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Effect of date, method of sowing and seed rate on growth, yield and seed quality attributes in garden pea

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Abstract

The effect of date of sowing (15th October, 5th November and 25th November), method of sowing (Raised bed and flatbed) and seed rate (100, 112.5 and 125 kg/ha) was evaluated on growth, yield and seed quality attributes in garden pea *cv.* Pusa Pragati under field conditions. Date of sowing significantly affected the growth, yield and seed quality parameters. Sowing on 15th October (DOS 1) resulted in earliest emergence and days taken to initiate flowering whereas sowing on 25th November (DOS 3) needed longest duration for both these characters. Plant height and number of primary branches per plant was recorded highest for DOS 1 and the lowest for DOS 3. The yield traits (pods per plant, pod length, seeds per pod and seed yield per plant) and seed quality traits (seed index, germination, seedling length and dry weight, vigour indices) were recorded maximum for DOS 2 (sowing on 5th November) and minimum for DOS 1. Electrical conductivity results also showed that DOS 2 and DOS 3 had better seed quality than DOS 1. Method of sowing could not affect significantly on most of the plant growth parameters except plant height but seed yield/plant and seeds/pod were higher in raised bed method of sowing. Most of the quality parameters were quantitatively higher in raised bed but it was statistically *at par* with flatbed. Seed rate also could not affect the most of the growth, yield attributes and quality traits but seed yield per plant was increased on increasing the seed rate.

Key words: Garden pea, Date of sowing, Seed rate, Seed yield, Seed quality

Introduction

Garden pea (*Pisum sativum* var. *hortense* L.) is one of the most popular vegetable crops grown all over the world, both for fresh market and canning. It is highly nutritive and contains high proportion of digestible protein, carbohydrates, minerals and vitamins (Sharma 2010). It is grown commercially as a winter crop in the northern Indian plains, as an early crop in the mid hills and popular off-season vegetable crop grown in north-western Himalayan region in India (Sharma et al. 2014). India ranks second after China in terms of area and production; however, it occupies third position in the world in productivity, after UK and Egypt. Garden pea is grown in in an area of 4.2 lakh ha with annual productivity of 9.5 t/ha in India. Among the states, Uttar Pradesh contributes about 47 % of the total garden pea production and having highest productivity. Other major garden pea growing states are Madhya Pradesh, Jharkhand, Himachal Pradesh and Punjab. Despite having lot of potential to feed and nourish the increasing population, it has received very less attention compared to other legumes which may be one of the reasons for no improvement in its productivity. High quality seed is essential prerequisite to profitable crop production. Maximum yield can be achieved by adopting optimum plant population. One of the key factors in achieving this optimum population is the use of high quality seed. Field conditions are often sub-optimal and therefore vigour tests provide additional information on the relative performance of seed lots in the fields under wide range of environments. Therefore, optimum sowing date is of primary importance for harnessing potential yield as well as seed quality (Amanullah et al. 2002, Vange and Obi 2006). No systematic research has been done in garden pea to evaluate the effect of sowing dates on quality seed formation and seed yield of different varieties under Delhi conditions. One of the major concerns in seed production of garden pea is optimization of seed rates so that maximum seed yield with high quality can be produced. Garden pea is very sensitive to water logged conditions and the plants of this variety are semi dwarf in nature so proper method of planting may be adopted to avoid the contact of plants and pods to the soil for maximising the seed yield and quality. Keeping these facts in view, the present investigation on vegetable pea, variety Pusa Pragati, was conducted at ICAR-IARI, New Delhi during 2014-15

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and 2015-16 to find out the effect of date of sowing, method of planting and seed rate on growth, yield and seed quality attributes.

