Indian J. Agric. Res., 53(4) 2019: 411-416
Print ISSN:0367-8245 / Online ISSN:0976-058X

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Standardisation of tree spacing and organic manure dose for growing garden pea under *Grewia optiva* D. based agri silviculture system

S. Kar*[1], K.S. Pant, A. Chandel and G.D. Dubey

Department of Silviculture and Agroforestry,
Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, Himachal Pradesh, India.
Received: 25-10-2018 Accepted: 17-05-2019 DOI: 10.18805/IJARe.A-5153

ABSTRACT

A field experiment was carried out to explore the possibilities of successful cultivation of garden pea as intercrop under different spacings of *Grewia optiva*, to standardise the tree spacing and organic manure dose for optimum growth and yield of garden pea. The experiment comprised of four treatment of tree spacing (8m×1m, 8m×2m, 8m×3m and open i.e. tree less area) and eight manure doses treatment (T_1-160% of recommended doses of Nitrogen through Vermicompost and Poultry manure in 50-50 ratio, T_2-140% of RD N through VC and PM, T_3-120% of RD N through VC and PM, T_4-100% of RD N through VC and PM, T_5-80% of RD N through VC and PM, T_6-60% of RD N through VC and PM, T_7-100% of RD of NPK and T_8-Control *i.e.* no manures and fertilisers). Growing of Garden pea with the use of 120% of the recommended doses of nitrogen through vermicompost and poultry manure, under 8m×3m spacing of grewia was found better to other treatment combinations with respect to growth, yield, net revenue and B:C ratio.

Key words: Agroforestry system, Garden pea, *Grewia optiva*, Poultry manure, Vermicompost.

INTRODUCTION

In our country, as a result of ban on green felling, plantation of fast growing and short rotation trees are emerging as a major source of raw material for multifarious wood based uses. Under high density short rotation plantations, trees are grown with rotation period less than 6 to 12 years and with high productivity atleast 10 to 30 m^3 ha^{-1} yr^{-1}. Also with the increase in population, the demand for agricultural and forest based products are increasing, whereas, the per capita availability of land is decreasing day by day. Under such circumstances, agroforestry can be advantageous over traditional agricultural and forest production methods, in which the same unit of land can be exploited for production of diverse products in a sustainable basis, and at the same time secures livelihood of the farmers, checks soil degradation and maintains ecological balance.

Grewia optiva is an important multipurpose tree species. According to Brandis (1972) Grewia is distributed throughout the sub-Himalayan tract, found up to an altitude of 1800 m. It belongs to family Tiliaceae and is one of the most important fodder trees of north-western Himalayas, which provides nutritive and palatable fodder during the lean winter season, when no other green fodder is available. It is sparingly found in forest area and is mostly raised along agriculture fields. It is very popular among the farmers of western Himalayas for its multipurpose use. Apart from fodder the branches are lopped for extracting shampoo, bast fibre and fuelwood. In addition, it also adds large quantities of organic matter to the soil through leaf and litter fall.

Garden pea (*Pisum sativum* Linn.) is an important vegetable crop grown commercially in many parts of Himachal Pradesh and Uttrakhand. Garden pea like many other legume crops contains symbiotic bacteria called Rhizobia within root nodules of their root systems. These bacteria have the special ability of fixing nitrogen from atmospheric into ammonia (NH_3). When pea plants are mixed to the soil, following the final harvest, all of its remaining nitrogen gets released back into the soil in the form of amino acids, which are later converted to nitrate (NO_3^-), making the nitrogen available to subsequent crops. Global production of green peas in 2016 was 19,870 million Kg, harvested from 25,89,087 hectares, with a yield of 7677 kg ha^{-1} (FAO, 2018). In India, pea is grown in 5,30,000 hectares area with production of 5345 million Kg. In Himachal Pradesh the area under pea is 23, 570 hectares with production of 276 million Kg (NHB, 2017).

