150g + K_2O @ 250g which was statistically at par with V_3F_3 i.e. vermi-compost @ 10 Kg + N @ 125 g + K_2O @ 200g and V_2F_4 (Vermicompost @ 7.5 Kg + N @ 150 g + K_2O @ 250g) whereas minimum plant girth (23.90 and 24.01 cm, respectively) was recorded in V_1F_1 i.e. vermi-compost @ 5kg + N @ 75g + K_2O @ 100g. Significant results were recorded for annual shoot extension during both the year of study (Table 2) and among the vermin-compost treatments highest annual shoot extension (44.18 and 46.42 cm) was recorded with the application of vermin-compost @ 10 kg which was statistically higher among all other treatments whereas minimum annual shoot extension (40.13 and 41.36 cm) was observed in vermin-compost @ 5 kg. With the application of different fertilizers, highest annual shoot extension (45.86 and 47.61 cm) was measured with N @ 150g + K_2O @ 250g which was statistically higher among all other treatments whereas minimum (37.83 and 38.99 cm) was recorded with N @ 75g + K_2O @ 100g. Interaction studies of vermin-compost and fertilizers also showed that maximum increment in annual shoot extension (47.43 and 50.96 cm) was recorded in treatment combination of V_3F_4 i.e. vermin-compost @ 10 kg + N @ 150g + K_2O @ 250g which was statistically higher among all other treatment combinations whereas the lowest (35.27 and 36.76 cm) was found in V_1F_1 i.e. vermin-compost @ 5kg + N @ 75g + K_2O @ 100g during the first and second year of investigation, respectively. The increment in plant girth and annual extension growth was probably due to more absorption of nitrogen and potassium by plant,

which is directly involved in carbohydrate synthesis in the leaves leading to formation of many bio-compounds *viz*; amino acids, proteins, chlorophyll and other amides. The absorbed nitrogen ultimately might have been utilized by the plants in the formation of complex substances like protein and amino acids which in turn help to build up new tissues (Cheng, 2002). The results are in agreement with the findings of Dar *et al.* (2016) who reported increment in plant girth and annual shoot extension of plum with application of fertilizers.

Table 2: Effect of soil application of nutrients on plant girth and incremental annual shoot extension of apple cv. silver spur

Fertilizer dose	Plant girth (cm)								Incremental annual shoot extension (cm)							
	2020				2021				2020				2021			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
F_1	23.90	24.24	24.70	24.28	24.01	24.33	25.23	24.34	35.27	38.68	39.56	37.83	36.76	39.70	40.53	38.99
F_2	24.10	24.53	25.30	24.64	24.23	24.73	25.53	24.83	39.23	41.62	44.40	41.75	40.33	43.33	46.55	43.40
F_3	24.33	25.10	25.41	24.94	24.45	25.43	25.76	25.22	41.59	43.53	45.33	43.48	43.16	45.53	47.65	45.45
F_4	24.71	25.30	25.42	25.14	25.24	25.77	25.91	25.63	44.46	45.69	47.43	45.86	45.21	46.66	50.96	47.61
Mean	24.26	24.79	25.20		24.48	25.06	25.47		40.13	42.38	44.18		41.36	43.80	46.42	
$CD_{0.05}$																
Fertilizer (F)		0.30				0.39				0.67				1.37		
Vermicompost (V)		0.25				0.42				0.52				1.18		
F x V		0.15				0.18				0.62				0.90		

Data presented in Fig 1 depicts significant results with respect to trunk cross sectional area with the application of vermin-compost and fertilizers, however interaction study showed non-significant results during both the year of study. Maximum increment in trunk cross sectional area (50.59 and 52.21 cm^2) was recorded with the application of vermin-compost @ 10 kg which was statistically higher among all other treatments whereas minimum increment in trunk cross sectional area (46.86 and 48.78 cm^2) was observed in vermin-compost @ 5 kg. During both the year of study, highest trunk cross sectional area (50.47 and 52.28 cm^2) was recorded with the application N @ 150g + K_2O @ 250g which was higher among all other treatments however minimum increment (46.94 and 47.89 cm^2) was recorded with the application of N @ 75g + K_2O @ 100g. Interaction studies of vermin-compost and fertilizers showed non-significant results for that maximum increment in trunk cross sectional area. The supply of nutrients at adequate doses would have increased the synthesis of IAA stimulating cell elongation and increasing the plant height and stem girth (Zhao, 2010). Present findings are in agreement with those of Zhong *et al*. (2019) and Fayaz *et al*. (2021) in apple.

