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Variation in biochemical attributes and rust reaction in response to crop geometry in mono-picking garden pea for mechanical harvesting

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Abstract

The present study was conducted on single-harvest garden pea to standardize the agronomic practices for mechanized cultivation in India. The experiment was laid out in split plot design with 30 treatments comprising five dates of sowing, viz. 20th October, 5th November, 20th November, 5th December and 20th December in main plots and 2 different planting methods (flat and bed) sown at three different spacing (20 × 5 cm, 20 × 7.5 cm and 20 × 10 cm) in subplots and replicated three times. The bed size was standardized according to front loading width of the pea combine. The sowing of garden pea cv. Punjab-89 on 5th November at intermediate spacing of 20 × 7.5 cm resulted into significantly higher green pod yield of 136.2 q/ha (in single harvest) which was statistically at par with same sowing date i.e. 5th November at wider (135.0 q/ha) and closer spacing (131.4 q/ha), which was due to cool temperature during plant growth, moderate temperature during pod development and filling stage. The significant interactions were observed between date of sowing and spacing for total yield, protein content and rust incidence. However, for all the traits, there is non-significant interaction for date of sowing with sowing method, spacing with sowing method and 3-way interaction between date of sowing, spacing and sowing method. The late sown (20th December) crop resulted lowest total yield but less incidence of rust incidence which was due to high temperature and low relative humidity at pod development and filling stage.

Key words: Crop geometry, Pea, Quality, Rust, Single-harvest, Yield

Introduction

Garden Pea (*Pisum sativum L.*) is one of the most important winter vegetable crops grown on commercial scale worldwide and is consumed either as a fresh succulent vegetable or in processed form. India is the second largest producer of pea in the world and accounts for 21% of the world production (Singh and Dhall 2018). In India, pea is grown on an area of 543 thousand hectares with production of 5425 thousand metric tons during 2017-2018 (Anonymous 2018). Pea is highly nutritive and contains digestible protein (7.2 g), carbohydrate (15.8 g), fiber (4.0 g), phosphorus (139 mg) per 100 g of edible portion. It plays an important role in the crop rotation system by providing nitrogen to the successive crop (nitrogen fixation by *Rhizobium leguminosarum*) without the added expense of supplemental fertilizer.

Now, India is in phase of using machines in all the agricultural operations. Although India's labour force seems to sufficient but still at the peak harvesting time, shortage of labour is experienced by the farmers. The most basic reason is that every farmer needs labour at the same time, which leads to high wages. Because of shortage of labour and high wages many farmers are moving towards mechanization. Mechanization creates the need for new approaches to cultural practices. Mechanized harvesting of pea will overcome the labour shortage problem, reduce the cost of production and enhance farmers' income. Due to mechanical harvesting, processing industry will ûourish, generating more employment and export of processed peas will increase (Dhall 2017). Time of sowing is known to impact yield, development and growth of the plants, and furthermore the environment experienced during seed advancement, both within and above the crop canopy (Castillo et al. 1994). Environmental factors during the seed development stages affect the seed yield. Even seed yield of early, mid or late season maturing pea crops at the same location is different because of prevailing environmental conditions during crop growth and maturity. Sowing at optimum period can make significant contribution towards yield. In addition, it reported that delay in sowing time beyond and optimum date, results

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in a progressive decrease in the potential yield of the crop (Siddique et al. 2002). Plant population is the main factor that contributes toward attaining maximum yield from per unit land area. At specific plant spacing, individual plants are likely to perform best. It has been observed that there is significant increase in the yield and yield attributing traits of garden pea, if seeds were sown at optimum plant density (Chandra and Polisetty 1998). The yields of vining pea cultivars having small seed sizes could be increased by sowing them at higher plant populations than are used conventional cultivars (Scott et al. 1991). Therefore, there is need to study the effect of different plant populations on yield and yield attributing components of single harvest garden pea. The method of planting also effects the plant growth and development. In ridge planting, due to loose soil structure, there is less weed population and it provides a good environment for aeration, light penetration and root development (Khan et al. 2012). Sowing on bed or ridge also give higher seed yield due to better crop growth and nutrient absorption. Pea is very sensitive to water stagnation can be cultivated on bed to protect them from excess water accumulation during heavy rains especially on medium to heavy textured soils. Sowing on raised beds provide a better option for management of water and nutrients (Freeman et al. 2007). Therefore, raised bed sowing method may help to attain good plant stand, increases fertilizer and water use efficiency, better weed management, boost aeration in root zone, increase yield and overall productivity. Therefore, there is need to standardize the method of sowing to obtain high yields in single harvest pea.

