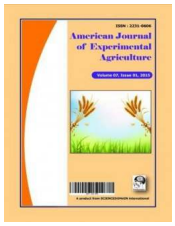

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Response of Different Walnut (*Juglans regia* L.) Selection to Combined Application of Inorganic Fertilizers and Organic Manures

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The effectiveness of combined application of inorganic fertilizers and organic manures was studied on four walnut selections in temperate region of India (Kashmir). The experiment consisted of four selections [SKAU/002 (S_1), SKAU/008 (S_2), SKAU/024 (S_3) and SKAU/040 (S_4)] and six treatments [T_1 (NPK recommended as per package of practices through inorganic fertilizers), T_2 {100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)}, T_3 (75% NPK through inorganic fertilizers + 25% through FYM), T_4 (75% NPK through inorganic fertilizers + 25% through vermicompost), T_5 (75% NPK through inorganic fertilizers + 25% through poultry manure) and T_6 {75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)} replicated five times and three tree in each replication in Factorial Randomized Block Design. All fertilizers and manures were applied in the first week of December beneath the tree canopy and incorporated well with soil. There was significant difference in vegetative growth

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and yield parameters among different treatments as well as different walnut selections. Results reveal that maximum increment in tree height (16.12%), tree girth (1.40%), tree canopy volume (37.85 m^3), shoot extension growth (0.81 m), fruit set (40.52%) fruit retention (58.21%), yield (5.87 kg/tree) was found in treatment T_4. Within selections S_1 showed maximum fruit set (38.96%) and fruit retention (57.53%), however S_2 recorded highest yield (5.53 kg/tree).

Keywords: Chemical fertilizers; growth; organic manure; walnut; yield.

1. INTRODUCTION

Jammu and Kashmir State has created a special place in the international trade of walnuts. The entire export of the country comes from Jammu and Kashmir State. In Jammu and Kashmir State walnut is grown on an area of about 89,788 ha with annual production of about 163,745 metric tons [1] with the productivity of 1.823 metric tons per hectare. It produces about 98 per cent of the total production in India.

The demand of quality walnuts is increasing in the national and international market, but production of walnut is still low as compared to China, USA, France and other developed countries. Production of horticultural crops has undergone enormous changes in the recent years due to the development of innovative technologies including nutrient management practice. The nutrient management of walnut is one of the important factors to boost the yield and improve the quality of nuts. The application of fertilizers to add N, P and K have influenced the growth of tree and production of fruits like chestnut, grapes, pears, figs and walnut trees [2-4]. Fertilization treatments have the potential for increasing growth and nut production of walnuts [5]. Though the chemical farming helped the farmers to accomplish new strides in horticulture, their indiscriminate and unscrupulous use in horticulture/agriculture has led to soil health deterioration. The increased use of fertilizers in non-judicious manner, has led to diminishing soil productivity and multiple nutrient deficiencies. The gravity of environmental degradation caused by the faulty cultivation practices has led to focus on ecologically sound, viable and sustainable farming systems.

Minimizing use of chemical fertilizers in fruit production is a goal of integrated fruit production [6,7]. Recently, environmental aspects of plant nutrient applications have received much interest. When applied to the soil, organic manures have positive impact on soil fertility leading to increased yields over several years. It has been reported that farm yard manure (FYM), vermicompost and poultry manure have increased growth, yield and quality in different crops [8-10]. Thus it has been realised that use of chemical fertilizers must be integrated through more economic and eco-friendly organic manures in order to achieve the substantial productivity with minimum deleterious effect of chemical fertilizers on soil health and environment. One such alternative horticulture system, which will help to overcome the problem of soil degradation and declining soil fertility and crop yield, is integrated nutrient management (INM). The target of this investigation was to study the influence of combined application of inorganic fertilizers and organic manures on four walnut selections.

