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Full Length Research Paper

Effect of combined application of inorganic fertilizers and organic manures on nut yield and quality of four walnut (*Juglans regia* L.) selections

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The effectiveness of combined application of inorganic fertilisers and organic manures was studied on four walnut selections in temperate region of India (Kashmir). The experiment consisted of four selections and six treatments 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 mixed well with soil. There was significant difference in yield and nut quality parameters among different walnut selections under different treatments. Maximum yield 6.82 kg/tree) was found in selection S_2 under treatment T_4. The quality parameters of walnut were found improved by combined effect of inorganic fertilisers and vermicompost. Maximum nut weight (13.16g), kernel weight (7.17 g), kernel protein content (18.31 per cent). Among selections highest nut weight (12.5 g) was found in S_4. Thus it may be concluded that application of 75% fertilizer through inorganic coupled with 25% vermicompost was the best treatment for optimum yield and fruit quality. Among the selections, S_2 showed better performance with respect to yield and quality followed by selection S_1.

Key words: Chemical fertilisers, growth, nutrients, organic manure, walnut, yield.

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 89788 ha with annual production of about 163745 metric tons (Anonymous, 2014) 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 day by day 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 (Shi et al.,2001; Zhang et al., 2004a; Zhang et al., 2004b). Fertilization treatments have the potential for increasing growth and nut production of walnuts (Ponder and Van-Sambeek 1997). Though the chemical farming helped the farmers to accomplish new strides in horticulture, but their indiscriminate and unscrupulous use in horticulture/agriculture has led to deterioration of soil health. The increased use of fertilizers in non-judicious manner, has led to diminishing soil productivity and multiple nutrient deficiencies. The gravity of environmental degradation

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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 growing is a goal of integrated fruit production (Reganold et al., 2001; Forge et al., 2002). Recently, environmental aspects of plant nutrient application have received much interest. The organic manures, when applied to soil increases the fertility status of soil and favourably influence the crop yield for several years. It has been reported that farm yard manure, vermicompost and poultry manure have increased growth, yield and quality in different crops (Ingle et al., 2003; Ram and Rajput, 2002; Arancon et al., 2003). Thus it has been realised that use of chemical fertilisers must be integrated through more economic and eco-friendly organic manures in order to achieve the substantial productivity with minimum deleterious effect of chemical fertilisers 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.

MATERIALS AND METHODS

The experimental orchard is located at Ambri Apple Research Station PahnooShopian. This experimental farm is located at 33.72^0N latitude and 74.83^0 E longitudes, at an elevation of 2057 m above msl, representing high hill zone of the state. The climate of the area is typically temperate. Before application of manures and chemical fertilisers a composite soil sample of the experimental orchard was drawn and analysed for different chemical properties and detailed information is presented in Table 1. The studies were conducted on 9 years old four bearing selections {SKAU/002 (S_1), SKAU/008 (S_2), SKAU/024 (S_3), SKAU/040 (S_4), of walnut grafted on seedling rootstock. For the conduct of experiment, trees with uniform age and vigour, placed at 6m×6m were selected. The treatments were laid out in Randomised block design (Factorial), containing five replications of three tree each the details of treatment 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 +1/3poultry manure). The recommended dose during first year is 200g N, 50g P and 200g K and during second year 250g N, 60g P and 250g 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 beneath the tree canopy and mixed well with soil. Chemical composition of organic fertilizers used for the experiment is given in Table 2.

The observation was recorded at time of harvesting of nuts from all the experimental trees. After harvesting, the nuts from each tree were dehulled, 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:

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

The weight of ten nuts randomly selected was recorded on electronic balance and the average nut weight was expressed in grams (g). The weight of kernels extracted from ten nuts was recorded on electronic balance and the average kernel weight was expressed in grams (g). Kernel percentage was calculated on the basis of nut weight and kernel weight by using the formula:

$$\text{Kernel per cent} = \frac{\text{Kernel weight}}{\text{Nut weight}} \times 100$$

The Kjeldahl's method as described by Kanwar and Chopra (1967) for estimation of crude protein in plant samples was followed. The nitrogen percentage was multiplied by a factor 5.3 as suggested for tree nuts by Khanizadeh et al. (1995) to calculate the crude protein percentage.

