Influence of seeding time, fertility level and genotype on productivity, quality and profitability of garden pea (Pisum sativum)

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Research Paper

Influence of seeding time, fertility level and genotype on productivity, quality and profitability of garden pea (*Pisum sativum*)

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ABSTRACT

The field experiment was conducted during 2017–18 and 2018–19 at Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India, to assess the response of pea (*Pisum sativum* L.) genotypes ('DPP-SP 6', 'DPP-SP 22' and 'Pb 89') to sowing dates (26 October and 10 November) and fertility levels (control, 100 and 125% NPK). The experiment was laid out in factorial randomized block design and each treatment replicated thrice. Early-sown pea (26 October) recorded higher pod yield (10.4 t/ha), being 24% more than late-sown crop along with better pods/plant, average pod weight, harvest duration and economic returns. Higher fertility level at 125% of recommended NPK (62.5:75:75 kg/ha) dose resulted in the maximum pod yield which was about 6% better than 100% NPK (50:60:60 kg/ha) over the years and also showed superior performance for yield attributes and economic returns. Among the genotypes, 'DPP-SP 6' significantly superseded 'DPP-SP 22' by 15%, and 'Pb 89' by 25% for pod yield and also provided higher net returns (₹1,43,000/ha) and benefit: cost ratio (2.78). The interactions effects revealed that early sowing of pea genotypes by following either 100% or 125% of recommended dose of NPK (100% NPK; 50-60-60 kg/ha) would be a better preposition for enhancing productivity and profitability under north-western Himalayan conditions.

Key words: Economics, Fertility, Genotypes, Interaction, Pod yield, Sowing dates

Garden pea (*Pisum sativum* L.), is an important food legume grown throughout India, especially in north-western Himalayan region comprising the states of Himachal Pradesh, Jammu and Kashmir and Uttarakhand (Sharma *et al.,* 2013). Green peas are rich in health-promoting phytonutrients, minerals, vitamins and antioxidants (Sharma *et al.,* 2020).

The sowing date ensures the complete harmony between vegetative and reproductive phase on the one hand and climatic rhythm on the other hand and thus, helps in realizing potential yield. The selection of sowing window also depends on the type of variety to be grown (Sarangi *et al*., 2021). It is a critical factor in determining the environmental conditions at planting, anthesis and pod filling hence, important in determining the success of crop in maximizing yields (Sharma *et al.,* 2014a). The growth of plants depends on the availability of nutrients from the soil which has to be regulated by appropriate use of fertilizers. The potential way to mitigate negative environmental impacts resulting from inefficient use of chemical fertilizers is to follow integrated use of organic manures and chemical fertilizers (Sharma *et al.,* 2014b). This will in turn help to meet out the nutrient requirement of the crops as well as maintaining sustainability in terms of productivity and soil fertility. High yield is the major objective of all crop breeding programmes and the development of genotype, with potential to surpass commercial adopted varieties, is essential along with preference of consumers for specific traits. In pea, the consumers/farmers have preference for varieties with few specific traits such as high, green and well filled pod with high shelling (%). Two garden pea genotypes namely 'DPP-SP 6' and 'DPP-SP 22' have been developed with desirable pod characteristics and high yield. It is important to access the response of these genotypes to planting dates and fertility levels. Therefore, the present study was conducted to investigate the effect of different sowing dates and fertility levels on yield, and related traits of new genotypes of garden pea.

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MATERIALS AND METHODS

A field experiment was conducted during the winter seasons of 2017–18 and 2018–19 at the Vegetable Research Farm of CSK, Himachal Pradesh Agricultural University, Palampur (32° 62N, 76° 32E, 1,290 m above mean sea-level), India. The location represents the mid-hill zone of Himachal Pradesh (Zone-II) having humid sub-temperate climate with high rainfall (2,500 mm). The soil is clay loam with *p*H 5.6 and is classified as Typic Hapludalf. Eighteen treatment combinations of 3 genotypes [‘DPP-SP 6’ (V_1), ‘DPP-SP 22’ (V_2) and ‘Pb 89’ (check) (V_3)]; 2 sowing dates [26 October (D_1) and 10 November (D_2)]; and 3 fertility levels, viz. no NPK (control), recommended dose of NPK (100% NPK, i.e. 50-60-60 kg N-P_2O_5-K_2O/ha, respectively) and 125% NPK were tested in randomized block design with 3 replications. A uniform dose of 20 t/ha of farmyard manure (FYM) was applied (Thakur, 2018).