2. MATERIALS AND METHODS

The experimental orchard is located at Ambri Apple Research Station Pahnoo Shopian. This experimental farm is located at 33.72°N latitude and 74.83° E longitudes, at an elevation of 2,057 m, representing high hill zone of the state. The climate of the area is typically temperate. Nutritional needs were determined based on a soil test results (Table 1) prior to fertilizer applications. The studies were conducted in a 9-year old walnut orchard on four selections SKAU/002 (S_1), SKAU/008 (S_2), SKAU/024 (S_3), and SKAU/040 (S_4) grafted on seedling rootstock planted at the 6 m X 6 m tree spacing Trees with uniform age and vigor were selected for this experiment. The treatments were laid out in randomized block design (Factorial), containing five replications with tree trees in each replication. The treatments are: T_1 (NPK recommended as per package of practices through inorganic fertilizers), T_2 {100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)}, T_3 (75% NPK through inorganic fertilizers + 25% through manure (FYM), T_4 (75% NPK through inorganic fertilizers + 25% through manure (vermicompost), T_5 (75% NPK through inorganic fertilizers + 25% through manure (poultry manure) and T_6 (75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure). The recommended dose during first year is 200 g N, 50 g P and 200 g K and

Table 1. Chemical properties of experimental orchard soil before start of experiment

pH	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Exchangeable Ca (ppm)	Exchangeable Mg (ppm)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)
6.82	1.15	308	17.5	230	1197.45	160.23	48.9	0.98	2.58	64.2

Table 2. Chemical composition of organic fertilizers used for the experiment

Parameter manure	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Organic carbon (%)
FYM	0.68	0.32	0.73	0.72	0.18	144.20	62.24	15.30	2.4	10.22
Vermicompost	2.48	0.89	1.67	0.82	0.17	162.15	71.50	22.00	3.72	17.85
Poultry manure	2.97	0.95	1.19	1.84	0.41	202.81	52.50	18.00	2.93	14.55

during second year 250 g N, 60 g P and 250 g K using urea, DAP and MOP as inorganic fertilizer source. There were 24 treatment combinations. Farm yard manure, vermicompost; poultry manure and inorganic fertilizer were applied to each replication as per the treatment details. All fertilizers and manures were applied in the first week of December under the tree canopy and incorporated well with soil. Chemical composition of organic fertilizers used for the experiment is given in Table 2.

The height of a tree was measured with the help of a graduated tape from the bottom to the top of the tree at the beginning and at the end of growing season and expressed as per cent increment. The trunk girth of each tree was recorded 10 cm above the graft union at the beginning and at the end of growing season with the help measuring tape and expressed as per cent increment in trunk girth in per cent. Volume of tree canopy was calculated by using the formula given by Westwood [11] and expressed in m^3.

a) For a tree that is taller than its width

$$\text{Volume} = \frac{4}{3}\ \pi\ ab^2$$

b) For a tree that is wider than its height

$$\text{Volume} = \frac{4}{3}\ \pi\ a^2b$$

Where π= 3.14159
a= one half of major axis
b= one half of minor axis

Annual Shoot extension growth was measured by taking ten shoots from the current season's growth randomly selected all over the periphery of each experimental tree and their length was measured with measuring tape at the end of growing season and expressed in meters. Fruit set on four marked branches was calculated as per the method suggested by Westwood [11].

$$\text{Fruit set (\%)} = \frac{\text{Number of fruits set}}{\text{Number of flowers}} \times 100$$

The total number of fruits retained on the tagged branches was counted at the time of harvest and the percentage of fruit retained was calculated on the basis of total number of fruits at the time of fruit set.

$$\text{Fruit retention (\%)} = \frac{\text{Number of fruits harvested}}{\text{Number of fruits at set}} \times 100$$

The yield observations were recorded at time of harvesting of nuts from all the experimental trees. After harvesting, the nuts from each tree were de-hulled, dried, weighed and expressed in Kg per tree. Yield efficiency of each experimental tree was calculated and expressed in kg cm^{-2} by using the formula:

$$\text{Yield efficiency} = \frac{\text{Yield (kg)}}{\text{Tree trunk cross sectional area (cm}^2\text{)}}$$

Statistical analyses were conducted using the SAS and means were compared by critical difference (C.D) at 0.05.

