



Effect of spacing and fertilizer levels on growth and yield of garden pea (*Pisum sativum*) in the humid temperate zone of north-western Himalayas

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ABSTRACT

A field experiment was conducted during winter (*rabi*) season 2019–20 and 2020–21 at Chaudhary Sarwan Kumar Himachal Pradesh Agricultural University, Palampur, Himachal Pradesh to study effect of different spacings and fertility levels on growth and productivity of newly developed powdery mildew resistant pyramid line of garden pea (*Pisum sativum* L.), Line 1–2. The experiment was laid out in randomised block design (RBD) with Azad Pea-1 as a standard check, replicated thrice. Treatment combinations comprising of three spacings (30 cm × 10 cm, 45 cm × 10 cm and 60 cm × 10 cm) and four fertility levels [100% RDF (recommended dose of fertilizer), 75% RDF, 125% RDF and 50 % N through urea + 50% N through FYM+100% Phosphorous (P) and Potassium (K)] were assigned to each plot along with Azad pea-1 as standard check. The results revealed that narrow spacing of 30 cm × 10 cm resulted in minimum number of days to 50% flowering and minimum number of days to first picking. Maximum shelling percentage was also observed in 30 cm × 10 cm spacing with application of 125% RDF. Spacing of 45 cm × 10 cm resulted in maximum number of primary branches/plant, number of nodes/plant, pod yield/ha, pod length and number of seeds/pod at 100% recommended dose of fertilizer. Wide spacing of 60 cm × 10 cm accompanied with 125% fertility level resulted in maximum number of pods/plant and pod yield/plant. Maximum seed yield/plant was recorded at 50% N through urea + 50% N through FYM + 100% PK. Interaction effects of 100% fertility level and 50% N through urea + 50% N through FYM + 100% PK with spacing of 45 cm × 10 cm resulted in better performance of Line 1–2 for gross return, net return and benefit cost ratio.

Keywords: Economics, Fertilizers, Garden pea, Growth, Spacing, Yield

Garden pea (*Pisum sativum* L.) belongs to the family Fabaceae, is one of the principal vegetable crops cultivated in temperate and sub-tropical areas of the world. Vavilov (1935) reported the mountainous region of southwest Asia, particularly Afghanistan and India as the primary centre of origin of peas. Near East and Ethiopia are considered as secondary habitats (Blixt 1970). It is the second most important food legume worldwide after common bean (*Phaseolus vulgaris*) (Taran *et al.* 2005). The crop is consumed for its green pods and is a rich source of proteins, vitamins, minerals and lysine. Owing to diverse agro-climatic conditions in Himachal Pradesh, it is grown year-round as an off-season cash crop during summer in the high-altitude areas and during winter in low and mid hills, fetching high remuneration. Due to the mono-cropping of garden pea, the commercial potential of varieties has declined due to a plethora of diseases. Powdery mildew is one of the most devastating diseases affecting garden pea

production in the state. High-yielding powdery mildew-resistant genotype, Line 1–2 has been developed through marker-assisted backcross breeding and has outyielded commercial check Azad Pea-1 in multilocation trials across the state (Rahman 2018).

The plant geometry plays a major role in maintaining the micro-climate in the cropping area as optimum spacing, improves aeration within the crop canopy, maximizes light utilization efficiency, enhances soil respiration, and provides better weed control therefore resulting in higher crop yields (Gautam *et al.* 2008).

The growth of plants depends on the availability of nutrients from the soil which has to be supplied by appropriate use of fertilizers for sustenance growth. Of late, there has been serious concern about long-term adverse effects of continuous and indiscriminate use of inorganic fertilizers to enhance soil fertility and crop productivity as it leads to the deterioration of the soil ecosystem (Sharma *et al.* 2014). Thus, it is necessary to standardize optimum spacing and fertilizer doses for gaining higher yield of the crop. Therefore, an attempt has been made to study the effect of spacing and fertilizer doses on the yield and other related traits in garden pea, Line 1–2.