The experimental field was prepared 5 days before sowing with the help of a tractor-drawn disc plough, followed by rotavator. Farmyard manure was mixed in the soil during field preparation. The seeds of each genotype were treated with Bavistin at 3 g/kg seed before sowing. After treatment, seeds of the respective genotypes were sown manually on the respective dates of sowing, i.e. on 26 October and 10 November of both the years, with inter-and intra-row spacing of 45 cm and 7.5 cm respectively. The NPK fertilizers were applied as per treatments at sowing. Irrigation was provided before sowing after the field preparation. Thereafter, the crop was irrigated at 15 days interval. In all, 8 irrigations were provided during the whole cropping season using sprinkler in the initial stages of growth and basin method of irrigation during flowering and pod formation/ development stages. The pre-emergence herbicide pendimethalin @ 1.5 kg a.i./ha was applied immediately after sowing, followed by hand-weeding thrice to keep the field weed-free. The observations were recorded on 10 random plants for days to flowering, days to first picking, internodal length (cm), nodes/plant, branches/plant, plant height (cm), pod length (cm), seeds/pod, shelling percentage and pods/plant. Pod yield was recorded on plot basis and was converted to tonnes/ha (t/ha). Quality parameters such ascorbic acid content (‘2, 6-dichlorophenol-indophenol Visual Titration Method’ as described by Ranganna, 1979) and total soluble solids (ERMA hand refractrometer in °Brix) were also estimated. The economics of the treatments was computed based on prevalent prices or those fixed by the university. The data in the respective years and pooled over years were statistically analysed as per the standard statistical procedures.

RESULTS AND DISCUSSION

Sowing dates

Sowing time significantly influenced the phenological (days to flowering and first picking), structural traits (nodes per plant, internodal length and plant height) and pod yield along with yield attributes during both the years and averaged over environments (Tables 1, 2). Significantly higher number of days to flowering were taken in 10 November-sown crop than 26 October-sown crop during both the years and pooled over years (Table 1). More number of days for flowering with late sowing might be due to lower temperature, bright sunshine and day-length during December and January. During the first year, the difference to flowering which was about 6 days between 2 dates of sowing was reduced to about 2 days for first picking indicated relatively favourable temperature for pod initiation and development from February onwards which reduced the 15 days gap of sowing to about 1 week for flowering and only about 2 days for first picking. Contrary to this, days to first picking were observed less in 10 November-sown crop during 2018–19. It is due to the fact that, early flowering in early-sown crop coincided with chill temperature and heavy rainfall in December and January which affected fertilization and pod formation and hence delayed picking in early-sown crop. Also, early sowing on 26 October resulted in a greater number of nodes/plant (24.6 and 25.2) and maximum plant height (66.0 cm and 65.8 cm) during 2018–19 and pooled over years, respectively (Table 1). The better performance of these traits was the result of long-crop duration of early-sown crop which may have led to the accumulation of more carbohydrates and thereby enhanced vegetative growth of plants.

On the other hand, pod length (2017–18), pod width (2017–18 and on pooled basis) and shelling percentage (both years and on pooled basis) was higher in the late-sown crop. However, significantly longer pod length was observed in 26 October-sown crop during 2018–19. The difference in pod length, pod width and shelling (%) was due to low temperature during the early period of pod formation during the first year that might have resulted in shorter pod size in early-sown crop. Better climatic conditions during pod-development stage might have resulted in better accumulation of nutrients and had better pod and seed development and thus resulted in longer pod length, more pod width and high shelling (%) in late-sown crop. Significantly highest pod yield and pods/plant during both the years and pooled over years and average pod weight during 2017–18 were observed in early-sown crop on 26 October as compared to 10 November-sown crop (Table 2). There was 24% increase in mean yield over years in early-sown crop over late-sown one. Mukherjee *et al.*

Table 1. Effect of sowing dates, fertility levels and varieties on phenological and structural traits of garden pea

Treatment	Days to flowering			Days to 1 picking			Nodes/plant			Branches/plant			Internodal length (cm)			Plant height (cm)		
	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled
Date of sowing																		
26th October	76	83	80	113	133	123	25.8	24.6	25.2	2.2	1.8	2	5.92	4.9	5.41	65.6	66	65.8
10th November	82	99	90	115	132	123	25.3	23	24.2	2.4	1.9	2.1	5.62	5.17	5.4	64.3	63.2	63.8
SEm±	0.24	0.35	0.21	0.35	0.31	-	-	0.21	0.17	-	-	-	0.08	0.06	-	-	0.66	0.59
CD (P=0.05)	0.7	1.0	0.6	1.0	0.9	NS	NS	0.6	0.5	NS	NS	NS	0.23	0.16	NS	NS	1.9	1.7
Fertility level																		
Control	77	92	84	113	133	123	25.7	22.8	24.2	2.4	1.5	1.9	5.25	4.63	4.94	55.5	57.2	56.4
100% NPK	80	91	85	114	132	123	25.7	24.3	25	2.3	1.9	2.1	5.99	5.37	5.68	68.5	68.8	68.6
125% NPK	81	91	86	115	133	124	25.3	24.3	24.8	2.3	1.9	2.1	6.07	5.1	5.59	70.9	67.8	69.4
SEm±	0.31	-	0.24	0.42	-	0.28	-	0.24	0.21	-	0.07	0.03	0.10	0.07	0.06	1.22	0.80	0.70
CD (P=0.05)	0.9	NS	0.7	1.2	NS	0.8	NS	0.7	0.6	NS	0.2	0.1	0.28	0.2	0.17	3.5	2.3	2
Variety																		
'DPP SP 6'	80	93	86	116	134	125	25.9	23.7	24.8	2.3	1.7	2	5.8	5.01	5.41	64.7	65.2	64.9
'DPP SP 22'	78	90	84	113	131	122	25.8	24.1	24.9	2.3	1.8	2	5.48	4.79	5.13	65.2	63.2	64.2
'Pb 89' (Check)	79	91	85	114	133	123	25.1	23.6	24.3	2.3	1.8	2	6.03	5.3	5.67	64.9	65.5	65.2
SEm±	0.31	0.45	0.24	0.42	0.38	0.28	-	-	-	-	-	-	0.10	0.07	0.06	-	-	-
CD (P=0.05)	0.9	1.3	0.7	1.2	1.1	0.8	NS	NS	NS	NS	NS	NS	0.28	0.2	0.17	NS	NS	NS