Material and Methods

Plant Material and Experimental Conditions: The seeds of garden pea variety Pusa Pragati were obtained from the seed production unit of ICAR-IARI, New Delhi. Two field experiments were conducted at the research farm of ICAR-IARI, New Delhi during two successive winter seasons of 2014-15 and 2015-16. The experimental plot was sown in double split (split-split) design with three replications in which date of sowing was main plot, method of planting as sub plot and seed rate was taken as sub-sub plot. Planting was done in three different dates of sowing (15th October, 5th November and 25th November). Two methods of sowing were adopted *viz.* flat bed and raised bed. The plot size was 5 × 2 m^2 with eight rows per plot and row spacing of 25 cm. Paired row sowing was done on raised bed with 5 cm shallow channel space and 30 cm raised bed width having two rows. Three seed rates *viz.* 100, 112.5 and 125 kg/ ha were taken as sub-sub plot treatment. Basal recommended dose of N, K_2O and P_2O_5 in the ratio 20:40:50 kg/ha was applied to each plot.

Growth and yield attributes: Data was recorded on plant height, days to flowering, number of primary branches/plant, number of pods/plant, pod length, number of seeds/pod, seed yield/plant, seed index, seed germination percentage, seedling length, seedling dry weight, vigour index, and electrical conductivity from ten randomly selected plants from each replicate / treatment and their seeds.

Statistical Analysis: The average values were used for the statistical analysis. Statistical analysis was carried out using Statistical Analysis Software version 9.3 (SAS 9.3). Data were subjected to analysis of variance and means were compared. Valid conclusions were drawn only on significant differences between the treatment mean at 0.05 level of probability. The least significant difference test was used to decipher the effect of treatments at 5% level of significance (P=0.05).

Results and Discussion

Effect of date of sowing: Data on growth and yield attributes of garden pea (*cv* Pusa Pragati) under the effect of different dates of sowing are presented in Table 1. Results showed that date of sowing significantly affected the growth, yield and seed quality parameters. DOS 1 resulted in earliest emergence and days taken to initiate flowering whereas DOS 3 needed longest duration for both these characters. Plant height and number of primary branches per plant was recorded highest for DOS 1 and least for DOS 3. The yield traits (pods per plant, pod length, seeds per pod and seed yield per plant) and seed quality traits (seed index, germination, seedling length and dry weight, vigour indices) were recorded maximum for DOS 2 and minimum for DOS 1. Electrical conductivity results also showed that DOS 2 and DOS 3 had better seed quality than DOS 1.

The soil and air temperature during DOS 1 was quite higher which resulted in early emergence of the seedling (6.3 days). As the sowing was delayed, the days to emergence increased up to 11.2 days in DOS 3. Plant height decreased with delay in sowing from 53.7 cm in DOS 1 to 49.6 cm in DOS 3. The optimum temperature for vegetative growth in DOS 1 led to higher plant height, whereas the lower temperature during DOS 2 and DOS 3 decreased the plant height significantly. Primary branches per plant decreased with delay in sowing as the environmental condition during DOS 1 were congenial for vegetative development of plant. Maximum number of primary branches per plant was recorded in DOS 1 (3.8), whereas minimum was recorded in DOS 3 (2.87). The days to flowering increased from 39.9 days in DOS 1 to 45.1 days in DOS 3. The higher temperature during DOS 1 hastened the flowering by 4 to 5 days. Number of pods per plant was significantly affected by date of sowing. Highest number of pods per plant was recorded for in DOS 2 (10.90) which was significantly higher than DOS 1 (8.90). However, no significant difference was observed for pods per plant in DOS 2 and DOS 3. The highest pod length was observed in DOS 2 (8.60 cm) followed by DOS 3 (7.97 cm) and DOS 1 (7.30 cm). The DOS 2 plants gave highest number of seeds per pod (8.40) followed by DOS 3 (7.97) and DOS 1 (5.65). The DOS 2 recorded maximum seed yield per plant (20.50 g) followed by DOS 3 (17.65 g) and DOS 1 (9.90 g).