3. RESULTS AND DISCUSSION

Supply of all the essential plant nutrients in sufficient quantity and appropriate proportion is one of the major factor controlling the yield and quality of fruit plants. Production of fruit crops has undergone enormous change due to

continuous use of inorganic fertilizer over a long period causing serious damage to soil fertility, environment and health. Sustainability in horticulture with respect to maintenance of soil fertility and stabilized fruit production is the main concern in the present situation. Good soil environment is the precursor to high crop productivity. Hence, there is a need to think of alternate source of safe fertilizers which may enhance crop yield without having adverse effects on soil properties. In the recent past, there has been a resurgence of interest in environment friendly sustainable and organic agricultural practices [12]. The high nutrient requirement of fruit crops can be met through an integrated use of organic manures and chemical fertilizer since organic manures in INM generally improve the physical, chemical and biological properties of the soil along with its moisture holdings capacity which results in enhanced crop productivity and the quality of crop produced. The results obtained are discussed under appropriate headings:

3.1 Effect of Integrated Nutrient Management on the Growth Parameters

Organic manures in combination with inorganic chemical fertilizers significantly increased tree height. Maximum height increment was attained by the walnut trees fertilized with recommended dose (15.92 cm) followed by T_4 (14.35 cm) and minimum with T_3 in 2011. However, during 2012, highest increment in tree height (17.82 cm) was observed with treatment T_4 followed by T_2 (16.85 cm). Recommended dose of fertilizer alone recorded significantly higher value for growth parameters during first year. It could be attributed to the quick and readily availability of major nutrients like NPK to plants at earlier stages of growth, while organic manure recorded significantly lower value for growth parameter because of slow release of nutrients to the plants. The increase in tree height with combination of NPK and vermicompost might be due to increased uptake of nutrients, availability of ideal soil moisture as well as increased growth factors in the root zone during 2012. Marimuthu et al. [13] have also reported an increase in tree height due to the application of organic manure along with chemical fertilizers in coconut. The importance of vermicompost in improving growth of fruit crops is well established by many workers [14,15]. The increase in vegetative parameters could be attributed to the higher amount of nutrients as well as some growth stimulating substances exerted by earthworm in their castes.

The present investigations revealed that application of different fertilizer combinations influenced the canopy volume significantly. Maximum tree canopy volume was observed in treatment T_4 followed by T_1, whereas least tree canopy volume was recorded in treatment T_2. The significant improvement in plant growth parameters on account of vermicompost application along with inorganic source of NPK might be attributed due to the translocation of nutrients from soil which enhanced supply of macro and micro-nutrient during entire growth season and microbial decomposition. Similar findings have also been reported by Mishra et al. [16] who found increased plant spread in ber/jujube *(Ziziphus mauritiana)* orchard with combined application of vermicompost with inorganic fertilizer. The low response of organic manure might be due to slow release of nutrients to the plants. These findings are supported by Rainia et al. [17] who recorded maximum tree canopy volume in apple with application of 75% NPK + enriched manure.

Annual extension growth of walnut plants differed significantly with different treatments. Maximum annual shoot length was found in treatment T_4 (0.81 m) followed by treatment T_1 and T_5 while minimum annual shoot extension growth was observed in treatment T_2. Better growth in combined application may be due to improvement in soil microbial activity, leading to higher N-fixation and phosphate mobilization. This was supported by the findings of Korwar et al. [18]. This increased nutrient availability and uptake might have helped in better growth of walnut trees.

3.2 Effect of Integrated Nutrient Management on Yield Parameters

The present investigation revealed that fruit set was not affected significantly by different treatments. However, maximum fruit set was found in treatment T_4 (40.52%) followed by T_5 (38.35%) and T_1 (37.24%), whereas minimum was found in treatment T_2 (33.81%). Integrated nutrient management had profound influence on fruit set which may be due to favorable effect of INM in extracting the various micro-nutrients from soil by the crop which play critical role in increasing longevity of ovule and fast growth of pollen tube. Mitra et al. [19] found maximum fruit set in Guava trees receiving combined application of organic and inorganic fertilizers.