*NS, Non-significant

Table 2. Effect of sowing dates, fertility levels and variety on yield attributes and yield of garden pea

Treatment	Pod length (cm)			Pod width (cm)			Seeds/pod			Shelling (%)			Avg. pod weight (g)			Pods/plant			Pod yield (t/ha)			Harvesting duration (days)		
	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled
Date of sowing																								
26 October	10.3	11.3	10.8	1.07	1.21	1.14	8.2	7.3	7.8	45.1	43.9	44.6	6.09	4.78	5.44	11.8	8.4	10	12.7	8.04	10.4	28.7	20.3	24.5
10 November	10.8	10.6	10.7	1.15	1.21	1.17	8.4	6.9	7.7	50.5	47.2	48.9	5.75	4.88	5.31	10.7	6.4	8.5	10.85	6.17	8.51	22.44	16.1	19.3
SEm±	0.10	0.07	-	0.01	-	0.01	-	-	-	0.66	0.52	0.42	0.07	-	-	0.21	0.10	0.10	0.14	0.08	0.08	0.68	0.56	0.44
CD (P=0.05)	0.3	0.2	NS	0.02	NS	0.02	NS	NS	NS	1.9	1.5	1.2	0.19	NS	NS	0.6	0.3	0.3	0.4	0.22	0.23	1.95	1.6	1.26
Fertility level																								
Control	10.2	10.4	10.3	1.12	1.21	1.16	7.8	6.1	6.9	47.6	44.3	45.9	5.69	4.67	5.18	8.1	4.8	6.5	8.17	4.43	6.29	23.72	16.4	20.1
100% NPK	10.6	11.5	11	1.12	1.24	1.18	8.6	7.7	8.2	47.9	45.9	46.9	6.22	5.0	5.61	12.2	8.3	10	13.29	8.16	10.7	27.06	19.9	23.5
125% NPK	10.9	11	10.9	1.1	1.17	1.13	8.6	7.6	8.1	47.9	46.7	47.3	5.86	4.82	5.34	13.5	9.1	11	13.87	8.72	11.3	25.94	18.2	22.1
SEm±	0.10	0.10	0.07	-	0.01	0.01	0.10	0.21	0.14	-	0.66	-	0.08	0.08	0.06	0.24	0.14	0.14	0.17	0.10	0.10	0.83	0.69	0.54
CD (P=0.05)	0.3	0.3	0.2	NS	0.04	0.03	0.3	0.6	0.4	NS	4.9	NS	0.23	0.24	0.16	0.7	0.4	0.4	0.49	0.28	0.28	2.39	1.97	1.54
Variety																								
'DPP-SP 6'	11.2	11.8	11.5	1.15	1.27	1.21	8.8	7.7	8.3	49.9	47.0	48.5	6.36	5.07	5.72	11.8	8.3	10.0	13.23	8.35	10.8	25.89	19.6	22.7
'DPP-SP 22'	10.3	10.8	10.6	1.11	1.2	1.16	8.3	7.1	7.7	47.6	46.1	46.9	5.78	4.86	5.32	11.7	7.2	9.4	11.94	6.89	9.42	26.00	17.9	22.0
'Pb 89' (Check)	10.2	10.3	10.2	1.08	1.15	1.12	7.9	6.6	7.2	45.9	43.7	44.8	5.62	4.55	5.09	10.2	6.8	8.5	10.15	6.05	8.1	24.83	17.1	20.9
SEm±	0.10	0.10	0.07	0.01	0.01	0.01	0.10	0.21	0.14	0.84	0.66	0.52	0.08	0.08	0.06	0.24	0.14	0.14	0.17	0.10	0.10	-	0.69	-
CD (P=0.05)	0.3	0.3	0.2	0.03	0.04	0.03	0.3	0.6	0.4	2.4	1.9	1.5	0.23	0.24	0.16	0.7	0.4	0.4	0.49	0.28	0.28	NS	1.96	NS

NS, Non-significant

(2013) also observed significantly higher pod production in crop sown on 26 October over other dates of sowing. The significant better pod yield in early sown crop was the result of higher number of pods/plants, average pod weight and longer harvest duration. Sharma *et al.,* (2014a) and Sharma *et al*., (2016a) also reported better performance for yield and other traits in early-sown crop. This indicated that optimum planting date helps plants to take advantage of climatic factors such as temperature, moisture and day-length and thus improved the yield characters.