Recently, a pea combine-harvester has been imported in India from Holland to do mechanization in pea cultivation but many problems has been faced during harvesting by this combine like traditional bed planting method causes bumpy movement to combine which left over the vines in the field, traditional wider spacing reduces yield, method of irrigation causes more weeds and incidence of more powdery mildew and rust. Therefore, to meet the objective of mono-picking and mechanical harvesting of garden pea in India, there is need to standardize the sowing time, spacing and method of planting for getting maximum yield and quality green shelled peas.

Materials and Methods

Experiment site: The present research work was conducted at Vegetable Research Farm and Biochemistry Laboratory in the Department of Vegetable Science, Punjab Agricultural University Ludhiana during 2016-17 and 2017-18 but polled mean of all observations were given in this manuscript.

Weather and climate: Ludhiana is situated at latitude of 30° -55' N and longitude of 75°- 54' E and at a mean altitude of 247 meters above sea level. This place is characterized by very hot and dry summer (April to June) followed by a hot and humid monsoon period and cold winters during December- January. The average rainfall of the area is 600 mm most of which is received during monsoon season.

Plant materials: The main season variety of garden pea i.e. 'Punjab-89' was used in the experiment. The plants of this variety are medium dwarf, vigorous, having more number of well filled pods (28-30 plant^{-1}). The pods borne in doubles and are dark green, long, very attractive having 9-10 grains per pod. It takes about 90 days for first picking. Shelled peas are very sweet and shelling out turn is more than 55 per cent. Average green pod yield is 150 q/ha.

Experimental design and treatments: The experiment consists of thirty treatments which comprises of five main plot treatments including five sowing dates viz., 20th October (D_1), 5th November (D_2), 20th November (D_3), 5th December (D_4) and 20th December (D_5) and two sub plot treatments [Flat vs. Bed sowing and 3 different spacing that are Row to Row and Plant to Plant] i.e. M_1S_1 (Flat sowing, R×R=20 cm, P×P=5.0 cm), M_1S_2 (Flat sowing, R×R=20 cm, P×P= 7.5 cm), M_1S_3 (Flat sowing, R×R=20 cm, P×P=10.0 cm), M_2S_1 (Bed sowing, R×R=20 cm, P×P=5.0 cm), M_2S_2 (Bed sowing, R×R=20 cm, P×P= 7.5 cm), M_2S_3 (Bed sowing, R×R=20 cm, P×P= 10.0 cm). The experiment was conducted for two years i.e. 2016-2017 and 2017-2018. In the plot size of 9m^2 with row to row spacing of 20 cm, flat sown plot has 16 rows whereas bed sown plot has 15 rows. The experiment was laid out in split plot design and replicated thrice; hence there were total 90 plots (Plot size: 3 × 3 m= 9m^2) in the experiment for each season.

Experiment cultural practices: The land was ploughed once with mould board plough and harrowed twice to bring the soil to a fine tilth. Stubbles and weeds were collected and disposed off. The soil was Gangetic alluvial with a sandy clay loam texture, pH 8.5, organic carbon 0.18%, available N: 240 kg/ha , available P: 13.6 kg/ha and available K: 75 kg/ha at the time of initiation of the experiment. Recommended doses of inorganic N as urea (110 kg/ha/year), inorganic P as P_2O_5 (62 kg/ha/year) were applied. To control weeds, Stomp 30 EC (pendimethalin) @2.5 litre/ha was sprayed as pre-emergence i.e. within 2 days of sowing by dissolving it in 150 litres of water. Thereafter, one hand weeding was done after one month of sowing. The normal cultural practices were followed as per standard agronomic

practices (Anonymous 2019). The single harvesting of each plot was done after 110-120 days of sowing expect late sown crop (20th December). However, December 20th sown crop becomes ready for single harvesting in 90 days after sowing.