RESULTS AND DISCUSSION

Effect of integrated nutrient management on yield parameters

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 (Table 3). 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 (Govindan and Purushothamam, 1984). The prolonged availability of nutrients during crop growth

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

period from vermicompost might have enhanced plant growth and yield attributes (Rajkhowa *et al.*, 2000). 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 (Sinha *et al.*, 2005). 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 (Shivaputra *et al.*, 2004 and Dutta *et al.*, 2010). The present findings are in agreement with those of Osman (2003), Hebbara *et al.* (2006) and Singh (2007). 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 behaviour of selections.

Effect of integrated nutrient management on nut and quality parameters

Nut weight and kernel weight were affected significantly by different fertiliser treatments during second year of study. Maximum nut weight was found in treatment T_4, whereas minimum was observed in treatment T_2. Treatment T_4 recorded maximum kernel weight whereas lowest was found in T_2. This increase in nut parameter with combined application of vermicompost and inorganic fertilisers might be due to the fact that vermicompost would have improved soil texture and provided micronutrients such as zinc, iron, copper, manganese etc. and better microbial establishment in the soil. The biological activity of the micro-organism would have helped the soil to become ready to serve zone for essential nutrients to plant root system. Zinc is involved in the biochemical synthesis of the most important phytohormone IAA through the pathways of conversion of tryptophan to IAA. Iron is involved in the chlorophyll synthesis besides being part of co-enzymes of respiratory chain reaction. Copper and manganese are important activators of co-enzymes. Organic manures in combination with inorganic fertilisers must have helped in metabolic changes through the supply of such important micro-nutrients and enzyme activation which ultimately must have improved nut parameters (Hayworth *et al.*, 1996). The increase in fruit parameters have been reported by different workers in several crops, Khan *et al.* (2002) in peach, Kumar *et al.* (2003) in plum, and Raina *et al.* (2011) in apple.

Different selections differ significantly with respect to nut weight, kernel weight and kernel percentage. With respect to nut weight S_4 differ significantly from S_1 and S_3 but is statistically at par with S_2. S_1 showed highest kernel weight which differed significantly from S_3 and S_4 but is at par with S_2. Kernel percentage was maximum in S_1 followed by S_3 and S_2. This difference in nut parameters among different selections might be due to their genetic makeup.

The results obtained in present study indicate that kernel

Table 3. Effect of inorganic and organic fertilisers on yield, yield efficiency and nut weight of four walnut selections.