Dates of sowing significantly affected quality traits, viz. total soluble solids (TSS) and ascorbic acid (Table 3). The early sowing resulted in significantly higher TSS (14.4% Brix) during 2017–18, whereas significant higher ascorbic acid content (25.1 and 22.6 mg/100 g fresh-weight basis) was recorded in late-sown crop during 2017–18 and pooled year basis, respectively. The effects of different treatments were significant on economic parameters, viz. gross returns, net returns and benefit: cost ratio (Table 3). Higher net returns (₹1,81,000, ₹88,000 and ₹1,35,000 during respective years and pooled years) were accrued when crop was sown on 26 October as compared to 10 November-sown crop (₹1,45,000, ₹49,000 and ₹97,000) over the years. The better economics of this treatment could be ascribed to higher pod yield obtained in the treatment. Our results confirm the findings of Mukherjee *et al.,* (2013).

Fertility levels

Fertility levels revealed significant variation in phenological, structural, pod yield, and related traits. Significantly lesser numbers of days to flowering and first picking were recorded under the control conditions with no application of NPK fertilizers in 2017–18 and pooled over years. Amongst the phenological traits, the maximum nodes/plants, branches/plant and plant height were recorded in treatments comprising 100 and 125% of recommended dose of fertilizers and found significantly higher than the control over years. During both the years and pooled over years, a greater number of pod length, seeds/pod, average pod weight and harvest duration were recorded due to 100 or 125% NPK over the control. Higher number of seeds/pod and better pod weight at optimal fertility levels were also reported by Gupta *et al.,* (2017). The reduction in average pod weight at 125% NPK in comparison

Table 3. Effect of date of sowing, fertility levels and varieties on quality and economics of pea production at Palampur (mid-hill conditions of Himachal Pradesh)

Treatment	TSS (°Brix)			Ascorbic Acid (mg/100 g fresh weight basis)			Gross returns (₹/ha)			Net returns (₹/ha)			Benefit: cost ratio		
	2017–18	2018–19	Pooled	2017-18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled	2017–18	2018–19	Pooled
Date of sowing															
D_1, 26th October	14.4	14.0	14.2	22.6	20.3	21.5	261,000	167,000	214,000	181,000	88,000	135,000	3.27	2.08	2.68
D_2, 10th November	13.8	14.2	14	25.1	20.1	22.6	224,000	128,000	176,000	145,000	49,000	97,000	2.79	1.6	2.19
SEm±	0.17	-	-	0.35	-	0.36	0.03	0.02	0.00	0.03	0.02	0.00	0.03	0.02	-
CD (P=0.05)	0.50	NS	NS	1.00	NS	1.02	8,000	5,000		8,000	5,000		0.1	0.06	
Fertility level															
F_1, Control (no NPK)	14.4	14.3	14.3	22.7	20.8	21.8	168,000	92,000	13,000	93,000	17,000	55,000	2.24	1.23	1.74
F_2, 100% of recommended NPK	13.8	14.5	14.2	25.0	19.6	22.3	274,000	170,000	222,000	193,000	89,000	141,000	3.38	2.09	2.73
F_3, 125% of recommended NPK	14.1	13.7	13.9	23.8	20.3	22.0	285,000	181,000	233,000	203,000	99,000	151,000	3.47	2.20	2.83
SEm±	-	-	-	0.45	-	-	0.03	0.02	-	0.03	0.02	-	0.04	0.02	-
CD (P=0.05)	NS	NS	NS	1.3	NS	NS	10,000	6,000		10,000	6,000		0.12	0.07	
Varieties															
V_1, 'DPP-SP 6'	14.0	14.4	14.2	24.5	20.4	22.5	2.72	1.73	2.23	1.92	0.93	1.43	3.40	2.16	2.78
V_2, DPP-SP 22'	14.0	13.8	13.9	24.1	20.8	22.5	2.45	1.43	1.94	1.66	0.64	1.15	3.07	1.79	2.43
V_3, 'Pb 89' (Check)	14.3	14.2	14.3	22.9	19.4	21.2	2.10	1.26	1.68	1.30	0.47	0.89	2.62	1.58	2.1
SEm±	-	-	-	0.45	-	-	0.03	0.02	-	0.03	0.02	-	0.04	0.02	-
CD (P=0.05)	NS	NS	NS	1.3	NS	NS	0.10	0.06		0.10	0.06		0.12	0.07	