In our study the days to emergence was significantly affected by the date of sowing. The soil and air temperature during the first date of sowing (15th October) was quite higher which resulted in early emergence of the seedling. As the sowing was delayed, the days to emergence increased up to 11.2 days in third date of sowing (25th November) because of low soil temperature prevailing at that time. Days to flowering also increased because of delay in sowing from first to third date of sowing because of the temperature get lowered towards later date of sowing and hence last November sowing took 45 days for initiation of flowering. Because of congenial environment for growth during first date of sowing the plant height was also better but no significant difference in plant height was observed in second and

Table 1: Effect of date of sowing on growth and yield attributes of garden pea *cv.* Pusa Pragati

Time of sowing	Days to emergence			Days to flowering			Plant height (cm)			Primary branches per plant			Pods per plant			Pod length (cm)			Seeds per pod			Seed yield(g) per plant		
	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
DOS 1 (15 October)	6.20^{C}	6.40^{C}	6.30^{C}	39.70^{C}	40.20^{C}	39.90^{C}	53.10^{A}	54.30^{A}	53.70^{A}	3.88^{A}	3.78^{A}	3.80^{A}	8.80^{B}	9.01^{B}	8.90^{B}	7.40^{C}	7.30^{C}	7.30^{C}	5.66^{B}	5.70^{B}	5.65^{C}	9.50^{C}	10.30^{C}	9.90^{C}
DOS 2 (5 November)	8.90^{B}	8.90^{B}	8.90^{B}	42.40^{B}	42.40^{B}	42.40^{B}	50.95^{B}	52.20^{AB}	51.60^{AB}	3.10^{B}	3.10^{B}	3.10^{B}	11.01^{A}	10.80^{A}	10.90^{A}	8.70^{A}	8.60^{A}	8.60^{A}	8.46^{A}	8.40^{A}	8.40^{A}	20.50^{A}	20.50^{A}	20.50^{A}
DOS 3 (25 November)	11.17^{A}	11.20^{A}	11.20^{A}	45.20^{A}	45.10^{A}	45.10^{A}	49.40^{C}	49.80^{B}	49.60^{B}	2.80^{C}	2.90^{B}	2.87^{C}	10.47^{A}	10.50^{A}	10.50^{A}	7.99^{B}	7.95^{B}	7.97^{B}	7.98^{A}	7.97^{A}	7.97^{B}	17.70^{B}	17.65^{B}	17.65^{B}
LSD @5%	0.36	0.68	0.14	1.45	1.81	0.59	1.12	3.97	2.15	0.19	0.28	0.2	0.69	0.99	0.81	0.6	0.38	0.25	0.66	0.45	0.35	0.75	1.24	0.93

Y1: 2014-15; Y2: 2015-16. Values with the same letters in each column are not significantly different (P<0.05)

Table 2: Effect of date of sowing on seed quality attributes of garden pea *cv.* Pusa Pragati

Time of sowing	Seed index (g)			Germination (%)			Seedling length (cm)			Seedling dry weight (mg)			Vigour index I			Vigour index II			Electrical conductivity (µS/cm/g)		
	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
DOS 1 (15 October)	15.96^{B}	15.90^{B}	15.90^{B}	89.70^{B}	89.80^{B}	89.70^{C}	15.70^{B}	15.80^{B}	15.70^{B}	0.0143^{B}	0.0154^{B}	0.0148^{B}	1408^{C}	1414^{C}	1411^{C}	1.28^{B}	1.37^{B}	1.33^{B}	23.80^{A}	22.93^{A}	23.38^{A}
DOS 2 (5November)	21.78^{A}	21.80^{A}	21.80^{A}	97.90^{A}	97.10^{A}	97.50^{A}	21.90^{A}	21.80^{A}	21.80^{A}	0.0316^{A}	0.0306^{A}	0.0311^{A}	2148^{A}	2116^{A}	2132^{A}	3.09^{A}	2.97^{A}	3.03^{A}	16.86^{B}	17.53^{B}	17.22^{B}
DOS 3 (25 November)	21.09^{A}	21.10^{A}	21.10^{A}	96.20^{A}	95.30^{A}	95.80^{B}	20.70^{A}	20.70^{A}	20.70^{A}	0.0304^{A}	0.0298^{A}	0.0300^{A}	1996^{B}	1972^{B}	1984^{B}	2.91^{A}	2.83^{A}	2.87^{A}	18.26^{B}	18.73^{B}	18.50^{B}
LSD @5%	1.17	0.86	0.94	2.75	1.91	1.36	1.7	1.17	1.43	0.008	0.003	0.005	134.4	104.69	116.28	0.71	0.22	0.42	3.49	1.22	2.2