Data collection: Ten plants were selected at random and pods were collected to record data on protein content (%) on fresh weight basis, dry matter (%) of shelled green peas, total sugars (%) on dry weight basis, reducing sugar (%) on dry weight basis, alcohol insoluble solids (%) on dry weight basis, pod yield (q/ha) and reaction to rust (*Uromyces vicia fabae*) disease. To measure dry matter (%) of shelled green peas, fresh samples from each treatment were dried in an oven at 65 ± 2ÚC till the weight becomes constant. Protein content in green pea seeds at fresh stage was estimated by Lowry's method (Lowry et al., 1951). Total sugar (%) content was estimated by method of Dubios et al. (1956). Reducing sugar in green pea seeds at dry stage was estimated by Nelson somogyi's method (Marais et al., 1966). Alcohol insoluble solids (%) on dry weight basis were measured by method proposed by Moyer and Holgate (1948). For field screening for reaction to rust (*Uromyces vicia fabae*), plants were observed over time to investigate the rust severity under natural conditions. The estimation of the severity of the infection by rust was done depending on the devised scale (0-9) (Mayee and Datar, 1986).

Data analysis: Statistical analysis of the data recorded on various aspects of investigation was done by Split Plot Design as per the procedure given by Cochran and Cox (1959) and adapted by Cheema and Singh (1991) in statistical package CPCS-I, software developed by the Department of Mathematics and Statistics, Punjab Agricultural University, Ludhiana. The comparisons were made at five per cent level of significance.

Results and Discussion

Protein content (%) on fresh weight basis: It is revealed from the data that the date of sowing significantly affects the protein content, however, protein content was not affected by the sowing method and spacing (Table 1). It was observed that early sowing on 20th October gave maximum protein content (3.75%) which was significantly higher than 5th November (3.52%) sown crop and other sowing dates. The results regarding increase in protein content with early sowings were in close line with the findings of Bertholdsson (1990). Among interactions, two way interactions between date of sowing & sowing method and spacing & sowing method was found to be non-significant. However, interaction between date of sowing & spacing was observed, wherein, highest protein content (3.96%) was observed in 20th October sown crop at wider spacing (20 × 10 cm) which was statistically at par with 20th October sown crop at 20 × 7.5 cm (3.85%) and 5th November sown crop at 20 x 7.5 cm (3.70%). Three way interactions between the factors viz. date of sowing, sowing method and spacing were found to be non-significant.

Dry matter of shelled peas (%): It is revealed from the data that sowing date and sowing method significantly affected the dry matter content of shelled green seeds, however, spacing does not significantly affect it (Table 1). The data analysis showed that sowing of garden pea on different dates significantly affected the dry matter content of shelled peas. The higher dry matter accumulation in green seeds (28.05%) was observed in early sown crop (20th October) which was significantly higher than rest of sowing dates. It was observed that delay in sowing leads to decline in dry matter accumulation in shelled green seeds. Similar results for dry matter accumulation were also corroborated by Ehdaie and Waines (1992). Sowing method significantly affected the dry matter accumulation of shelled green seeds. The bed sown crop accumulated significantly higher dry matter of 1.91% as compared to flat sown crop. Similar results of maximum dry matter accumulation on bed planted crop were observed by Chandra and Polisetty (1998). Three way interactions between the factors viz. date of sowing, sowing method and spacing and two-way interaction between the factors viz. date of sowing & sowing method, date of sowing & spacing and spacing & sowing method was found to be non-significant.

Total sugar (%) on dry weight basis: The data analysis showed that the sowing of garden pea on different dates significantly affects the total sugar content (Table 2). The maximum total sugar (19.70%) was observed in 20th October sown crop which was significantly higher than 5th November sown crop. The findings were in close conformity with those of Almodares and Hoseini (2016) in sweet sorghum, as they reported that timely sown crop gave higher total sugar content as compared to late sown. It was observed that the spacing of 20 × 10 cm significantly affects the total sugar content and spacing of 20 × 7.5 cm and 20 × 5 cm were statistically at par with each other. Among interactions, two way interactions between date of sowing & sowing method, spacing & sowing method and date of sowing & sowing method were found to be non-significant. Three-way interaction between the factors viz. date of sowing, sowing method and spacing was also found to be non significant.