Recommended dose: 50: 60: 60 kg N: P_2O_5: K_2O/ha to 100% NPK might be the result of more pods/plant in the former treatment since pod weight and pods/plant are negatively correlated. The pods/plant and pod yield/ha increased consistently and significantly with increasing fertility level. Application of 125% NPK resulted in significantly higher pod yield and pods/plant over 100% NPK and the control treatments in both the years and pooled over years. The mean increase of pod yield was 5.6% over 100% NPK. Gupta *et al.,* (2017) also reported higher yield at increasing fertility levels. Poor pod yield under no NPK application in comparison to 100 and 125% NPK levels showed that, sink capacity of a plant depends mainly on vegetative growth which is affected positively by application of nutrients and supply of photosynthates for the formation of yield component (Sharma *et al.,* 2016b). The increased availability of nutrients through addition of fertilizers increases the physiological activity, leading to build up of sink and finally better pod development. Improvement in yield owing to the use of fertilizers might be brought about by the synergistic effect of FYM application and inorganic nutrients from fertilizers on nutrient uptake, physiological growth and yield-contributing parameters that improved physiochemical and microbial environment of the rhizosphere leading to better expression of response to applied chemical fertilizers (Sharma *et al.,* 2003). The added fertilizer enhanced the availability of these nutrients and thereby absorption by the plants which might have resulted in profuse shoot and root growth, yield attributes and finally yield. Such a response of pea crop to higher levels of NPK, i.e., 100% to 125% NPK in a soil having low to medium N and medium P, K and organic matter was obvious. The fertility treatments have significant effect on ascorbic acid content with the maximum content at 100 and 125% NPK during 2017–18.

The net returns and benefit: cost ratio at 125% fertility level was at par with 100% NPK fertility level during 2017–18 and significantly higher net returns (₹2,03,000 and 99,000) and B : C ratio (3.47 and 2.20) were obtained with 125% NPK during 2017–18 and 2018-19, respectively. The higher economic returns were obtained in treatments with high pod yield. Although the cost of cultivation increased with increasing levels of synthetic fertilizers, proportionally better pod yield improvement made fertilizer application profitable. Paik *et al.,* (2020) recorded 12.95% profit increment through application of 150% RDF (225 N + 90 P_2O_5 + 60 K_2O kg/ha) over RDF in wheat.

Genotypes

Genotypes differed significantly in terms of days to 50% flowering and days to first picking with 'DPP-SP 22' taking significantly lesser number of days to attain both the phenological stages on pooled basis which was at par with 'Pb 89' genotype for days to 50% flowering in 2017–18 as well as 2018–19. 'DPP-SP 6' genotype took significantly higher number of days to reach both the phenological stages over the years. Pea cultivars have a sufficiently wide range of duration of vegetative period and their consequent phases (flowering, maturation etc.). The duration of vegetative period corresponds to agro-climatic peculiarities of the area. Days to flowering has positive relation with days to first pod picking. The structural traits namely, primary branches/plant, nodes/plant and plant height were found statistically similar in all genotypes. However, varieties had a significant effect on internodal length in both the years and on pooled basis with the maximum in 'Pb 89' (6.03 cm).

Under Indian conditions, consumer prefers well-filled, long and green pods. The longest and widest pod along with maximum seeds/pod, shelling (%) and average pod weight were recorded in 'DPP-SP 6' followed by 'DPP-SP 22' but significantly better than 'Pb 89' during both the years and on pooled basis. The higher shelling (%) in 'DPP-SP 6' and 'DPP-SP 22' may be ascribed to more seeds/pod and better seed size than check variety 'Pb 89'. 'DPP-SP 6' produced significantly higher numbers of pods/plant during 2018–19 and pooled years followed by 'DPP-SP 22', but both showed at par performance during 2017–18. Similarly, 'DPP-SP 6' gave the highest pod yield/ha during both the years and on pooled basis, being 14.65 and 24.69% higher than 'DPP-SP 22' and 'Pb 89', respectively, on pool year basis. This increase in pod yield was the result of its better performance for pod characteristics that include average pod weight, pods/plant, shelling (%), seeds/pod and pod length. The highest yield by 'DPP-SP 6' reflected in monetary gains also with maximum mean average net returns of ₹1,43,000 and benefit: cost ratio of 2.78 that was followed by 'DPP-SP 22' (₹1,15,000 and 2,43,00), better than check variety 'Pb 89' (₹89,000 and 2,10,000), respectively. Mukherjee *et al.,* (2013) also found that, best performance in superior genotype was the result of maximum value of yield attributes. In garden pea, consumers prefer long pods with more seeds/pod and high shelling (%) and thereby these traits play a very crucial role in determining the choice of a variety to be adopted by the growers (Sharma *et al.,* 2016b). Interestingly, 'DPP-SP 6' followed by 'DPP-SP 22' showed significant, better performance for these traits in comparison to 'Pb 89' besides high economic benefits and as such may be a better choice for the growers. Genotype 'DPP-SP 6' remaining at par with DPP-SP-22 had significantly higher ascorbic acid content over 'Pb 89' during 2017–18.