In green revolution, intensive use of synthetic agrochemicals, such as fertilizers and pesticides with adoption of nutrient responsive high yielding varieties of crops has no doubt boosted the production to a great extent but at the cost of degradation of soil health, environment and food quality. The long-term use of inorganic fertilizers without organic supplements has changed the soil physical, chemical and biological properties. So under these circumstances organic farming has potential for reducing some of the negative impacts of conventional agriculture to the environment and an option to restore the productivity of degraded soils (Ghosh *et al.*, 2007). Growing of garden pea

*Corresponding author's e-mail: satyajeetkar1010@gmail.com, Dr YSPUHF, Nauni, Solan-173 230, Himachal Pradesh, India.

using organic manures under widely spaced *Grewia optiva* can offer economically more benefits than sole cropping of garden pea in open condition when the tree component is properly managed.

MATERIALS AND METHODS

Site description: The experimental trial of garden pea under Grewia was conducted at the experimental field of Department of Silviculture and Agroforestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during the period of October, 2017 to February, 2018 to study the effect of tree spacing and organic manure on growth and yield of garden pea. The experimental site is located at 30º 51' N latitude and 76º 11' E longitude, with an elevation of 1200 m above MSL and slope of 7-8 percent which falls in sub-tropical, sub-humid agro-climatic zone of Himachal Pradesh, India. The area receives an annual rainfall which varies from 1000-1400 mm and about 75 per cent of it is received during the monsoon period (June-September). The average annual temperature is 17.4 ºC. The soil of the area belongs to Typic Eutrochrept subgroup as per the soil taxonomy of USDA. The soil is gravelly sandy loam in texture and the pH of the top layer of the soil (15 cm) is neutral and containing high organic matter.

Details of structural components of agrisilviculture system: The experiment consisted of two structural and functional components *viz*; *Grewia optiva* D. trees rows as woody perennial and *Pisum sativum*. The tree rows of *Grewia optiva* D. tree consisting of 3 spacings (8m×1m, 8m×2m and 8m×3m) were planted in the year July 2004 with rows running in East – West direction. *Rabi* (winter) season crop *i.e.*, garden pea (*Pisum sativum* L.), variety Azad P-1 was grown with a spacing of 60cm×10cm, solely and also with Grewia trees, in plots of size 3m×1m. Garden pea was sown in the 2nd week of October 2017, accommodated 50 pea plants per plot. In addition, the impact of increasing doses (60-160%) of vermicompost and poultry manure on performance of *Pisum sativum*, growing along with and without Grewia was studied. The Grewia trees were lopped after the start of flowering in garden pea, i.e. during 3rd week of January as shown in the Fig 1 and 2.

Design of the experiment and treatment details: The experiment was established as per split-plot design, in which the main plot treatment was tree spacing and sub plot treatment was the manure doses, details of which are given in the Table. In the treatments T_1-T_6, respective quantities of vermicompost and poultry manure were applied to the respective treatment plots during bed preparation. For T_7, full dose of SSP, MOP and half dose of urea was applied as basal application, and rest ½ dose of urea was applied in 2 equal splits i.e. after 1 month of transplanting/ sowing & during flowering.

Parameters recorded: Growth and yield parameters of garden pea *i.e.* plant height at harvest (cm), total numbers of pods per plant, number of seeds per pod, green pod yield per hectare were recorded at physiological maturity stage by randomly selecting 10 plants from each plot. Economic parameters like net return and benefit cost ratio were analysed for estimating the economic viability of the treatment combinations. During calculation of cost of cultivation under agroforestry system, annuity method was used to calculate the cost of cultivation of the tree component to take into consideration the initial establishment cost, branch lopping cost and fibre extraction cost. And during return calculations, returns from leaf fodder, fibre and fuel wood was also considered. The data obtained from various characters under study were analyzed by the method of analysis of variance as described by (Gomez and Gomez, 1984).

Fig 1: Experimental field before lopping of branches of grewia.

Fig 2: Experimental field after lopping of branches of grewia.

Table 1: Design details.

Experimental design	:	split-plot design
Main plot treatments	:	tree spacing (4)
Sub plot treatments	:	manure doses (8)
Total number of treatments combinations	:	4 × 8 = 32
Number of replications	:	3
Total number of experimental plots	:	32 × 3 = 96

Table 2: Details of main plot and sub plot treatments.