Table 1: Effect of different treatments on protein content (%) and dry matter (%) of garden pea (pooled of 2 years)

Time of sowing	Spacing	Sowing method					
		Protein content (%) on fresh weight basis			Dry matter (%) of shelled green seeds		
		Flat (M_1)	Bed (M_2)	Mean	Flat (M_1)	Bed (M_2)	Mean
20th October (D_1)	20 × 5 cm (S_1)	3.45	3.47	3.46	28.30	28.39	28.34
	20 × 7.5 cm (S_2)	3.88	3.83	3.85	27.52	28.71	28.11
	20 ×10 cm (S_3)	3.87	4.04	3.96	27.74	27.68	27.71
	Mean	3.73	3.78	3.75	27.85	28.26	28.05
5th November (D_2)	20 × 5 cm (S_1)	3.34	3.26	3.30	26.38	27.13	26.76
	20 × 7.5 cm (S_2)	3.71	3.69	3.70	26.89	27.74	27.31
	20 ×10 cm (S_3)	3.73	3.40	3.56	27.51	27.35	27.43
	Mean	3.59	3.45	3.52	26.93	27.41	27.17
20th November (D_3)	20 × 5 cm (S_1)	3.18	3.14	3.16	26.37	26.32	26.34
	20 × 7.5 cm (S_2)	3.59	3.63	3.61	26.18	27.50	26.84
	20 ×10 cm (S_3)	3.56	3.65	3.60	26.29	27.42	26.86
	Mean	3.44	3.47	3.46	26.28	27.08	26.68
5th December (D_4)	20 × 5 cm (S_1)	3.11	3.10	3.11	24.61	25.21	24.91
	20 × 7.5 cm (S_2)	3.31	2.86	3.08	24.08	25.10	24.59
	20 ×10 cm (S_3)	2.80	2.75	2.77	24.84	25.72	25.28
	Mean	3.07	2.90	2.99	24.51	25.34	24.93
20th December (D_5)	20 × 5 cm (S_1)	2.82	2.73	2.77	25.08	24.99	25.03
	20 × 7.5 cm (S_2)	2.30	2.18	2.24	25.19	25.72	25.46
	20 ×10 cm (S_3)	2.55	2.29	2.42	26.10	25.63	25.86
	Mean	2.55	2.40	2.47	25.45	25.44	25.45
Mean	20 × 5 cm (S_1)	3.18	3.14	3.16	26.14	26.40	26.27
	20 × 7.5 cm (S_2)	3.36	3.24	3.30	25.97	26.95	26.46
	20 ×10 cm (S_3)	3.30	3.22	3.26	26.50	26.76	26.63
	Mean	3.28	3.20		26.20	26.70	
CD (p= 0.05)							
Time of sowing(D)			0.17			0.50	
Sowing method(M)			NS			0.31	
Spacing(S)			NS			NS	
D × S			0.32			NS	
D × M			NS			NS	
S × M			NS			NS	
D × S × M			NS			NS	

Reducing sugar (%) on dry weight: The sowing of garden pea on different dates significantly affects the reducing sugar during both the years individually and their combined mean analysis (Table 2). The maximum reducing sugar (4.43%) was observed when in 20th October sown crop, which was statistically at par with 5th November (4.36%) and 20th November (4.29%) sown crop. It was observed that delay in sowing leads to decline in reducing sugar content. The bed planted crop has significantly higher reducing sugar as compared to flat sown method, wherein, maximum reducing sugar content was observed on bed planted crop having 2.40% more reducing sugar as compared to flat planted crop. Similar results for reducing sugar were observed by Naresh et al., 2017. It was also observed that plant to plant spacing had non-significant effect on reducing sugar content. Among interactions, two-way interaction between the factors viz. date of sowing & spacing, date of sowing & sowing method and spacing & sowing method and three way interactions between date of sowing, sowing method and spacing was found to be non-significant which clearly shows that reducing sugar is non-significantly affected by the combined effect of all the factors.

Alcohol insoluble solids (%) on dry weight basis: The date of sowing, sowing method and spacing does not significant effect the alcohol insoluble solids during both the years individually and their pooled mean analysis (Figure 1). Among interactions, two-way interaction between date of sowing & sowing method, date of sowing & spacing and spacing & sowing method and three-way interaction between all the factors were found to be non-significant. This clearly shows that all these three factors do not affect this trait significantly.