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Table 1 Performance of Line 1–2 for phenological traits and structural traits in response to different spacing and fertility levels

Treatment	Days to 50% flowering			Days to first picking			Number of primary branches/plant			Number of nodes/plant			Internodal length			Plant height	
	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21
Spacings (S)																	
30 cm × 10 cm	103.17	95.33	99.25	132.08	128.17	130.13	3.41	3.37	3.39	33.12	31.62	32.37	3.42	3.21	3.31	56.92	53.18
45 cm × 10 cm	103.67	95.75	99.71	132.83	128.17	130.50	3.49	3.49	3.49	33.18	31.73	32.46	3.44	3.24	3.34	56.84	53.81
60 cm × 10 cm	104.50	96.50	100.50	133.67	128.25	130.96	3.44	3.47	3.45	33.05	31.53	32.29	3.45	3.24	3.34	55.30	50.86
SEm±	0.36	0.38	0.28	0.38	0.27	0.20	0.03	0.05	0.02	0.07	0.15	0.07	0.07	0.04	0.04	0.36	0.39
CD ($P=0.05$)	0.75	0.79	0.58	0.78	NS	0.42	0.05	0.10	0.05	NS	NS	NS	NS	NS	NS	0.74	0.80
Fertility levels (F)																	
100% recommended dose of fertilizer	104.11	96.11	100.11	133.22	129.00	131.11	3.60	3.61	3.61	33.81	32.42	33.12	3.48	3.27	3.37	57.08	53.79
75% recommended dose of fertilizer	103.22	95.22	99.22	132.89	127.33	130.11	3.36	3.32	3.34	32.42	31.08	31.75	3.41	3.21	3.31	56.18	52.59
125% recommended dose of fertilizer	104.44	96.56	100.50	132.89	129.11	131.00	3.49	3.54	3.52	33.32	31.73	32.53	3.44	3.19	3.32	56.95	53.70
50% N through urea + 50% N through FYM + 100% PK	103.33	95.56	99.44	132.44	127.33	129.89	3.34	3.29	3.32	32.91	31.28	32.09	3.41	3.25	3.33	55.21	50.38
SEm±	0.42	0.44	0.32	0.44	0.31	0.23	0.03	0.05	0.03	0.08	0.17	0.08	0.08	0.05	0.04	0.41	0.45
CD ($P=0.05$)	0.87	0.91	0.67	NS	0.64	0.48	0.06	0.11	0.06	0.16	0.35	0.16	NS	NS	NS	0.85	0.92
S × F	NS	NS	NS	NS	NS	NS	0.11	NS	0.10	0.27	NS	0.29	NS	NS	NS	1.48	1.59
Check vs others																	
Check	95.33	92.00	93.67	124.33	120.67	122.50	2.47	2.27	2.37	24.10	23.40	23.75	4.53	4.80	4.67	63.61	59.27
Others	103.78	95.86	99.82	132.86	128.19	130.53	3.45	3.44	3.44	33.12	31.63	32.37	3.44	3.23	3.33	56.35	52.62
SEm±	0.54	0.56	0.41	0.56	0.39	0.30	0.04	0.07	0.04	0.10	0.22	0.10	0.10	0.06	0.05	0.53	0.57
CD ($P=0.05$)	1.11	1.16	0.85-	1.15	0.81	0.61	0.08	0.14	0.08	0.20	0.45	0.21	0.20	0.13	0.11	1.09	1.17

Table 2 Performance of Line 1-2 for yield and related horticultural traits in response to different spacing and fertility levels