Table 3. Effect of inorganic and organic fertilizers on tree height, girth and canopy volume of four walnut selections

Selections	Treatments	Increment in tree height (%)			Increment of girth (%)			tree canopy volume in walnut (m^3)		
		2011	2012	Avg.	2011	2012	Avg.	2011	2012	Avg.
	T_1	15.82	16.42	16.12	0.90	1.50	1.20	36.62	38.36	37.49
	T_2	9.00	17.33	13.17	0.60	1.40	1.00	32.04	33.74	32.89
	T_3	9.65	15.35	12.50	0.70	1.20	0.90	34.97	35.81	35.39
	T_4	14.36	17.66	16.01	1.30	1.40	1.30	38.87	39.44	39.16
S_1	T_5	13.77	16.13	14.95	0.80	1.20	1.00	35.71	36.71	36.21
	T_6	10.54	15.24	12.89	0.70	1.00	0.80	31.44	32.71	32.08
	Average	**12.20**	**16.40**	**14.30**	**0.83**	**1.28**	**1.03**	**34.94**	**36.13**	**35.54**
	T_1	16.40	16.40	16.40	0.89	1.50	1.20	36.40	37.90	37.15
	T_2	10.57	16.82	13.69	0.64	1.40	1.00	31.77	32.81	32.29
	T_3	10.54	15.39	12.97	0.75	1.30	1.00	33.10	33.13	33.12
	T_4	14.52	17.20	15.86	1.30	1.30	1.30	36.91	37.38	37.14
S_2	T_5	14.35	16.07	15.21	0.81	1.40	1.10	33.93	35.00	34.47
	T_6	11.28	15.02	13.15	0.76	1.20	1.00	30.71	31.65	31.18
	Average	**12.90**	**16.20**	**14.50**	**0.86**	**1.35**	**1.10**	**33.80**	**34.64**	**34.22**
	T_1	15.93	16.20	16.07	1.00	1.90	1.40	34.28	36.12	35.20
	T_2	10.05	16.52	13.28	0.70	1.70	1.20	33.97	35.63	34.80
	T_3	9.93	15.75	12.84	0.80	1.40	1.10	32.10	33.00	32.55
	T_4	14.47	17.34	15.90	1.60	1.60	1.60	38.32	38.72	38.52
	T_5	13.81	16.51	15.16	0.70	1.30	1.00	32.30	33.00	32.65
S_3	T_6	10.87	15.46	13.17	0.70	1.40	1.00	31.13	32.10	31.62
	Average	**12.50**	**16.30**	**14.40**	**0.92**	**1.55**	**1.22**	**33.68**	**34.76**	**34.22**
	T_1	15.52	15.92	15.72	0.90	1.70	1.30	36.90	39.10	38.00
	T_2	10.67	16.73	13.70	0.70	1.70	1.20	32.69	34.42	33.56
	T_3	9.82	15.41	12.62	0.70	1.40	1.10	35.57	36.30	35.93
S_4	T_4	14.04	19.07	16.56	1.10	1.60	1.40	36.18	37.00	36.59
	T_5	13.79	16.21	15.00	0.80	1.50	1.10	35.04	36.54	35.79
	T_6	10.73	15.71	13.22	0.70	1.40	1.10	30.10	30.80	30.45
	Average	**12.40**	**16.50**	**14.50**	**0.82**	**1.55**	**1.20**	**34.41**	**35.69**	**35.05**
General Avg.		**12.50**	**16.35**	**14.43**	**0.86**	**1.43**	**1.14**	**34.21**	**35.31**	**34.76**