Y1: 2014-15; Y2: 2015-16. Values with the same letters in each column are not significantly different (P<0.05)

Table 3: Effect of method of sowing on growth and yield attributes of garden pea *cv.* Pusa Pragati

Method of sowing	**Days to emergence (day)**			**Days to flowering (day)**			**Plant height (cm)**			**Primary branches per plant**			**Pods per plant**			**Pod Length (cm)**			**Seeds per pod**			**Seed Yield per plant**		
	Y1	**Y2**	**pooled**	**Y1**	**Y2**	**pooled**	**Y1**	**Y2**	**pooled**	**Y1**	**Y2**	**pooled**	**Y1**	**Y2**	**pooled**	**Y1**	**Y2**	**Pooled**	**Y1**	**Y2**	**pooled**	**Y1**	**Y2**	**Pooled**
Raised bed	8.70A	8.90A	8.77A	42.60A	42.60A	42.60A	51.80^{A}	53.05^{A}	52.40^{A}	3.30^{A}	3.30^{A}	3.28^{A}	10.30^{A}	10.20^{A}	10.30^{A}	8.06^{A}	8.04^{A}	8.05^{A}	7.50^{A}	7.50^{A}	7.50^{A}	16.30^{A}	16.36^{A}	16.30^{A}
Flat bed	8.80A	8.80A	8.80A	42.30A	42.50A	42.40A	50.50^{B}	51.2^{A}	50.80^{B}	3.20^{A}	3.28^{A}	3.25^{A}	9.90^{A}	9.90^{A}	9.90^{A}	7.96^{A}	7.86^{A}	7.90^{A}	7.30^{B}	7.20^{B}	7.20^{B}	15.40^{B}	15.90^{A}	15.70^{B}
LSD @ 5%	0.62	0.43	0.35	1.48	0.99	0.78	1.14	2.04	1.16	0.44	0.16	0.21	0.92	0.52	0.5	0.46	0.34	0.34	0.18	0.21	0.15	0.3	0.98	0.55

Y1: 2014-15; Y2: 2015-16. Values with the same letters in each column are not significantly different (P<0.05)

Table 4: Effect of method of sowing on seed quality attributes of garden pea *cv.* Pusa Pragati

Method of sowing	Seed Index (g)			Germination (%)			Seedling length (cm)			Seedling dry weight (mg)			Vigour Index I			Vigour Index II			Electrical Conductivity (µ S/cm/g)		
	Y1	Y2	pooled	Y1	Y2	Pooled	Y1	Y2	pooled	Y1	Y2	pooled	Y1	Y2	pooled	Y1	Y2	pooled	Y1	Y2	pooled
Raised bed	19.50^{A}	19.68^{A}	19.50^{A}	94.80^{A}	94.10^{A}	94.50^{A}	19.50^{A}	19.45^{A}	19.50^{A}	0.0249^{A}	0.0253^{A}	0.0251^{A}	1863^{A}	1837^{A}	1850^{A}	2.39^{A}	2.40^{A}	2.39^{A}	19.5^{A}	19.95^{A}	19.51^{A}
Flat bed	19.70^{A}	19.54^{A}	19.70^{A}	94.40^{A}	94.04^{A}	94.20^{A}	19.40^{A}	19.40^{A}	19.40^{A}	0.0258^{A}	0.02518^{A}	0.0255^{A}	1838^{A}	1831^{A}	1835^{A}	2.47^{A}	2.39^{A}	2.43^{A}	19.82^{A}	19.52^{A}	18.89^{A}
LSD @ 5%	0.44	0.29	0.28	1.37	1.49	1.2	0.96	0.9	0.89	0.008	0.001	0.003	103.31	88.98	92.16	0.74	0.13	0.33	1.28	1.05	0.99

Y1: 2014-15; Y2: 2015-16. Values with the same letters in each column are not significantly different (P<0.05)

Table 5: Effect of seed rate on growth and yield attributes of garden pea *cv.* Pusa Pragati