Total yield (q/ha): The data analysis showed that all the three factors viz. dates of sowing, sowing method and spacing individually affect the total yield significantly (Figure 2). Among all the five dates of sowing, maximum yield (134.2 q/ha) was observed in 5th November (D_2) sown crop which was significantly higher than rest of sowing dates. The late sown crop

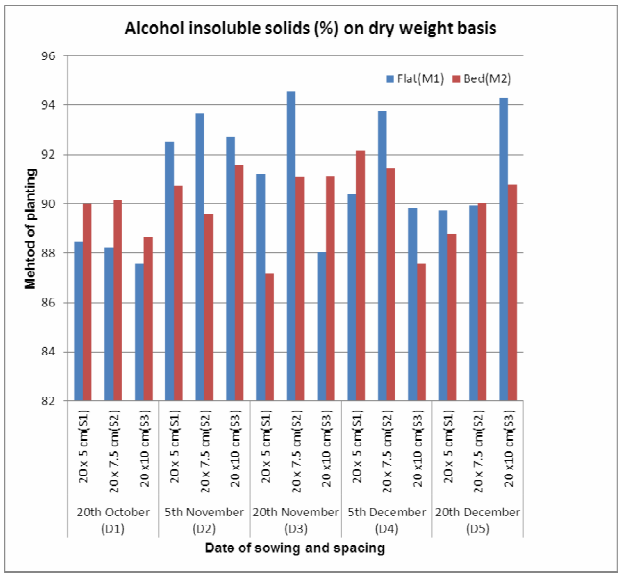

Figure 1: Effect of different treatments on alcohol insoluble solids (%) on dry weight basis of garden pea

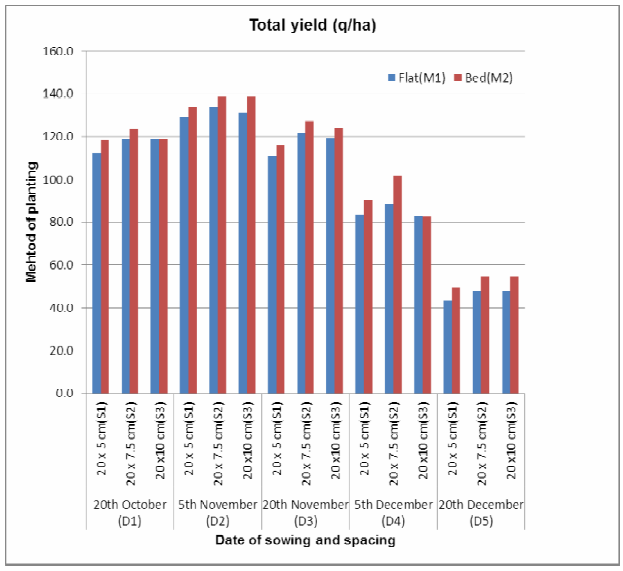

Figure 2: Effect of different treatments on total yield (q/ha) of garden pea

leads to decrease in total yield, wherein minimum yield of 49.7 q/ha was observed in D_5 (20th December). High yield in early sown crop may be due to the fact that the early sown crop gets sufficient time for its growth and development under suitable climate conditions and resulted into better yield attributes as compare to late sown crop. The findings were in close conformity with those of Castillo et al (1994), as they reported that timely sown crop gave higher yield as compared to late sown. Among the two sowing methods, bed sowing (M_2) and flat sowing (M_1) method gave yield of 104.9 kg and 99.3 quintals per hectare, respectively. With respect to total yield, bed sowing (M_2) method was observed to be significantly superior as compared to flat sowing (M_1). Similar results of higher yield on bed sowing method in sweet corn were observed by Amin et al. (2006). The significant differences were observed for yield per plot with spacing. Among different spacing, intermediate spacing of 20 x 7.5 cm (S_2) gave highest yield per plot (105.7 q/ha) which was significantly higher than wider spacing (20 x 10 cm) and close spacing (20 x 5 cm). Among interactions between all the 3 factors, two-way interaction between date of sowing & sowing method, spacing & sowing method and three way interactions (date of sowing, spacing and sowing method) were found to be non-significant. However, significant interaction was observed between date of sowing & spacing. The results showed that the maximum yield of 136.2 quintal per hectare was observed in 5th November sown crop at spacing of 20 x 7.5 cm which was statistically at par with same sowing date i.e. 5th November at wider (135.0 q/ha) and closer spacing (131.4 q/ha). These results are in according with those obtained by Charak et al. (2006) and Dong et al. (2006).