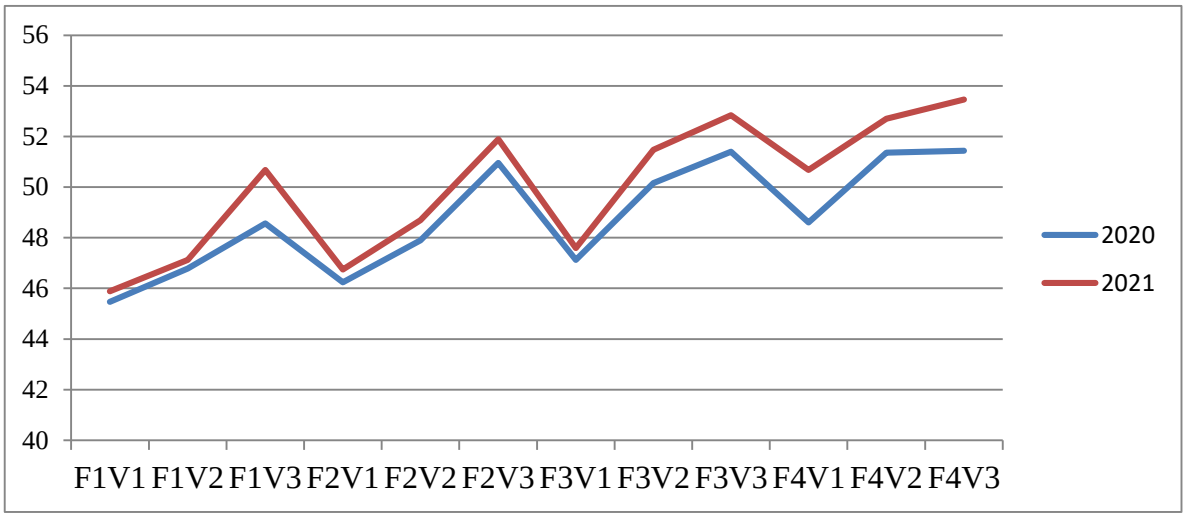

Fig. 1: Effect of soil application of nutrients on trunk cross sectional area (cm^2) of apple cv. silver spur

Table 3 depicts significant effect of vermin-compost and fertilizer on fruit weight during both the year of study. Highest (210.28 and 212.86 g) fruit weight was recorded with the application of 10 kg vermin-compost which was statistically higher among all the vermin-compost treatments whereas lowest (203.68 and 205.65 g) fruit weight was obtained with 5 kg vermin-compost, respectively during both the years i.e. 2020 and 2021. Fertilizer dose @ N: 150 g + K_2O: 250g showed highest fruit weight (219.16 and 221.27 g) which was statistically higher among all other treatments and lowest fruit weight (196.13 and 198.29 g) was recorded with N @ 75g + K_2O @ 100g. Interaction study of vermicompost and fertilizers showed significant results for fruit weight and maximum fruit weight (222.68 and 224.63 g) was observed with V_3F_4 (vermicompost @ 10 kg + N @ 150g + K_2O @ 250g) combination which was statistically higher among all the treatment combinations however minimum (193.02 and 195.03 g) fruit weight was obtained with V_1F_1 (vermicompost @ 5 kg+ N @ 75g + K_2O @ 100g) treatment combination. Increase in fruit weight with the application of fertilizers and vermicompost is mainly attributed to the roles played by nitrogen, potassium and vermicompost in increasing cell division and cell elongation, thereby increasing photosynthetic activities of plant leading to increased fruit weight. Furthermore, the increase in fruit weight may be due to the fact that these nutrients help in higher CO_2 assimilation, which leads to higher rate of synthesis and supply of carbohydrates towards the sink i.e. fruit, thereby increasing fruit weight (Kumar *et al.*, 2017). Similar results in apple were also obtained by Nava *et al*. (2008). Fruit yield was significantly influenced with the application of vermicompost and fertilizers during the both the years 2020 and 2021 (Table 3). Considering the effect of vermicompost significantly highest fruit yield (15.80 and 16.53 kg/tree) was observed with the application of 10 kg vermicompost and lowest (12.87 and 13.98 kg/tree) was recorded with 5 kg vermicompost. With respect to fertilizer dose, highest fruit yield (15.80 and 16.54 kg/tree) was recorded with the application of N @ 150g + K_2O @ 250g which was statistically higher among all other treatments and lowest (12.87 and 13.44 kg/tree) with the application of N @ 75g + K_2O @ 100g. Treatment combinations of vermicompost and fertilizers depicts that highest fruit yield (17.63 and 18.38 kg/tree) was recorded with V_3F_4 (vermicompost @ 10 kg + N @ 150g + K_2O @ 250g) treatment combinations during both the years of study which was statistically higher among all other treatment combinations and lowest fruit yield (12.00 and 12.70 kg/tree) was obtained with V_1F_1 (vermicompost @ 5 kg+ N @ 75g + K_2O @ 100g) treatment combination. Increase in fruit yield may be due to the availability of nutrients at adequate doses that would have increased the synthesis of IAA, thereby stimulating cell elongation, increasing the fruit physical parameters like fruit length, breadth, weight and ultimately yield. Furthermore, at optimized nutrient distribution, growth hormones like auxins, gibberellins and cytokinins are produced which increases the nutrient uptake and translocation of assimilates aiding toward enhanced yield (Nava and Dachen, 2009). These findings are in agreement with those of Kachwaya *et al*. (2016) in strawberry and Zhong *et al*. (2019) in apple.