Interaction effects

Early sowing in conjunction with different fertility

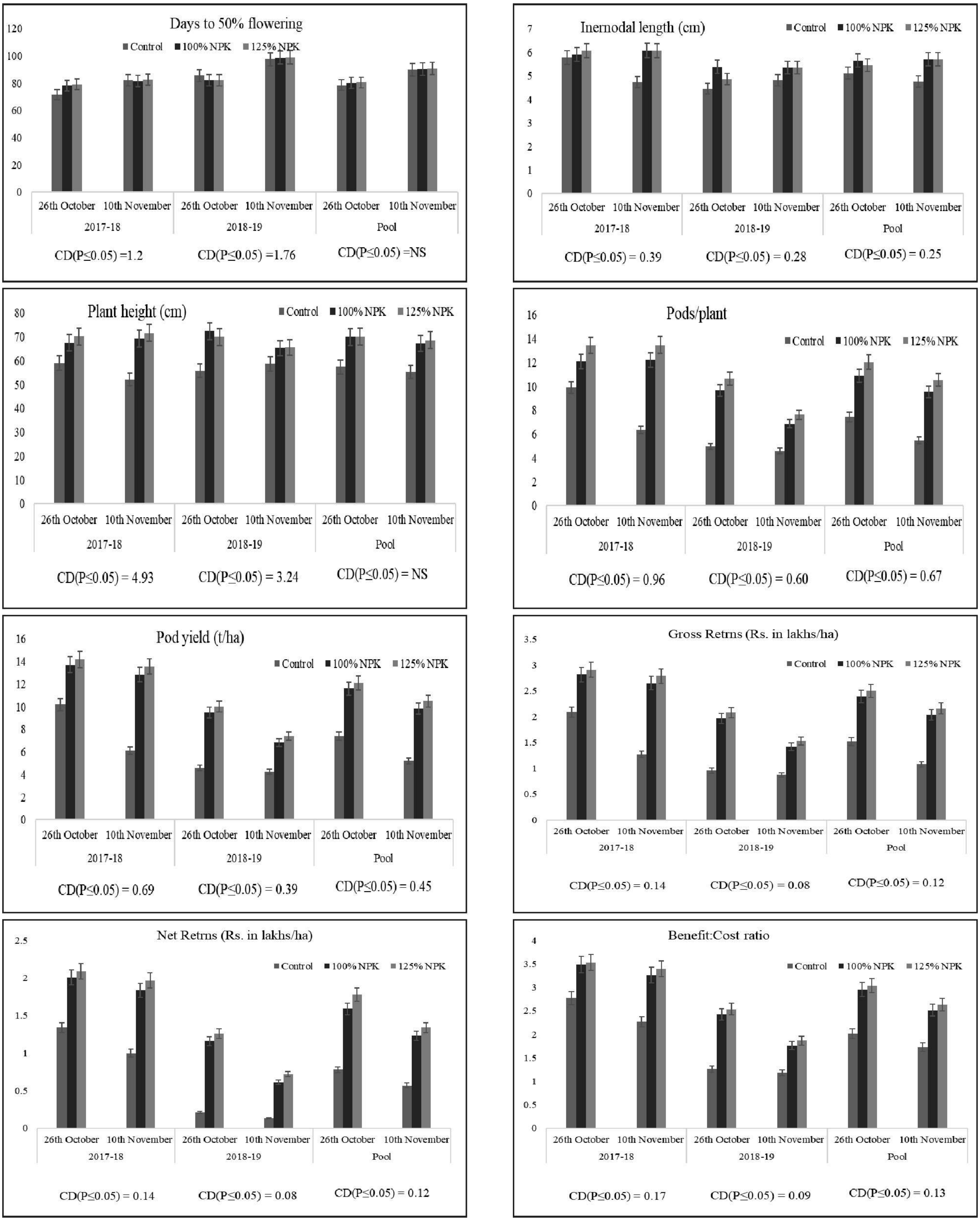

Fig. 1. Interaction effect of sowing dates and fertility levels on flowering, yield attributes and yield of garden pea

levels took the minimum numbers of days to flowering as compared to delayed sowing at different fertility levels (Fig. 1). Significantly shortest internodal length was recorded under the combination of 2 date of sowing and the control treatment during 2017–18 (4.73 cm) and pooled over years (4.77), while 1 sowing date with the control was observed with shorter internodal length during 2018–19 (4.45 cm). Irrespective of the sowing dates, pea plants had significantly more plant height under 100 or 125% of recommended NPK during both the years.

The application of 100 and 125% NPK resulted in significantly higher number of pods/plant in comparison to the control in both the sowing dates in 2017–18. Application of 100 and 125% NPK in early-sown crop and that of 125% NPK in late-sown crop produced similar pod yield but significantly better than the control in both sowing dates and 100% NPK in late-sown crop in 2017–18. On the other hand, in 2018–19, early-sown crop provided with 125% NPK level resulted in significantly a greater number of pods/plant (10.64) and higher pod yield (10.02 t/ha) as