Selections	Treatments	Yield per tree (kg)			Yield efficiency (kg/cm^2)			Nut weight (g)		
		2011	2012	Avg.	2011	2011	Avg.	2011	2012	Avg.
S_1	T_1	4.7	5.07	4.89	0.06	0.06	0.06	11.23	11.67	11.45
	T_2	4.1	5.63	4.87	0.01	0.02	0.02	10.77	11.93	11.35
	T_3	4.5	5.25	4.88	0.05	0.02	0.03	11.23	11.23	11.23
	T_4	6.0	6.0	6.00	0.08	0.06	0.07	12.87	13.00	12.93
	T_5	5.1	5.27	5.19	0.07	0.07	0.07	12.70	12.70	12.70
	T_6	4.2	5.5	4.85	0.02	0.05	0.04	11.99	12.30	12.15
	Average	**4.77**	**5.45**	**5.11**	**0.05**	**0.05**	**0.05**	**11.80**	**12.14**	**11.97**
S_2	T_1	4.4	5.82	5.11	0.04	0.04	0.04	12.90	13.03	12.97
	T_2	4.0	6.38	5.19	0.03	0.03	0.03	11.20	12.20	11.70
	T_3	4.5	6.15	5.33	0.04	0.03	0.04	12.43	12.43	12.43
	T_4	6.6	7.03	6.82	0.09	0.08	0.08	13.53	13.80	13.66
	T_5	5.2	6.38	5.79	0.05	0.06	0.06	12.00	13.00	12.50
	T_6	4.0	5.93	4.97	0.03	0.04	0.03	11.60	12.58	12.09
	Average	**4.78**	**6.28**	**5.53**	**0.05**	**0.05**	**0.05**	**12.28**	**12.84**	**12.56**
S_3	T_1	4.7	4.5	4.60	0.06	0.03	0.04	10.65	11.79	11.22
	T_2	4.0	5.17	4.59	0.01	0.02	0.02	10.34	12.12	11.23
	T_3	4.4	5.48	4.94	0.04	0.05	0.04	10.99	12.44	11.72
	T_4	4.9	5.92	5.41	0.06	0.07	0.06	12.48	13.26	12.87
	T_5	5.0	5.05	5.03	0.05	0.05	0.05	12.13	12.13	12.13
	T_6	4.9	5.52	5.21	0.03	0.03	0.03	10.91	13.14	12.03
	Average	**4.65**	**5.27**	**4.96**	**0.04**	**0.04**	**0.04**	**11.25**	**12.48**	**11.87**
S_4	T_1	4.6	3.83	4.22	0.04	0.01	0.03	12.21	12.83	12.52
	T_2	3.9	4.5	4.20	0.02	0.02	0.02	11.27	13.60	12.43
	T_3	4.1	4.38	4.24	0.02	0.03	0.03	11.51	13.66	12.59
	T_4	5.0	5.53	5.27	0.05	0.06	0.05	12.49	13.89	13.19
	T_5	5.1	5.26	5.18	0.05	0.05	0.05	11.26	13.15	12.21
	T_6	4.1	5.18	4.64	0.02	0.02	0.02	10.83	13.08	11.95
	Average	**4.47**	**4.78**	**4.62**	**0.04**	**0.03**	**0.03**	**11.60**	**13.37**	**12.48**
General Avg.		**4.67**	**5.45**	**5.06**	**0.05**	**0.04**	**0.04**	**11.73**	**12.71**	**12.22**
Average of fertilser+ manure treatment	T_1	**4.60**	**4.81**	**4.70**	**0.05**	**0.04**	**0.04**	**11.75**	**12.33**	**12.04**
	T_2	**4.00**	**5.42**	**4.71**	**0.02**	**0.02**	**0.02**	**10.90**	**12.46**	**11.68**
	T_3	**4.38**	**5.32**	**4.85**	**0.04**	**0.03**	**0.03**	**11.54**	**12.44**	**11.99**
	T_4	**5.63**	**6.12**	**5.87**	**0.07**	**0.07**	**0.07**	**12.84**	**13.49**	**13.16**
	T_5	**5.10**	**5.49**	**5.30**	**0.06**	**0.06**	**0.06**	**12.02**	**12.75**	**12.38**
	T_6	**4.30**	**5.53**	**4.92**	**0.03**	**0.04**	**0.03**	**11.33**	**12.78**	**12.05**
C.D. at 5%										
Selection (S)		**0.15**	**0.62**	**0.32**	**NS**	**NS**	**NS**	**0.65**	**0.54**	**0.57**
Treatments (T)		**NS**	**0.89**	**0.36**	**NS**	**0.02**	**NS**	**NS**	**0.09**	**0.04**
S× T		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

protein was significantly affected by different fertilizer treatments (Table 4) Maximum kernel protein content was found in treatment T_4 which differ significantly from treatments T_1, T_2, T_3 and T_6 but is statistically at par with treatment T_5. The improvement in nut quality might be due to improvement in physical properties of soil and increase growth of micro-organisms (Chattopadhyay, 1994). The maximum kernel protein content in treatment T_4 might be due to the fact that protein is made up of amino acid which is mostly constituent of nitrogen. Treatment T_4 enhanced the uptake of nitrogen which must have assimilated in amino acid and finally into protein. Tekin *et al.* (1995) also found maximum protein and fat content in combined application of inorganic and organic fertiliser in pistachio. Sharma *et al.* (2002) also reported higher protein content with the

Table 4. Effect of inorganic and organic fertilisers on kernel weight, kernel percentage and kernel protein content selections.