Seed rate (Kg/ha)	Days to emergence (day)			Days to flowering (day)			Plant height (cm)			Primary branches per plant			Pods per plant			Pod length (cm)			Seeds per pod			Seed yield (g) per plant		
	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled
100	8.60^{A}	8.70^{A}	8.69^{A}	42.60^{A}	42.60^{A}	42.60^{A}	51.40^{A}	51.90^{A}	51.60^{A}	3.30^{A}	3.33^{A}	3.32^{A}	10.20^{A}	10.15^{A}	10.15^{A}	8.08^{A}	8.03^{A}	8.10^{A}	7.20^{A}	7.20^{A}	7.20^{A}	15.23^{B}	15.66^{B}	15.40^{B}
112.5	8.70^{A}	8.80^{A}	8.80^{A}	42.30^{A}	42.50^{A}	42.40^{A}	51.30^{A}	52.20^{A}	51.80^{A}	3.37^{A}	3.35^{A}	3.36^{A}	10.30^{A}	10.12^{A}	10.19^{A}	7.89^{A}	7.93^{A}	7.91^{A}	7.40^{A}	7.39^{A}	7.40^{A}	16.05^{A}	16.26^{AB}	16.10^{A}
125.0	8.80^{A}	8.90^{A}	8.89^{A}	42.27^{A}	42.60^{A}	42.40^{A}	50.80^{A}	52.20^{A}	51.50^{A}	3.12^{A}	3.15^{A}	3.13^{B}	9.90^{A}	10.05^{A}	9.98^{A}	8.04^{A}	7.90^{A}	7.97^{A}	7.50^{A}	7.44^{A}	7.47^{A}	16.35^{A}	16.52^{A}	16.40^{A}
LSD @ 5%	0.62	0.54	0.35	1.47	1.3	1.04	2.93	3.1	2.47	0.3	0.16	0.18	1.02	0.45	0.57	0.47	0.49	0.33	0.36	0.33	0.25	0.69	0.72	0.52

Y1: 2014-15; Y2: 2015-16. Values with the same letters in each column are not significantly different (P<0.05)

Table 6: Effect of seed rate on seed quality attributes of garden pea *cv.* Pusa Pragati

Seed rate (Kg/ha)	Seed index (g)			Germination (%)			Seedling length (cm)			Seedling dry weight (mg)			Vigour index I			Vigour index II			Electrical conductivity (µS/cm/g)		
	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled	Y 1	Y 2	Pooled
100	19.68^{A}	19.61^{A}	19.65^{A}	94.60^{A}	94.10^{A}	94.36^{A}	19.70^{A}	19.60^{A}	19.60^{A}	0.0239^{A}	0.0248^{A}	0.0243^{A}	1873^{A}	1853^{A}	1863^{A}	2.2818^{A}	2.349^{A}	2.3153^{A}	20.06^{A}	19.92^{A}	19.99^{A}
112.5	19.54^{A}	19.6^{A}	19.57^{A}	95.17^{A}	93.70^{A}	94.40^{A}	19.20^{A}	19.30^{A}	19.30^{A}	0.0267^{A}	0.0257^{A}	0.0262^{A}	1842^{A}	1815^{A}	1829^{A}	2.5662^{A}	2.434^{A}	2.5002^{A}	19.74^{A}	20.02^{A}	19.88^{A}
125.0	19.6^{A}	19.62^{A}	19.60^{A}	94.05^{A}	94.40^{A}	94.20^{A}	19.40^{A}	19.35^{A}	19.40^{A}	0.0256^{A}	0.0252^{A}	0.0254^{A}	1836^{A}	1835^{A}	1835^{A}	2.4463^{A}	2.404^{A}	2.425^{A}	19.18^{A}	19.27^{A}	19.22^{A}
LSD @ 5%	0.71	0.44	0.4	1.2	1.22	0.86	0.88	0.76	0.78	0.0054	0.0028	0.0032	82.3	82.02	77.55	0.52	0.24	0.29	1.64	1.12	0.88

Y1: 2014-15; Y2: 2015-16. Values with the same letters in each column are not significantly different (P<0.05)

third date of sowing. The primary branches come out when the vegetative stage temperature is good for branching and therefore the number of branches significantly decreased from first to last date of sowing. Therefore, the soil temperature during sowing, the temperature at vegetative stage strongly affects the growth characteristics of the plant. Yield attributing traits like number of pods per plant, pod length, number of seeds per pod and seed yield per plant was highest in DOS 2 followed by DOS 3. The growth characteristics were good in DOS 1 but the plants could not withstand the lower temperature at pod formation stage and the reproductive growth was highly affected by the lower prevailing temperature. The DOS 3 caused a reduction in the yield and yield attributes because of forced maturity caused by high temperature at the time of maturity which reduces the seed fill duration of the crop.