Rust incidence (%): The data analysis on rust incidence (%) after arc sign. transformation was found to be significantly affected by different sowing dates, spacings and two-way interaction between date of sowing & spacing (Figure 3). The incidence of rust disease was maximum (43.16%) on 20th November sown crop which was significantly higher than rest of sowing dates. It was observed that there is continuous increase in rust incidence from 20th October (37.11%) to 20th November (43.16%) sown crop. It was also observed

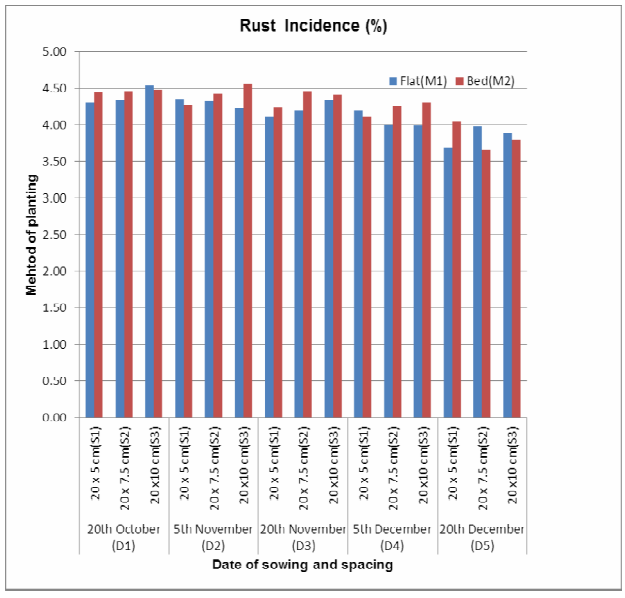

Figure 3: Effect of different treatments on rust incidence (%) of garden pea

Table 2: Effect of different treatments on total sugar (%) and reducing sugar (%) of garden pea (pooled of 2 years)

Time of sowing	Spacing	Sowing method					
		Total sugar (%) on dry weight basis			Reducing sugar (%) on dry weight basis		
		Flat(M_1)	Bed(M_2)	Mean	Flat(M_1)	Bed(M_2)	Mean
20th October (D_1)	20 × 5 cm(S_1)	19.45	19.29	19.37	4.31	4.44	4.37
	20 × 7.5 cm(S_2)	19.86	19.57	19.71	4.34	4.46	4.40
	20 ×10 cm(S_3)	20.11	19.92	20.02	4.54	4.48	4.51
	Mean	19.81	19.59	19.70	4.39	4.46	4.43
5th November (D_2)	20 × 5 cm(S_1)	19.20	19.23	19.21	4.35	4.27	4.31
	20 × 7.5 cm(S_2)	19.65	19.58	19.61	4.33	4.42	4.37
	20 ×10 cm(S_3)	19.83	19.88	19.85	4.23	4.56	4.39
	Mean	19.56	19.56	19.56	4.30	4.41	4.36
20th November (D_3)	20 × 5 cm(S_1)	19.20	19.18	19.19	4.11	4.24	4.17
	20 × 7.5 cm(S_2)	19.38	19.46	19.42	4.19	4.46	4.33
	20 ×10 cm(S_3)	19.74	19.80	19.77	4.34	4.41	4.37
	Mean	19.44	19.48	19.46	4.21	4.37	4.29
5th December (D_4)	20 × 5 cm(S_1)	17.76	17.91	17.84	4.19	4.11	4.15
	20 × 7.5 cm(S_2)	17.23	17.84	17.53	4.00	4.26	4.13
	20 ×10 cm(S_3)	17.90	17.86	17.88	3.99	4.31	4.15
	Mean	17.63	17.87	17.75	4.06	4.22	4.14
20th December (D_5)	20 × 5 cm(S_1)	16.73	17.65	17.19	3.69	4.05	3.87
	20 × 7.5 cm(S_2)	16.29	16.83	16.56	3.98	3.66	3.82
	20 ×10 cm(S_3)	17.01	17.24	17.12	3.89	3.80	3.85
	Mean	16.67	17.24	16.95	3.85	3.84	3.84
Mean	20 × 5 cm(S_1)	18.47	18.65	18.56	4.13	4.22	4.17
	20 × 7.5 cm(S_2)	18.48	18.65	18.57	4.17	4.25	4.21
	20 ×10 cm(S_3)	18.92	18.94	18.93	4.20	4.31	4.25
	Mean	18.62	18.75		4.16	4.26	
CD (p= 0.05)							
Time of sowing(D)			0.09			0.19	
Sowing method(M)			NS			0.08	
Spacing(S)			0.23			NS	
D × S			NS			NS	
D × M			NS			NS	
S × M			NS			NS	
D × S × M			NS			NS	