Selections	Treatments	Kernel weight (g)			Kernel percentage			Kernel protein content (%)		
		2011	2012	Avg.	2011	2012	Avg.	2011	2012	Avg.
S_1	T_1	6.40	6.53	6.47	56.99	56.76	56.88	16.26	16.19	16.23
	T_2	6.15	6.61	6.38	57.01	57.01	57.01	14.41	15.15	14.78
	T_3	6.07	6.67	6.37	54.05	54.80	54.43	15.26	15.17	15.21
	T_4	7.46	7.53	7.50	58.01	58.14	58.08	18.79	18.85	18.82
	T_5	7.21	7.21	7.21	56.77	56.85	56.81	16.92	17.21	17.06
	T_6	6.47	6.70	6.58	53.96	55.46	54.71	15.32	15.52	15.42
	Average	**6.63**	**6.88**	**6.75**	**56.13**	**56.50**	**56.32**	**16.16**	**16.35**	**16.25**
S_2	T_1	6.73	6.73	6.73	52.18	52.45	52.32	16.84	16.8	16.82
	T_2	6.07	6.13	6.10	54.20	54.20	54.20	15.48	15.48	15.48
	T_3	6.55	6.68	6.62	52.69	53.13	52.91	16.35	16.55	16.45
	T_4	7.40	7.50	7.45	55.43	55.62	55.53	18.81	19.07	18.94
	T_5	6.52	6.76	6.64	54.33	54.22	54.28	17.95	17.85	17.9
	T_6	6.15	6.39	6.27	53.35	54.01	53.68	16.74	16.75	16.75
	Average	**6.57**	**6.70**	**6.63**	**53.70**	**53.94**	**53.82**	**17.03**	**17.08**	**17.05**
S_3	T_1	5.70	5.84	5.77	53.57	53.71	53.64	15.41	15.52	15.47
	T_2	5.53	5.70	5.62	53.53	53.53	53.53	15.07	15.23	15.15
	T_3	5.78	5.78	5.78	52.59	52.73	52.66	16.57	16.75	16.66
	T_4	6.87	6.97	6.92	55.05	55.37	55.21	17.58	17.63	17.61
	T_5	6.57	6.63	6.60	54.16	54.44	54.30	17.14	17.14	17.14
	T_6	5.86	5.89	5.88	53.71	53.81	53.76	15.29	15.39	15.34
	Average	**6.05**	**6.14**	**6.09**	**53.77**	**53.93**	**53.85**	**16.18**	**16.28**	**16.23**
S_4	T_1	6.37	6.43	6.40	52.22	52.31	52.27	16.21	15.28	15.74
	T_2	5.71	5.89	5.80	50.71	52.47	51.59	14.33	15.33	14.83
	T_3	5.99	6.46	6.23	52.20	52.40	52.30	16.49	16.29	16.39
	T_4	6.66	7.00	6.83	53.32	53.55	53.43	17.8	17.97	17.88
	T_5	5.90	6.07	5.99	52.40	52.60	52.50	17.13	17.23	17.18
	T_6	5.67	6.01	5.84	52.35	52.57	52.46	16.1	16.27	16.18
	Average	**6.05**	**6.31**	**6.18**	**52.20**	**52.65**	**52.43**	**16.34**	**16.39**	**16.37**
General Avg.		**6.325**	**6.51**	**6.41**	**53.95**	**54.26**	**54.11**	**16.43**	**16.53**	**16.48**
Average of fertilser+ manure treatment	T_1	**6.30**	**6.38**	**6.34**	**53.74**	**53.81**	**53.78**	**16.18**	**15.95**	**16.06**
	T_2	**5.87**	**6.08**	**5.97**	**53.86**	**54.30**	**54.08**	**14.82**	**15.30**	**15.06**
	T_3	**6.10**	**6.40**	**6.25**	**52.88**	**53.27**	**53.07**	**16.17**	**16.19**	**16.18**
	T_4	**7.10**	**7.25**	**7.17**	**55.45**	**55.67**	**55.56**	**18.25**	**18.38**	**18.31**
	T_5	**6.55**	**6.67**	**6.61**	**54.42**	**54.53**	**54.47**	**17.29**	**17.36**	**17.32**
	T_6	**6.04**	**6.25**	**6.14**	**53.34**	**53.96**	**53.65**	**15.86**	**15.98**	**15.92**
C.D. at 5%										
Selection (S)		**0.27**	**0.37**	**0.21**	**1.76**	**1.56**	**1.18**	**0.70**	**0.62**	**0.58**
Treatments (T)		**NS**	**0.48**	**0.45**	**NS**	**NS**	**NS**	**1.45**	**1.85**	**1.22**
S× T		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

increased total nitrogen in plant. Muzaffar (2004) also found increased fat content in brown sarson with conjoint application of organic and inorganic fertilisers. Similar results were also found by Singh and Pal (2011) in mustard.

Different selections showed marked differences with regard to kernel protein content and maximum protein content was observed in selection S_2 which differed significantly from S_1, S_2 and S_3.

CONCLUSION

Thus it may be concluded that conjoint application of

organic and inorganic fertilizers showed substantial improvement in nut yield and nut quality parameters. Application of 75% RDF through inorganic coupled with 25% vermicompost was the best treatment for optimum nut yield nut and nut quality. S_2 showed better performance with respect to yield and quality followed by selection S_1 in walnut under Kashmir conditions.

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