Table 3: Effect of soil application of nutrients on fruit weight and yield of apple cv. silver spur

Fertilizer dose	Fruit weight (g)								Yield (kg/tree)							
	2020				2021				2020				2021			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
F_1	193.02	196.29	199.10	196.13	195.03	198.74	201.12	198.29	12.00	12.71	13.92	12.87	12.70	13.20	14.42	13.44
F_2	199.66	202.59	205.33	202.52	201.64	205.10	209.45	205.39	12.33	13.50	14.86	13.56	14.84	13.80	15.83	14.82
F_3	206.39	210.37	214.03	210.26	208.32	212.55	216.29	212.38	13.00	14.50	16.80	14.76	13.53	15.40	17.50	15.47
F_4	215.66	219.14	222.68	219.16	217.64	221.56	224.63	221.27	14.18	15.60	17.63	15.80	14.84	16.40	18.38	16.54
Mean	203.68	207.09	210.28		205.65	209.47	212.86		12.87	14.07	15.80		13.98	14.70	16.53	
$CD_{0.05}$																
Fertilizer (F)	2.60				1.64				0.49				0.58			
Vermicompost (V)	2.25				1.42				0.42				0.50			
F x V	3.10				2.84				0.80				0.65			

Total sugar was significantly influenced with the application of vermicompost, fertilizers and their treatment combinations during both the years of study i.e. 2020 and 2021 (Table-4). Maximum total sugar (11.66 and 12.00 %) was recorded with 10 kg of vermicompost which was statistically higher among all other vermicompost treatments whereas minimum (9.93 and 10.24 %) total sugar was recorded with 5 kg vermicompost in both the years, respectively. During both the years of study, application of fertilizer dose @ N @ 150g + K_2O @ 250g registered maximum (11.68 and 11.94 %) total sugars which was statistically at par with the application of N @ 125g + K_2O @ 200g (11.15 and 11.94 %) whereas minimum (9.91 and 10.29 %) total

sugar was recorded with fertilizer dose of N @ 75g + K_2O @ 100g. The interaction effect of vermicompost and fertilizer also reveal the significant effect on total sugar content and highest value (12.34 and 12.40 %) was recorded in treatment combination V_3F_4 (vermicompost @ 10kg + N @ 150g + K_2O @250 g) which was statistically at par with V_3F_3 (vermicompost @ 10kg + N @ 125g + K_2O @ 200g) having a value of (12.30 and 12.32 %, respectively) and lowest (9.20 and 9.45 %) total sugar was recorded with V_1F_1 (vermicompost @ 5 kg+ N @ 75g + K_2O @ 100g) treatment combination. Enhancement in total sugars may be due to the role of nutrients especially potassium in enhancing the rate of hydrolysis of polysaccharides into mono-saccharides, transport of sugars into the fruit and improving the efficiency of metabolic and physiological processes of plants (Taiz and Zeiger, 2004). The present findings are in accordance with those of Wojcik (2005) in apple and Dar *et al*. (2012) in pear.

Table 4: Effect of soil application of nutrients on total sugars of apple cv. Silver Spur

Fertilizer dose	**Total sugar (%)**							
	2020				2021			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
F_1	9.20	9.80	10.74	9.91	9.45	10.23	11.20	10.29
F_2	9.46	10.24	11.28	10.32	9.84	10.55	12.08	10.82
F_3	10.06	11.10	12.30	11.15	10.35	11.65	12.32	11.44
F_4	11.03	11.67	12.34	11.68	11.32	12.10	12.40	11.94
Mean	9.93	10.70	11.66		10.24	11.13	12.00	
$CD_{0.05}$								
Fertilizer (F)		0.65				0.82		
Vermicompost (V)		0.56				0.71		
F x V		0.11				0.20		

CONCLUSION

In the present study soil application of nutrients viz. vermicompost @ 10 Kg + N @ 150 g + K_2O @ 250g significantly improved the growth, yield and quality of the apple cv. Silver Spur in terms of the studied parameters thereby proved to be best treatment combination in enhancing the vegetative growth of plant.

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