Selections	Treatments	Increment in tree height (%)			Increment of girth (%)			tree canopy volume in walnut (m^3)		
		2011	2012	Avg.	2011	2012	Avg.	2011	2012	Avg.
Average of fertilizer+ manure treatment	T_1	15.92	16.24	16.08	0.92	1.65	1.28	36.05	37.87	36.96
	T_2	10.07	16.85	13.46	0.66	1.55	1.10	32.62	34.15	33.38
	T_3	9.99	15.48	12.73	0.74	1.33	1.03	33.94	34.56	34.25
	T_4	14.35	17.82	16.12	1.33	1.48	1.40	37.57	38.14	37.85
	T_5	13.93	16.23	15.08	0.78	1.35	1.05	34.25	35.31	34.78
	T_6	10.86	15.36	13.11	0.72	1.25	0.98	30.85	31.82	31.33
C.D. at 5%										
Selection (S)		N.S	N.S	N.S	N.S	N.S	N.S	NS	NS	NS
Treatments (T)		1.98	2.12	2.01	N.S	N.S	N.S	1.83	2.25	2.08
S× T		N.S	N.S	N.S	N.S	N.S	N.S	NS	NS	NS

Table 4. Effect of inorganic and organic fertilizers on annual shoot growth, fruit set and fruit retention of four walnut selections

Selections	Treatments	Annual shoot extension growth (m)			Fruit set (%)			Fruit retention (%)		
		2011	2012	Avg.	2011	2012	Avg.	2011	2012	Avg.
	T_1	0.78	0.80	0.79	38.33	41.74	40.04	57.93	60.12	59.03
	T_2	0.33	0.96	0.65	27.08	37.89	32.49	50.93	57.27	54.1
	T_3	0.52	0.78	0.65	31.67	40.53	36.1	56.67	60.20	58.43
	T_4	0.85	0.97	0.91	45.67	45.72	45.69	62.33	57.92	60.13
S_1	T_5	0.76	0.88	0.82	41.59	40.07	40.83	58.00	61.47	59.73
	T_6	0.71	0.79	0.75	35.96	41.24	38.6	46.30	61.16	53.73
	Average	**0.66**	**0.86**	**0.76**	**36.72**	**41.2**	**38.96**	**55.36**	**59.69**	**57.53**
	T_1	0.84	0.84	0.84	32.00	39.16	35.58	52.46	59.73	56.10
	T_2	0.43	0.92	0.68	26.39	38.19	32.29	52.33	59.04	55.69
	T_3	0.65	0.87	0.76	35.34	40.89	38.11	54.78	59.88	57.33
	T_4	0.53	0.96	0.75	37.33	43.44	40.39	59.2	59.2	59.2
S_2	T_5	0.67	0.79	0.73	38.18	38.18	38.18	56.67	62.74	59.71
	T_6	0.63	0.80	0.71	29.67	40.5	35.08	42.33	60.42	51.38
	Average	**0.62**	**0.86**	**0.74**	**33.15**	**40.06**	**36.61**	**52.96**	**60.17**	**56.57**
	T_1	0.73	0.74	0.74	35.63	40.55	38.09	54.58	54.71	54.65
	T_2	0.43	0.79	0.61	34.74	39.78	37.26	50.00	54.75	52.37