that the late sown crop suffered less by the rust incidence. The results were in close line to the findings of Singh et al. (2012) in field pea. Rust disease showed non-significant effect due to sowing methods (bed and flat). It was observed from the data that spacings significantly affect the disease incidence wherein maximum rust pustules (34.46%) were observed with closer spacing (20 × 5 cm) which was significantly higher than the intermediate (20 × 7.5 cm) and wider spacing (20 × 10 cm). The findings were in close conformity with those of Manjesh et al., 2018, as they reported higher rust incidence at closer spacing. Among interactions, two way interactions between date of sowing & spacing was found to be significant. The rust incidence was maximum (44.08%) in 20th November sown crop at closer spacing (20 × 5 cm). Further, two way interactions between spacing & sowing method and date of sowing & sowing method and three-way interaction between the three factors (date of sowing, spacing and sowing method) were found to be non-significant.

Conclusion

It is concluded that for single harvesting garden pea with combine-harvester, the garden pea cv. Punjab-89 should be sown on 5th November at intermediate spacing of 20 × 7.5 cm on bed as it resulted into highest productivity during single harvest due to cool temperature during plant growth and development and moderate temperature during pod development and pod filling stage. For all the traits under study, there is non-significant interaction for date of sowing with sowing method, spacing with sowing method and 3-way interaction between date of sowing, spacing and sowing method. The late sown (20th December) crop resulted lowest total yield but less incidence of rust incidence which was due to high temperature and low relative humidity at pod development and filling stage.

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सारांश

वर्तमान अध्ययन भारत में सब्जी मटर की एकल तुड़ाई को यांत्रिक विधि से मानकीकरण हेतु सस्य पद्धतियों का मूल्यांकन किया। प्रयोग को विभेदित भूखण्ड संरचना में 30 उपचारों को समाहित कर 5 तिथियों जैसे–20 अक्टूबर, 5 नवम्बर, 20 नवम्बर, 5 दिसम्बर व 20 दिसम्बर को मुख्य भूखण्ड तथा 2 बुआई विधियों (जैसे–लैट व बेड) को तीन दूरियों (20 x 5 सेमी., 20 x 7.5 सेमी. व 20 x 10 सेमी.) को उपखण्डों में रखकर 3 बार प्रतिकृति किया गया। बेड के मानकीकरण हेतु मटर पौधे के अग्र भार को कम्बाइन से किया गया। सब्जी मटर की किस्म पंजाब–89 की बुआई 5 नवम्बर को मध्यम दूरी 20 x 7.5 सेमी. पर लगाने से सार्थक रूप से ज्यादा हरी फलियाँ 136.2 कु. प्रति हे. एकल तुड़ाई में प्राप्त हुयी जो सांख्यिकीय रूप से 5 नवम्बर को बुआई से 135.0 कु. प्रति हे. के सममूल्य रही और समीप बुआई से 131.4 कु. प्रति हे. उपज प्राप्त हुई जो पौध विकास के समय मध्यम तापमान, फली विकास के समान तथा दाना में भरते समय रही। सार्थक परस्पर क्रिया, बुआई की ठण्डी तापमान तिथि व दूरी में कुल उपज, प्रोटीन की मात्रा तथा रस्ट रोग के आयतन से हुआ जबकि सभी गुणों के असार्थक परस्पर क्रिया बुआई की तिथि के साथ बुआई की विधि, दूरी के साथ, बुआई विधि तथा 3 प्रकार की परस्पर क्रिया बुआई की तिथि, दूरी व बुआई की विधि हेतु पाया गया। पिछेती बुआई (20 दिसम्बर) से सबसे कम उपज पायी गयी लेकिन रस्ट रोग का प्रकोप इस समय कम थी जो अधिक तापमान तथा कम सापेक्ष आर्द्रता फली विकास व फल भराव से हो रहा है।

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