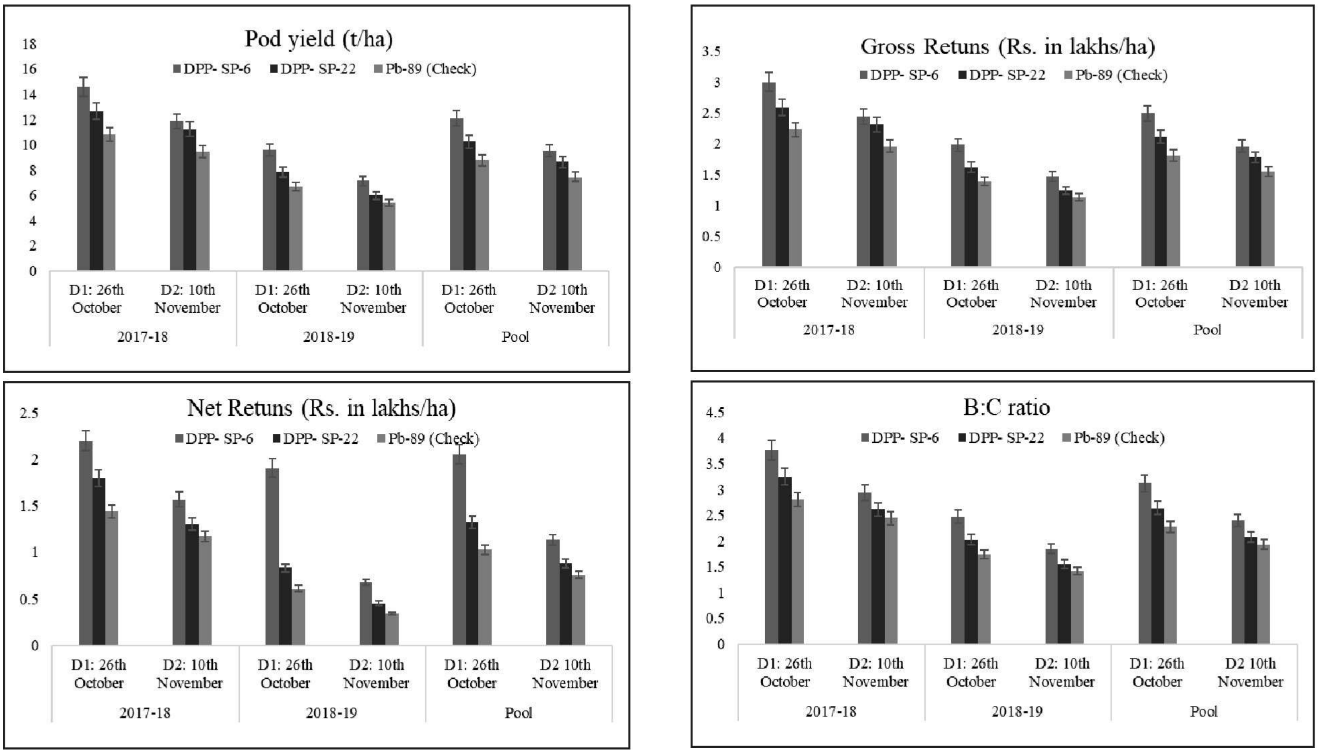

Fig. 2. Interaction effects of date of sowing with genotypes on pod yield (t/ha) and economic returns (₹ 1 lakh=01 million) of pea production

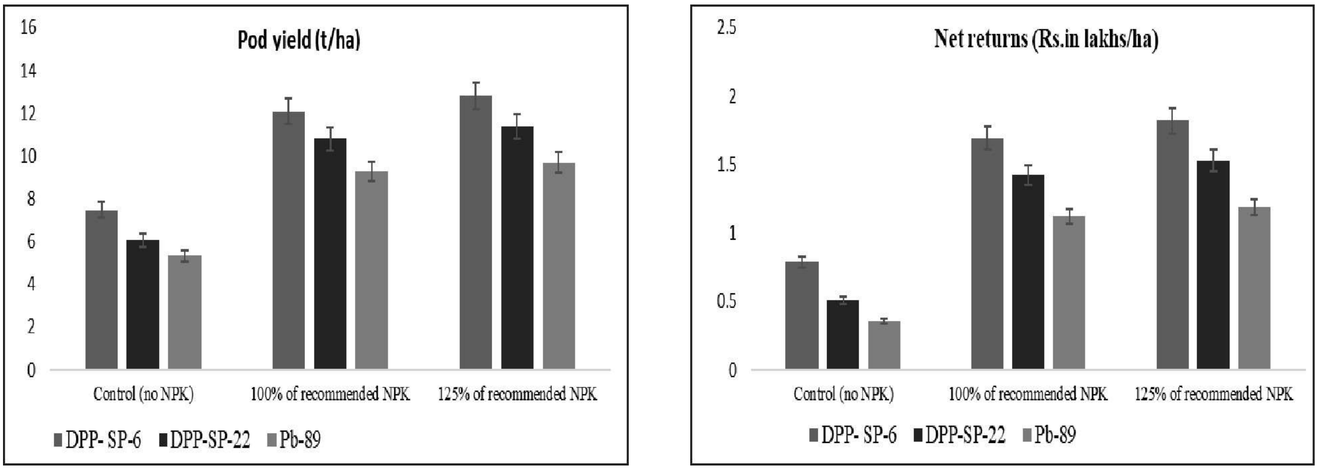

Fig. 3. Interaction effect of fertility levels and varieties on pod yield and net returns of garden pea

compared to late-sown crop in conjunction with other fertility levels as well as same fertility levels. Data clearly indicated that the highest gross returns, net returns and benefit: cost ratio were obtained in the first sowing date supplemented with 125% NPK fertility level during 2017–18, 2018–19 and pooled over years (Fig. 1) which was at par with 100% NPK level sown on same sowing date, i.e. 26 October and 125% NPK fertility level with 10 November-sown crop during 2017–18 only.