Treatment	Number of pods/plant			Pod yield/plant			Pod yield/ha			Pod length			Number of seeds/pod			Seed yield/plant		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Spacings (S)																		
30 cm × 10 cm	15.10	13.54	14.32	60.40	54.17	57.28	140.93	126.39	133.66	9.67	9.36	9.52	8.67	8.50	8.58	7.50	6.85	7.18
45 cm × 10 cm	18.83	18.18	18.51	108.26	104.55	106.41	168.40	162.63	165.51	9.96	9.52	9.74	8.74	8.60	8.67	10.96	11.11	11.04
60 cm × 10 cm	22.73	20.67	21.70	118.21	107.47	112.84	137.91	125.37	131.64	9.57	9.29	9.43	8.34	8.46	8.40	12.83	11.63	12.23
SEm±	0.13	0.11	0.07	0.63	0.58	0.38	1.07	0.94	0.58	0.13	0.14	0.10	0.15	0.17	0.12	0.10	0.14	0.06
CD ($P=0.05$)	0.26	0.23	0.15	1.29	1.20	0.78	2.21	1.93	1.20	0.27	NS	0.21	0.31	NS	NS	0.20	0.28	0.13
Fertility levels (F)																		
100% recommended dose of fertilizer	19.67	17.57	18.62	99.63	89.75	94.69	155.62	138.39	147.00	9.90	9.47	9.69	8.68	8.72	8.70	11.97	10.99	11.48
75% recommended dose of fertilizer	17.44	16.11	16.78	88.14	81.81	84.97	138.04	127.21	132.62	9.76	9.31	9.53	8.57	8.44	8.51	9.64	9.35	9.49
125% recommended dose of fertilizer	19.70	18.26	18.98	99.66	92.59	96.13	154.79	143.50	149.15	9.77	9.40	9.59	8.47	8.44	8.46	10.65	10.67	10.66
50 % N through urea + 50% N through FYM + 100% PK	18.73	17.92	18.33	95.08	90.77	92.92	147.86	143.43	145.65	9.50	9.38	9.44	8.62	8.47	8.54	9.47	8.46	8.96
SEm±	0.15	0.13	0.08	0.72	0.67	0.44	1.24	1.08	0.67	0.15	0.16	0.12	0.18	0.19	0.14	0.11	0.16	0.07
CD ($P=0.05$)	0.30	0.27	0.17	1.49	1.38	0.91	2.56	2.23	1.39	NS	NS	NS	NS	NS	NS	0.23	0.33	0.14
S × F	0.52	0.47	0.30	2.58	2.39	1.57	4.43	3.87	2.41	NS	NS	NS	NS	NS	NS	0.40	0.56	0.25
Check vs others																		
Check	14.27	12.11	13.19	71.33	60.56	65.94	110.96	94.19	102.58	9.17	8.20	8.68	6.67	6.70	6.68	8.63	6.73	7.68
Others	18.89	17.46	18.18	95.62	88.73	92.18	149.08	138.13	143.60	9.73	9.39	9.56	8.58	8.52	8.55	10.43	9.87	10.15
SEm±	0.19	0.17	0.11	0.92	0.85	0.56	1.58	1.38	0.86	0.19	0.21	0.15	0.22	0.24	0.18	0.14	0.20	0.09
CD($P=0.05$)	0.39	0.34	0.22	1.90	1.76	1.16	3.26	2.85	1.77	0.39	0.43	0.30	0.46	0.50	0.38	0.30	0.41	0.18

MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) season 2019–20 and 2020–21 at Chaudhary Sarwan Kumar Himachal Pradesh Agricultural University, Palampur (32°62' N and 76°32' E, 1291 m amsl), Himachal Pradesh. The soil was silty in texture, acidic in reaction and classified as Typic Hapludalf. Twelve treatment combinations were laid out in randomised block design (RBD) with Azad Pea-1 as a standard check, replicated thrice. Garden pea Line 1–2 was sown with treatment combinations comprising of three spacings (30 cm × 10 cm, 45 cm × 10 cm and 60 cm × 10 cm) and four fertility levels (100% RDF, 75% RDF, 125% RDF and 50% N through FYM + 50% N through urea + 100% PK) in 1.5 m × 1.8 m plots on 6th November in the respective years. The recommended dose (100%) of N: P₂O₅: K₂O was 25:60:60 kg/ha, respectively. Ten plants were randomly selected in each plot for recording data on different growth and yield related attributes. The observations recorded were subjected to statistical analysis using randomized block design of experimentation as per procedure suggested by Gomez and Gomez (1982).

RESULTS AND DISCUSSION

The superior performance of the line for phenological traits, viz. days to 50% flowering and days to first picking was recorded at a spacing of 30 cm × 10 cm with the

application of 75% recommended dose of fertilizer (Table 1). The number of days taken for first flowering was found to be increased with increasing fertilizer dose. The increased availability of nutrients by increasing fertilizer dose (125% of recommended dose of fertilizer) might have increased the plant growth and thus resulted delay in first flowering and pod formation (Vimala and Natarajan 2000). The number of branches/plant, nodes/plant, pod length, number of seeds/pod and pod yield/ha were found maximum at 45 cm × 10 cm spacing with the application of 100% RDF (Table 2). These findings were supported by those of Attar *et al.* (2013) and Sharma *et al.* (2016). The higher number of primary branches/plant with a spacing of 45 cm × 10 cm (Table 2) might be related to better vegetative growth, more horizontal growth plant canopy area, and efficient photosynthetic activities which might have enhanced the vegetative phase unlike narrow spacing (Bahadur and Singh 2005). More number of branches/plant at 100% RDF may be due to the availability of optimum phosphorous content which may have attributed to the fact that phosphorus helped in producing a higher nodulation count, which resulted in higher nitrogen fixation which led to the production of more branches for higher photosynthetic ability (Ndor 2012). Spacing of 60 cm × 10 cm with 100% RDF resulted in significantly high number of pods/plant, pod yield/plant and seed yield/plant (Table 2). The increase in number of pods/

Table 3 Performance of Line 1–2 for economics in response to different spacing and fertility levels