Main plot treatment		**Spacing (S)**
S_1	:	8m × 1m
S_2	:	8m × 2m
S_3	:	8m × 3m
S_0	:	open condition
Sub plot treatment		**Manure doses (T)**
T_1	:	160 % RD N through VC & PM on 50:50 N-equivalence basis
T_2	:	140 % RD N through VC & PM on 50:50 N-equivalence basis
T_3	:	120 % RD N through VC & PM on 50:50 N-equivalence basis
T_4	:	100 % RD N through VC & PM on 50:50 N-equivalence basis
T_5	:	80 % RD N through VC & PM on 50:50 N-equivalence basis
T_6	:	60 % RD N through VC & PM on 50:50 N-equivalence basis
T_7	:	100 % RD NPK (chemical fertilizers- urea, SSP, MOP)
T_8	:	Control (no fertilizer & no manure)

RD- Recommended dose, VC-Vermicompost, PM- Poultry manure.

Table 3: Effect of tree spacing and organic manures on plant height at harvest (cm) of garden pea under Grewia based agrisilviculture system.

Manure Doses	**Tree Spacing**				**Mean**
	S_1(8m×1m)	**S_2(8m×2m)**	**S_3(8m×3m)**	**S_0 (Open)**	
T_1 (160% VC+PM)	75.56	80.78	84.66	93.34	**83.59**
T_2 (140% VC+PM)	72.87	77.57	82.59	87.27	**80.08**
T_3 (120% VC+PM)	70.12	75.78	79.78	83.45	**77.28**
T_4 (100% VC+PM)	68.56	73.34	77.67	81.87	**75.36**
T_5 (80% VC+PM)	67.09	70.45	75.75	78.12	**72.85**
T_6 (60% VC+PM)	64.96	69.39	71.35	73.68	**69.85**
T_7 (100% NPK)	71.97	76.24	81.78	86.59	**79.15**
T_8 (no manures)	60.12	62.47	63.67	65.78	**63.01**
Mean	**68.91**	**73.25**	**77.16**	**81.26**	
			$CD_{0.05}$	**S**	1.95
				T	1.97
				S×T	NS

Table 4: Effect of tree spacing and organic manures on total number of pods per plant of garden pea under Grewia based agrisilviculture system.

Manure Doses	**Tree Spacing**				**Mean**
	S_1(8m×1m)	**S_2(8m×2m)**	**S_3(8m×3m)**	**S_0 (Open)**	
T_1 (160% VC+PM)	10.18	13.71	18.12	20.19	**15.55**
T_2 (140% VC+PM)	10.07	13.56	17.86	20.04	**15.38**
T_3 (120% VC+PM)	9.87	13.41	17.64	19.71	**15.16**
T_4 (100% VC+PM)	7.50	12.60	16.03	18.25	**13.59**
T_5 (80% VC+PM)	6.21	9.78	12.02	14.98	**10.75**
T_6 (60% VC+PM)	5.12	8.09	9.11	10.61	**8.23**
T_7 (100% NPK)	6.87	12.65	16.41	18.35	**13.57**
T_8 (no manures)	4.54	4.93	5.36	6.07	**5.23**
Mean	**7.55**	**11.09**	**14.07**	**16.03**	
			$CD_{0.05}$	**S**	0.68
				T	0.70
				S×T	1.45

RESULTS AND DISSCUSSION

Effect of tree spacings on the growth and yield parameters of garden pea: Growth and yield parameters of pea were recorded in different spacing of Grewia based agroforestry system as well as in open condition. The results presented in the Tables 3,4,5 and 6 showed that parameters of pea such as plant height, total number of pods per plant, number of seeds per pod, and green pod yield per hectare were significantly affected by tree spacing in comparison to open condition. The higher values of- plant height (81.26 cm), total number of pods per plant (16.03 number of seeds per pod (8.57) and green pod yield per hectare (10320.09 Kg ha^{-1}) were recorded in S_0 (open condition), whereas, minimum values of plant height (68.91 cm), total number of

Table 5: Effect of tree spacing and organic manures on number of seeds per pod of garden pea under Grewia based agrisilviculture system.