Selections	Treatments	Annual shoot extension growth (m)			Fruit set (%)			Fruit retention (%)		
		2011	2012	Avg.	2011	2012	Avg.	2011	2012	Avg.
	T_3	0.58	0.70	0.64	35.95	40.89	38.42	53.81	54.82	54.31
	T_4	0.67	0.90	0.78	34.33	42.09	38.21	61.00	54.07	57.53
	T_5	0.66	0.81	0.74	37.33	37.97	37.65	55.33	55.84	55.59
S_3	T_6	0.63	0.75	0.69	33.67	41.09	37.38	46.63	54.85	50.74
	Average	**0.62**	**0.78**	**0.70**	**35.28**	**40.4**	**37.84**	**53.56**	**54.84**	**54.2**
	T_1	0.75	0.76	0.75	32.13	38.36	35.24	54.83	54.80	54.83
	T_2	0.64	0.84	0.74	28.06	38.33	33.19	50.48	50.44	50.48
	T_3	0.53	0.70	0.61	32.33	39.15	35.74	52	51.89	52
S_4	T_4	0.73	0.88	0.81	34.34	41.23	37.79	58.41	58.39	55.97
	T_5	0.64	0.75	0.70	34.67	38.83	36.75	55.21	55.24	55.21
	T_6	0.63	0.78	0.71	27.67	39.52	33.6	43.53	43.38	48.93
	Average	**0.65**	**0.78**	**0.72**	**31.53**	**39.24**	**35.39**	**52.41**	**52.41**	**52.9**
General Avg.		**0.64**	**0.82**	**0.73**	**34.17**	**40.23**	**37.20**	**53.57**	**56.78**	**55.30**
Average of fertilizer+ manure treatment	T_1	0.78	0.79	0.78	34.52	39.95	37.24	54.95	57.35	56.15
	T_2	0.46	0.88	0.67	29.07	38.55	33.81	50.94	55.39	53.16
	T_3	0.57	0.76	0.67	33.82	40.37	37.09	54.32	56.73	55.52
	T_4	0.70	0.93	0.81	37.92	43.12	40.52	60.24	57.4	58.21
	T_5	0.68	0.81	0.75	37.94	38.76	38.35	56.30	58.82	57.56
	T_6	0.65	0.78	0.71	31.74	40.59	36.16	44.70	54.99	51.19
C.D. at 5%										
Selection (S)		NS	NS	NS	0.55	0.23	0.37	0.63	0.40	0.31
Treatments (T)		0.11	0.12	0.09	NS	0.28	NS	2.44	1.22	1.15
S× T		NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Effect of inorganic and organic fertilizers on yield, yield efficiency and nut length of four walnut selections

Selections	Treatments	Yield per tree (kg)			Yield efficiency (kg/cm^2)		
		2011	2012	Avg.	2011	2012	Avg.
	T_1	4.7	5.07	4.89	0.06	0.06	0.06
	T_2	4.1	5.63	4.87	0.01	0.02	0.02
	T_3	4.5	5.25	4.88	0.05	0.02	0.03
	T_4	6.0	6.0	6.00	0.08	0.06	0.07
S_1	T_5	5.1	5.27	5.19	0.07	0.07	0.07
	T_6	4.2	5.5	4.85	0.02	0.05	0.04
	Average	**4.77**	**5.45**	**5.11**	**0.05**	**0.05**	**0.05**
	T_1	4.4	5.82	5.11	0.04	0.04	0.04
	T_2	4.0	6.38	5.19	0.03	0.03	0.03
	T_3	4.5	6.15	5.33	0.04	0.03	0.04
	T_4	6.6	7.03	6.82	0.09	0.08	0.08
S_2	T_5	5.2	6.38	5.79	0.05	0.06	0.06
	T_6	4.0	5.93	4.97	0.03	0.04	0.03
	Average	**4.78**	**6.28**	**5.53**	**0.05**	**0.05**	**0.05**
	T_1	4.7	4.5	4.60	0.06	0.03	0.04
	T_2	4.0	5.17	4.59	0.01	0.02	0.02
	T_3	4.4	5.48	4.94	0.04	0.05	0.04
	T_4	4.9	5.92	5.41	0.06	0.07	0.06
	T_5	5.0	5.05	5.03	0.05	0.05	0.05
S_3	T_6	4.9	5.52	5.21	0.03	0.03	0.03
	Average	**4.65**	**5.27**	**4.96**	**0.04**	**0.04**	**0.04**
	T_1	4.6	3.83	4.22	0.04	0.01	0.03
	T_2	3.9	4.5	4.20	0.02	0.02	0.02
	T_3	4.1	4.38	4.24	0.02	0.03	0.03
S_4	T_4	5.0	5.53	5.27	0.05	0.06	0.05
	T_5	5.1	5.26	5.18	0.05	0.05	0.05
	T_6	4.1	5.18	4.64	0.02	0.02	0.02
	Average	**4.47**	**4.78**	**4.62**	**0.04**	**0.03**	**0.03**
General Avg.		**4.67**	**5.45**	**5.06**	**0.05**	**0.04**	**0.04**
Average of fertilizer+ manure	T_1	4.60	4.81	4.70	0.05	0.04	0.04
treatment	T_2	4.00	5.42	4.71	0.02	0.02	0.02
	T_3	4.38	5.32	4.85	0.04	0.03	0.03
	T_4	5.63	6.12	5.87	0.07	0.07	0.07
	T_5	5.10	5.49	5.30	0.06	0.06	0.06
	T_6	4.30	5.53	4.92	0.03	0.04	0.03
C.D. at 5%							
Selection (S)		0.15	0.62	0.32	NS	NS	NS
Treatments (T)		NS	0.89	0.36	NS	0.02	NS
S× T		NS	NS	NS	NS	NS	NS