The interaction effects between dates of sowings and varieties for pod yield revealed that early-sown 'DPP-SP 6' produced the highest pod yield, with average of 12.1 t/ha and net returns of 312,000/ha (Fig. 2) which was significantly better than other genotypes irrespective of dates of sowing over the years. Both the new genotypes 'DPP-SP 6' and 'DPP-SP 22' significantly surpassed 'Pb 89' in terms of monetary gains. Interaction effects of fertility levels and varieties indicated significantly the highest pod yield in 'DPP-SP 6' at 125% followed by 'DPP-SP 6' at 100% and 'DPP-SP 22' at 125% fertility levels than the check variety 'Pb 89' at all 3 fertility levels in pooled over years (Fig. 3). The significantly higher net returns were obtained in 'DPP-SP 6' genotype coupled with 125% NPK fertility levels, followed by same genotypes with 100% NPK fertility levels.

Based on the studies, it can be concluded that appropriate sowing time along with fertility levels and superior genotypes are the important factors responsible to enhance the productivity of garden pea. Early sowing on 26 October adjudged as the best sowing time for garden pea under mid-hill conditions of Himachal Pradesh to harness higher yield with better returns. 'DPP-SP 6' was the most promising genotype for pod yield along with better yield-contributing traits and monetary gains, followed by 'DPP-SP 22'. Performance of pea at higher NPK levels of 125% of recommended dose resulted in better yield irrespective of the genotype. These treatment combinations also resulted in high net returns per unit area.

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Research Paper

Performance of maize and pigeonpea under different sowing dates and cropping systems

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2010–11 and 2011–12 at Dharwad, Karnataka, to study the effect of sowing dates and cropping systems on growth and yield of maize (*Zea mays* L.) and pigeonpea [*Cajanus cajan* (L.) Millsp.] under rainfed condition. Pooled data over 2 years indicated that, maize and pigeonpea sown during the first fortnight of June revealed significantly higher grain/seed yield compared to subsequent sowing dates except sowing during the second fortnight of June (7.06 and 1.15 t/ha respectively). Among the cropping systems, sole maize and pigeonpea gave significantly higher grain/seed yield (7.48 and 1.42 t/ha respectively) than the intercropping systems. Among the intercropping systems, maize + piegonpea system in (4 : 2) row ratio recorded significantly higher maize grain-equivalent yield (9.04 t/ha) followed by maize + piegonpea in row (2 : 2) ratio (8.48 t/ha). The later treatment resulted in higher net returns and benefit: cost ratio (₹ 56,787/ha and 3.17, respectively) than rest of the cropping systems. Among the interaction effects, intercropping of maize + pigeonpea in 4 : 2 row ratio sown during the first fortnight of June recorded significantly higher maize-equivalent yield (10.23 t/ha), net returns (₹ 66,665/ha) and benefit: cost ratio (3.16) over other system.

Key words: Economics, Intercropping, Maize-equivalent yield, Pigeonpea, Sowing date

Intercropping of legumes with cereals is a recognized practice for economizing the use of nitrogenous fertilizers and enhancing the productivity and profitability per unit area and time (Willey *et al.,* 1981). One of the main reasons for higher yields in intercropping is that component crops are able to use growth resources differently and make better overall use of natural resources than grown separately (Willey, 1979). A careful selection of crops having different growth habit can reduce the mutual competition to a considerable extent. Maize and pigeonpea are important crops of the Southern Transitional Zone of Karnataka. The area under maize cultivation in the region is showing the increasing trend because of low cost of cultivation and high demand for maize grain from poultry industry.

Pigeonpea is a deep-rooted and slow growing crop in its early growth stage, during that period more rapidly growing crops like maize can be conveniently intercropped to utilize the natural resources more efficiently (Lingaraju *et al*., 2008). Both, maize and pigeonpea can be sown in different dates to study the crop-weather relationship. In view of this, the present investigation was conducted to study the productivity and economics of intercropping of maize and pigeonpea at different row ratios under rainfed conditions.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 2010–11 and 2011–12 at Main Agricultural Research Station, University of Agricultural Science, Dharwad, Karnataka. The soil was medium black, having *p*H 7.5. Available nitrogen, phosphorus and potassium contents of the soil were 223.8, 31.6 and 332.3 kg/ha, respectively. There were 4 cropping systems, comprising sole crop of maize (var. Kargil 900 M Gold) and 3 intercropping systems involving 2 : 1, 2 : 2 and 4 : 2 row proportion of maize and pigeonpea (var. 'Asha') and were sown in 4 dates, viz. I fortnight of June, II fortnight of June, I fortnight of July and II fortnight of July. These 20 treatments combinations were evaluated in randomized block design with factorial concept and replicated thrice in a gross plot size of 9.0 m × 4.2 m. The spacing adopted for intercropping was 60 cm × 20 cm for maize and 90 cm × 30 cm pigeonpea in sole crop, 45 cm/45 cm × 20 cm for maize and 90 cm × 20 cm for pigeonpea in maize + pigeonpea intercropping at 2:1 ratio, 90 cm/45 cm × 20 cm for maize and 90 cm/45 cm × 20 cm for pigeonpea in

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