Manure Doses	Tree Spacing				Mean
	S_1(8m×1m)	S_2(8m×2m)	S_3(8m×3m)	S_0(Open)	
T_1 (160% VC+PM)	8.78	8.89	8.93	9.16	**8.94**
T_2 (140% VC+PM)	8.69	8.78	8.85	9.03	**8.84**
T_3 (120% VC+PM)	8.43	8.69	8.76	8.86	**8.69**
T_4 (100% VC+PM)	8.16	8.48	8.45	8.77	**8.47**
T_5 (80% VC+PM)	7.57	7.86	7.94	8.26	**7.91**
T_6 (60% VC+PM)	7.14	7.45	7.79	7.94	**7.58**
T_7 (100% NPK)	8.25	8.54	8.76	8.77	**8.58**
T_8 (no manures)	6.96	7.21	7.51	7.76	**7.36**
Mean	**8.00**	**8.24**	**8.37**	**8.57**	
			$CD_{0.05}$	**S**	0.22
				T	0.21
				S×T	NS

Table 6: Effect of tree spacing and organic manures on average green pod yield (Kg ha^{-1}) of Garden pea under Grewia based agrisilviculture system.

Manure Doses	Tree Spacing				Mean
	S_1(8m×1m)	S_2(8m×2m)	S_3(8m×3m)	S_0(Open)	
T_1 (160% VC+PM)	6051.72	8426.75	11476.50	13004.95	9739.98
T_2 (140% VC+PM)	5988.29	8338.60	11310.61	12905.76	9635.82
T_3 (120% VC+PM)	5872.04	8240.18	11169.89	12693.20	9493.83
T_4 (100% VC+PM)	4458.02	7744.72	10150.22	11750.85	8525.95
T_5 (80% VC+PM)	3690.90	6012.26	7610.56	9647.12	6740.21
T_6 (60% VC+PM)	3046.67	4974.70	5768.12	6830.69	5155.05
T_7 (100% NPK)	4085.36	7775.53	10393.00	11819.06	8518.24
T_8 (no manures)	2699.79	3030.31	3394.67	3909.08	3258.46
Mean	4486.60	6817.88	8909.20	10320.09	
			$CD_{0.05}$	**S**	426.92
				T	437.77
				S×T	907.27

pods per plant (7.55), number of seeds per pod (8.00) and green pod yield per hectare (4486.60 Kg ha^{-1}) of pea were recorded in S_1 (8m×1m). In agroforestry system among the three spacings the growth and yield parameters of pea were in the order of S_3 (8m×3m) > S_2 (8m×2m) > S_1 (8m×1m). Lopping of Grewia was done in the month of January, so the crop received shade during the initial growth phase, affecting growth and yield under the system. Lesser available PAR (shade) caused due to presence of tree canopies and competition for other limited resources seems to be the key factors for adversely affecting the growth and yield of pea. These findings are in line with Yogeshwari (2015), who recorded that the number of pods/plant, economic yield, biological yield and harvest index increased with the distance from the tree trunk and maximum being outside the tree canopy. These readings were also in accordance to the findings of Singh (2002) in pea under Morus, Channabasappa *et al.,* (2007) in rice under Acacia, Thakur and Singh (2008) and Kaur and Puri (2013) in multiple tree crop combinations.

Effect of manure doses on the growth and yield parameters of garden pea: Application of different manure doses significantly affected the growth and yield parameters of garden pea in comparison to control (without manures and fertilisers) both in the agroforestry system and in open condition. Plant height, total number of pods per plant, number of seeds per pod, green pod yield per hectare of garden pea increased with increase in quantity of organic manure doses from 60 % to 160 %. However in case of green pod yield per hectare, the rate of marginal increment of the values decreased after 120 % (T_3). The higher values of plant height (83.59 cm), total number of pods per plant (15.55), number of seeds per pod (8.94) and green pod yield per hectare (97.40 q ha^{-1}) of garden pea were recorded when applied with 160 % of recommended dose of nitrogen through VC and PM (T_1), whereas, minimum values of plant height (63.01 cm), total number of pods per plant (5.23), number of seeds per pod (7.36) and green pod yield per hectare (32.59 q ha^{-1}) of garden pea were recorded when no fertilisers and manures were applied (T_8). The yield of the pea was in the order of T_1>T_2>T_3>T_4>T_7>T_5>T_6>T_8. Yield of pea achieved under application of 100% chemical fertiliser (T_7), was statistically at par with that achieved under application of 100% of recommended dose of nitrogen through VC and PM (T_4). Increase in these parameters with the increase in rate of manures may be attributed to proper root growth and establishment, better availability of nutrients

Table 7: Net return (Rs. lakh ha^{-1}) from garden pea under Grewia based agrisilviculture system.