Different selections vary significantly with regard to fruit set. S_1 recorded highest fruit set (38.96%) followed by S_3, S_2 and S_4. The difference in fruit set among different selections might be due to different genetic makeup.

Present findings indicate that fruit retention was markedly improved by integrated application of fertilizer during both years. The highest fruit retention was observed in treatment T_4 (58.21%) followed by T_5 (57.56%) and T_1 (56.15%). The positive effect of combined application of inorganic and organic source of nutrients on fruit retention might be due to sufficient availability and uptake of NPK in experimental field and balanced nutrition of crops with good photosynthesis. The better efficiency of organic manures in combination with inorganic fertilizers might be due to the fact that the organic manures would have provided the micro-nutrients such as zinc, iron, copper, manganese etc. in an optimum range. The results also agree with Mishra et al. [16] who reported that combined application of organic and inorganic fertilizers had minimum percentage of fruit drop in ber or jujube *(Ziziphus mauritiana).*

There were significant differences in fruit retention among different selections. Selection S_1 recorded highest fruit retention (57.53%) followed by S_2 (56.57%), S_3 (54.20%) and S_4 (52.90%) which might be due to different genetic

constitution of the selections. However, there were no significant interactions among selections with their response to fertilizer application.

The study revealed that fertilizer treatment had non-significant effect on yield during first year of study; however yield differed significantly during second year of study. Highest fruit yield was found in treatment T_4 (5.87 kg/tree) followed by T_5 (5.30 kg/tree) and T_6 (4.92 kg/tree). The higher yield with different combinations of organic and inorganic sources might be attributed to sustained release and uptake of major as well as minor elements which is evident from higher accumulation of nutrient elements in walnut leaves. Increase in yield might be on account of production of phytohormone like substances and increased uptake of micronutrients [20]. The prolonged availability of nutrients during crop growth period from vermicompost might have enhanced plant growth and yield attributes [21]. Vermicompost also serve as base for establishment and multiplication of beneficial symbiotic microbes which help in fixing nitrogen in soil besides enhancing the availability of phosphate and nitrogen and uptake of phosphate by plants [22]. Different workers have reported that yield increment with organic manures is due to improvement in soil aeration, better moisture storage and increased nutrient availability and uptake by plants [23,24]. The present findings are in agreement with those of Hebbara et al. [25] and Korwar et al. [18]. Among selections maximum yield was observed in S_2 (5.53 kg/tree) followed by S_1 (5.11 kg/tree) and S_3 (4.96 kg/tree). The maximum yield in selection S_2 might be due to genetic constitution of selection.

Results revealed that the walnut trees fertilized with different treatments varied significantly during second year and yield efficiency was highest in treatment T_4 (0.07 kg/cm^2) followed by T_5 (0.06 kg/cm^2) and T_1 (0.04 kg/cm^2). The higher yield efficiency in combination treatment might be due to balanced supply of nutrients which maintain balance between vegetative and reproductive growth of plants. Selections do not differ significantly with regard to yield efficiency. Highest yield efficiency was found in selection S_1 and S_2 (0.05 kg/cm^2) followed by S_3 (0.04 kg/cm^2), which may be due to different yielding behavior of selections.

4. CONCLUSION

Thus it may be concluded that conjoint application of organic and inorganic fertilizers showed substantial improvement in vegetative and yield parameters. Application of 75% RDF through inorganic coupled with 25% vermicompost was the best treatment for optimum growth and yield. Among the selections, S_2 showed better performance with respect to yield and quality followed by selection S_1 in walnut under Kashmir conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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