Data on seed quality attributes of garden pea (*cv* Pusa Pragati) under the effect of different dates of sowing are presented in Table 2. Seed index was found to increase with delay in date of sowing from 15.9 g in DOS 1 to 21.8 g in DOS 2 but further delay did not lead to any significant increase in seed index moreover it decreased insignificantly which may be attributed to forced maturity caused by increased temperature at maturity phase of plants sown on DOS 3. Germination percentage was significantly increased from DOS 1 (89.70 %) to DOS 2 (97.50 %) showing maximum germination followed by DOS 3 (95.80 %), where it decreases but it was more than first date of sowing. Seedling length increased with date of sowing from 15.7 cm in DOS 1 to 21.8 cm in DOS 2. It was recorded maximum in DOS 2 followed by DOS 3 (20.70 cm). Dry weight of seedlings obtained from germination test increased with date of sowing from 0.0148 mg in DOS 1 to 0.0311 mg in DOS 2 but no significant increment was found for DOS 3. Vigour index I was significantly affected by the date of sowing. Maximum vigour index I was observed in DOS 2 (2132) followed by DOS 3 (1984) and DOS 1 (1411). Vigour index II increased up to DOS 2 significantly with maximum vigour index II for DOS 2 (3.03) followed by DOS 3 (2.87) and DOS 1 (1.33). Electrical conductivity was found to decrease significantly with increase of date of sowing from DOS 1 (23.38µS/cm/g) to DOS 2 (17.22µS/cm/g), while no significant change was observed for DOS 3 in comparison to DOS 2.

DOS is an important factor in determining plant stand, flowering and pod filling in garden pea which in turn affects yield (Dapaah et al. 2000) by affecting the amount of radiation and temperature around crop canopy. The seed vigour in garden pea is greatly affected by the time of sowing which was also reported by Castillo et al. (1994). Sharma et al. (2014) also reported that garden pea variety "Arkel" and "Azad P1" gives a higher seed yield towards end of October to first quarter of November under sub humid temperate region. The finding of our study is in one line with the reports of Singh and Singh (2011) which indicates that early sowing dates result in poor seed yield and delayed sowing dates resulted in poor seed yield and quality in garden pea in many varieties

Effect of method of planting: Data on growth and yield attributes of garden pea (*cv* Pusa Pragati) under the effect of different methods of sowing are presented in Table 3. Results showed that method of sowing could not affect significantly most of the plant growth parameters except plant height, seed yield per plant and seeds per pod. However, the plant height was higher in case of raised bed method of sowing (52.40 cm) than flatbed (50.80 cm). Number of seeds per pod was found higher for raised bed method (7.50) than flatbed method (7.20). Similarly, seed yield per plant was higher for raised bed method of sowing (16.30 g) than flatbed method of sowing (15.70 g). Data on seed quality attributes of garden pea (*cv* Pusa Pragati) under the effect of different methods of sowing are presented in Table 4. Seed index, germination, seedling length and dry weight, Vigour indices and electrical conductivity were not significantly affected by method of sowing. However, most of the quality parameters were quantitatively higher in raised bed but it was statistically *at par* with flatbed. As garden pea is very sensitive to water logging and many times pea seeds are killed or damaged by soaking in water and the damage is aggravated by lower temperatures which are also confirmed by above results. Uzun and Esvet (2009) also reported that water logging caused a decrease in pea root mass, penetration depth, plant height, biomass and leaf chlorophyll. The results revealed that the plants sown on raised beds were higher than those sown in flatbed. Among the yield parameters only the number of seeds per pod and ultimately the seed yield per plant was significantly higher in plants grown on raised beds. However, other seed quality parameters were not affected significantly due to different methods of sowing.