Treatment	Gross returns (₹ in lakhs/ha)			Net returns (₹ in lakhs/ha)			B:C ratio		
	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled	2019–20	2020–21	Pooled
Spacings (S)									
30 cm × 10 cm	4.28	3.84	4.06	3.24	2.80	3.02	3.09	2.67	2.88
45 cm × 10 cm	5.11	4.93	5.02	4.06	3.89	3.97	3.87	3.71	3.79
60 cm × 10 cm	4.19	3.81	4.00	3.14	2.76	2.95	2.99	2.63	2.81
SEm±	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02
CD (<i>P</i> =0.05)	0.07	0.06	0.04	0.07	0.06	0.04	0.06	0.06	0.03
Fertility levels (F)									
100% recommended dose of fertilizer	4.73	4.20	4.47	3.68	3.16	3.42	3.51	3.01	3.26
75% recommended dose of fertilizer	4.19	3.86	4.03	3.16	2.83	2.99	3.05	2.74	2.89
125% recommended dose of fertilizer	4.70	4.36	4.53	3.64	3.30	3.47	3.43	3.11	3.27
50% N through urea + 50% N through FYM +100% PK	4.48	4.35	4.42	3.44	3.30	3.37	3.29	3.11	3.22
SEm±	0.04	0.03	0.02	0.04	0.03	0.02	0.04	0.03	0.02
CD (<i>P</i> =0.05)	0.08	0.07	0.04	0.08	0.07	0.04	0.07	0.06	0.04
S × F	0.13	0.12	0.07	0.13	0.12	0.07	0.13	0.11	0.07
Check vs others									
Check	3.39	2.89	3.14	2.34	1.84	2.09	2.24	1.76	2.00
Others	4.52	4.19	4.36	3.48	3.15	3.31	3.32	3.00	3.16
SEm±	0.07	0.04	0.03	0.05	0.04	0.03	0.05	0.04	0.02
CD (<i>P</i> =0.05)	0.10	0.09	0.05	0.10	0.09	0.05	0.09	0.08	0.05

plant with spacing might be due to better growth, efficient photosynthetic activities and carbohydrate accumulation at wider spacing (Bahadur and Singh 2005). The results were found in line with the findings of Siddique *et al.* (2003). Increase in number of pods/plant and pod yield/plant with spacing might be due to better availability of nutrients and less competition between plants for nutrients, water and sunlight which may have enhanced photosynthetic activities and resulted in more number of pods/plant. Among spacings, minimum plant height was found at the wider spacing of 60 cm × 10 cm. Maximum plant height was found at the spacing of 30 cm × 10 cm. A marked increase in plant height at close spacing might be attributed to higher plant population density which might have resulted in less plant canopy area and more vertical growth by producing weak and tall plants due to competition for space, light, nutrients and moisture compared to those at wider spacing (Shrikanth *et al.* 2008). Attar *et al.* (2013) also reported increased plant height with narrow spacing. Nutrients are crucial elements of proteins, nucleotides, chlorophyll, and enzymes, and hence facilitate numerous metabolic processes in plants, resulting in increased output (Sharma *et al.* 2023). Number of pods per plant, number of nodes per plant and pod yield per plant was found maximum with the application of 125% recommended dose of fertilizer (Table 2). Kurabiah and Thomas (2017), Yadav and Dhanai (2017) and Dhiman *et al.* (2018) also observed maximum pod yield per plant with the increased fertilizer dose. Highest yield per ha of Line 1–2 was observed at spacing of 45 cm × 10 cm with 100% RDF (Supplementary Table 1) which can be attributed to more number of primary branches/plants, more number of nodes/plant, long pods, more number of seeds/pod and optimum plant population and fertilizer dose. Sharma *et al.* (2016), Jyoti and Swaroop (2016), Gupta *et al.* (2017) and Chandel *et al.* (2023) also reported maximum pod yield with application of recommended dose of fertilizer.

A spacing of 45 cm × 10 cm gave significantly higher gross returns, net returns, and benefit-cost ratio at all the fertility levels being highest in 100% fertilizer application during 2019–20 and pooled basis (Table 3). During 2020–21, it was found to be highest in 50 % N through urea + 50% N through FYM + 100% P.K. Lowest gross returns net returns and benefit cost ratio were estimated in 75% fertility level at spacing of 60 cm × 10 cm. The results were supported by those of Sharma *et al.* (2006), Faheema *et al.* (2006), Dubey *et al.* (2012), Bhat *et al.* (2013) and Kalabandi *et al.* (2017).

This study revealed that spacing of 45 cm × 10 cm with application of 100% RDF is optimum for better performance of Line 1–2 for yield, net return and benefit cost ratio.

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