Manure Doses	Tree Spacing				Mean
	S_1(8m×1m)	S_2(8m×2m)	S_3(8m×3m)	S_0(Open)	
T_1 (160% VC+PM)	1.93	2.16	2.87	2.52	**2.37**
T_2 (140% VC+PM)	1.93	2.16	2.85	2.51	**2.36**
T_3 (120% VC+PM)	1.92	2.15	2.82	2.47	**2.34**
T_4 (100% VC+PM)	1.51	2.02	2.54	2.20	**2.07**
T_5 (80% VC+PM)	1.30	1.52	1.79	1.59	**1.55**
T_6 (60% VC+PM)	1.13	1.23	1.26	0.77	**1.10**
T_7 (100% NPK)	1.25	1.69	2.14	1.69	**1.69**
T_8 (no manures)	1.53	1.15	1.05	0.39	**1.03**
Mean	**1.56**	**1.76**	**2.17**	**1.77**	

Table 8: B:C of growing garden pea under Grewia based agrisilviculture system.

Manure Doses	Tree Spacing				Mean
	S_1(8m×1m)	S_2(8m×2m)	S_3(8m×3m)	S_0(Open)	
T_1 (160% VC+PM)	2.20	2.37	2.83	2.82	**2.55**
T_2 (140% VC+PM)	2.22	2.38	2.84	2.85	**2.57**
T_3 (120% VC+PM)	2.22	2.39	2.85	2.84	**2.57**
T_4 (100% VC+PM)	1.97	2.33	2.68	2.67	**2.41**
T_5 (80% VC+PM)	1.85	2.01	2.21	2.23	**2.07**
T_6 (60% VC+PM)	1.75	1.83	1.86	1.60	**1.76**
T_7 (100% NPK)	1.84	2.16	2.48	2.33	**2.20**
T_8 (no manures)	2.51	2.17	2.09	1.51	**2.07**
Mean	**2.07**	**2.20**	**2.48**	**2.36**	

NS- Non Significant at P > 0.05

during vital growth period, greater synthesis of carbohydrate through greater photosynthetic activities and their translocation (Singh 1990). Micro-organisms present in vermicompost like bacteria, fungi, yeast, actinomycetes and algae produces plant growth regulators (PGRs) such as auxins, gibberellins and cytokinins which might have resulted in better growth and yield (Frankenberger *et al.,* 1995). Poultry manure is used as a source of N, P and K but litter also contains Ca, Mg, S and some micronutrients, also increases the pore spaces, infiltration capacity and available water capacity. In a similar trend of experiment, Erman *et al.,* (2009) studied the response of pea to different levels of nitrogen application and reported that pod yield under the treatments of 20 kg N ha^{-1}, 40 kg N ha^{-1} and 60 kg N ha^{-1} were statistically at par.

Combined effect of tree spacings and manure doses on the growth and yield parameters of garden pea: Interaction effect of treatment and spacing (T×S) mostly influenced the yield contributing parameters of pea like total number of pods per plant and green pod yield per hectare, but didn't significantly influenced the growth parameters. Treatment combination S_0T_1 recorded highest yield, whereas, S_1T_8 treatment combination recorded the lowest yield. In the agroforestry system, treatment combination S_3T_1 recorded higher yield which were closely followed by S_3T_2 and S_3T_3, which were statistically at par.