Effect of Seed rate: Data on growth and yield attributes of garden pea (*cv* Pusa Pragati) under the effect of different seed rates are presented in Table 5 and the effect on seed quality attributes are shown in Table 6**.** In our study, seed yield per plant was found to increase from 15.40 g to 16.10 g with increase in seed rate from 100 to 112.5 kg/ha but no further increase in seed yield

per plant was observed for 125 kg/ha seed rate. This might be due to lodging of plants in lower seed rate plots reduced the yield therefore the yield increased initially on increasing the seed rate but further increase in seed rates bring the competition factor in role. Seed rate determines the density of the stand which by affecting the micro climate, weed incidence, pod distribution ultimately affects seed yield and quality (Azpilicueta et al. 2012). Lower seed rate resulted in higher number of green pods per plant and *vice versa* that might be attributed to the stronger competition among plants for various factors *viz.* sunlight, water and nutrients (Sharma and Singh, 2002).

It can be concluded that first week of November would be the ideal time of sowing of garden pea under Delhi conditions. Raised bed method of planting can be advised to the farmers in order to get seeds with better quality. The seed rate of 50 kg/acre will be good for seed crop which will yield higher with better seed quality under Delhi conditions making the seed production job profitable and also reducing the price of seed for the farmers.

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सब्जी मटर में वर्ष 2014–15 तथा 2015–16 के रबी मौसम के दौरान अध्ययन किया गया जिसमें बुवाई के समय (15 अक्टूबर, 5 नवम्बर तथा 25 नवम्बर) रोपण पद्धति (उथली क्यारी और समतल क्यारी) एवं बीज दर (100, 112.5 तथा 125 किलोग्राम प्रति हेक्टेयर) का प्रजाति पूसा प्रगति के पौधों की वृद्धि, बीज उपज एवं गुणवत्ता पर पड़ने वाले प्रभावों को देखा गया। अध्ययन में यह पाया गया कि बुवाई की तिथि का पौधों की वृद्धि, बीज उपज तथा गुणवत्ता पर प्रभाव पड़ता है। पहली बुवाई (15 अक्टूबर) के फलस्वरूप त्वरित अंकुर उद्भव तथा पुष्पण भी तीव्र पाया गया जबकि तीसरी बुवाई (25 नवम्बर) में इनकी शुरूआत देर से हुई। पौधों की ऊँचाई तथा प्रति पौध प्राथमिक शाखाओं की संख्या पहली बुवाई में सर्वाधिक जबकि तीसरी बुवाई में न्यूनतम दर्ज की गई। उपज निर्धारक गुण (प्रति पौध फलियाँ, फली की लम्बाई, प्रति फली बीज तथा बीज उपज प्रति पौध) तथा बीज गुणवत्ता निर्धारक लक्षण (बीज सूचकांक, अंकुरण प्रतिशत, नवोद्भिद की लम्बाई तथा शुष्क वजन, शक्ति सूचकांक) दूसरी बुवाई की अधिकतम जबकि पहली बुवाई में न्यूनतम दर्ज किया गया। विद्युत चालकता के नतीजों से यह पता चला कि पहली बुवाई की तुलना में दूसरी तथा तीसरी बुवाई में बीज गुणवत्ता बेहतर थी। उथली क्यारियों पर बुवाई से प्रति बीज उपज में सुधार हुआ। बीज की गुणवत्ता वाले मापदण्ड उथली क्यारियों में अधिक पाया गया। बीज दर भी पौध वृद्धि, उपज और बीज गुणवत्ता वाले मापदण्डों को प्रभावित नहीं कर सकी लेकिन बीज दर में वृद्धि करने पर प्रति पौध बीज उपज में बढ़ोत्तरी देखी गई जो प्रति इकाई क्षेत्र में उच्च गुणवत्ता वाले बीज की उत्पादन लागत को कम करने में सहायक सिद्ध हो सकता है। अतः वर्तमान अध्ययन से प्राप्त परिणामों के अनुसार नवम्बर के पहले सप्ताह में बुवाई बीज उत्पादन के लिए सर्वाधिक उपयुक्त पाया गया।

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