Economic parameters: The results on economics of growing *Pisum sativum* under *Grewia optiva* based agroforestry, presented in the Table 7 and 8 revealed that, growing of garden pea under *Grewia optiva* spaced at wider spacing (8m×3m) is more profitable than growing them as sole crops under open condition. The net return (Rs. 2.17 lakh ha^{-1}) and B:C (2.48) of garden under S_3(8m×3m) spacing was higher than the net return (Rs. 1.77 lakh ha^{-1}) and B:C (2.36) of sole cropping of pea under open condition. Net return increased with increase in organic manure rates upto treatment T_1 (application of 160% of recommended dose of nitrogen through VC and PM) in all spacings, however the marginal increment in the return reduced drastically after T_3 (application of 120% of recommended dose of nitrogen through VC and PM). The Benefit Cost Ratio increased upto T_3 (120% OM) and remained same even in T_2 and thereafter with the increase in dose of organic manures, it decreased. So it is clearly evident that, T_3 (120% of recommended dose of nitrogen through VC and PM) is the most economically viable treatment dose and treatment combination of S_3T_3 was the best treatment combination.

CONCLUSION

The growth and yield parameters of garden pea increased with the increase in tree spacing of *Grewia optiva* and rate of organic manure application. Among the different manure doses the treatment T_3 (application of 120% of

recommended dose of nitrogen through VC and PM) was the best dose, on the other hand, among different treatment combinations S_3T_3 was the best as compared to others. The yield reduction in garden pea under agroforestry system ranged between 13.67% - 56.52% in comparison to sole cropping of pea. The yield reduction was compensated by the income generated from the fodder, fibre and fuel wood generated from Grewia. So the farmers of the western Himalayas can be suggested to grow garden pea under wider spacing (8m×3m) of grewia using poultry manure and vermicompost so as to get greater return as compared to sole cropping.

REFERENCES

Brandis, D. (1972). *Indian Trees*. Bishen Singh Mahendra Paul Singh, Dehradun, India. pp. 767.

Channabasappa, K.S., Madiwalar, S.L. and Kumar P. (2007). Performance of rice in *Acacia auriculiformis* based agroforestry system. *Karnataka Journal of Agriculture Science.* **20**: 883-884.

Erman, M., Ari, E., Togay, Y. and Cig, F. (2009). Response of field pea (*Pisum sativum* sp. Arvense L.) to rhizobium inoculation and nitrogen application in eastern Anotolia. *Journal of Animal and Veterinary Advances.* **8**: 612-616.

FAO. (2018). *Food and Agriculture Organisation Statistical Database*. Food and Agriculture Organisation of the United Nations, Rome, Italy. (www.faostat.org/faostat/en/).

Frankenberger, W.T. and Arshad, M. (1995). *Phytohormones in Soils: Microbial Production and Function*. Marcel and Decker, New York. pp.503.

Ghosh, P.K., Saha, R., Das, A. and Munda, G.C. (2007). Organic farming in India: Potential and Prospects. In: *Advancing Organic Farming Technology in India* (Munda, G.C. *et al.*, eds.). pp. 1-17.

Gomez, L.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research. John Wiley and Sons, Singapore. pp. 680.

Kaur, R. and Puri, S. (2013). Productivity and nutrient dynamics in *Vigna mungo* and *Triticum aestivum* growing in an agroforestry system in Himachal Pradesh. *International Journal of Botany and Research.* **3**: 43-50.

NHB. (2017). *Indian Horticulture Database.* National Horticulture Board, Gurgaon. (www.nhb.gov.in).

Prakash, P. (2011). Effect of tree spacing and organic manures on growth, flower and seed production of *Calendula officinalis* L. under *Grewia optiva* Drummond. based agroforestry system. M.Sc. Thesis. Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, India. p65.

Singh, B. (1990). Note in response of garden pea to N and P application in North hills. *Indian Journal of Horticulture.* **4:** 107-108.

Singh, S. (2002). Effect of shade intensities on *Phaseolus mungo* and *Pisum sativum* in Morus based agroforestry system under rainfed conditions. M.Sc. Thesis. Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, India. p89.

Thakur, P.S. and Singh, S. (2008). Impact of tree management on growth and production behaviour of intercrops under rainfed agroforestry. *Indian Journal of Forestry.* **31**: 37-46.

Yogeshwari. (2015). Crop production and physico-chemical characteristics of soils under Toona ciliata M. trees in mid hill conditions of Himachal Pradesh. M.Sc. Thesis. Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan. p97.