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Genotype and Sowing date effect on growth, yield, and economics of Snow pea

Eshanee[1,2], Akhilesh Sharma[1], Sandeep Manuja[1], Shivanjali Sarswat[3*], Aaqib Ayub[3], Zarina[3], Ab Waheed Wani[4] and Sanjeev Kumar[4]

[1]*Chaudhary Sarwan Kumar Himachal Pradesh Agricultural University, Palampur, HimachalPradesh, India – 176062*
[2]*Department of Vegetable Science, College of Horticulture and Forestry, Punjab Agriculture University, Ludhiana, Punjab, India -141004*
[3]*Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, India*
[4]*Department of Horticulture, School of Agriculture, Lovely professional University, Phagwara, Jalandhar, Punjab-144411*

ABSTRACT

Detailed knowledge of the optimal sowing date for a specific variety in a particular location is crucial for maximizing yield. With this in mind, an experiment was conducted to assess the response of snow pea genotypes to different sowing times. Four genotypes namely, 'DPEPP-15-1', 'DPEPP-10-1', 'Arka Apoorva', and 'Mithi Phali' were evaluated under three sowing dates (21st October 5th and 20th November) during winter seasons of 2018-19 and 2019-20 at Palampur in split plot design using three replications. Early sowing on 21st October followed by 5th November resulted in higher dry matter accumulation, seed and straw yield. Among genotypes, 'DPEPP-15-1' was the most promising genotype followed by 'DPEPP-10-1' for seed yield, crop dry matter, straw yield, harvest index, and 100-seed weight. 'DPEPP-15-1' and 'DPEPP-10-1' had advantage of 53 and 45% for seed yield over 'Arka Apoorva' in pooled years, respectively. Interaction effects revealed that sowing of 'DPEPP-15-1' on 21st October followed by 5th November had higher crop dry matter, seed and straw yield, and monetary gains while 'DPEPP-10-1' ranked second and both of them significantly outperformed 'Arka Apoorva' and 'Mithi Phali'.

Keywords: *Snow pea, Pisum sativum var. saccharatum, sowing dates, varieties, seed yield, straw yield, dry weight, seed index, harvest index, economics.*

1. Introduction

Edible-pod pea [snow pea (*Pisum sativum* var. *saccharatum*) and sugar snap pea (*Pisum sativum* var. *macrocarpon*)] is the popular cool-season oriental vegetable [17]. The pods are mildly flavoured, sweet, crispy, and unlike garden peas lack pod parchment or fibre [2]. The pods along with partially developed seeds are eaten as a salad, after lightly boiling, steaming, or 'stir-frying' etc. In Asian countries, shoots of plants are also used in cooking. Snow pea has its significance as a short-duration crop with high yield and high value of produce, hence it may be a good alternative for small and marginal farmers. Moreover, it could increase farm profitability by providing diversity in produce as specialty crop interest to direct market consumers [10]. Besides the local market, edible pea has great potential for export and processed vegetable. Recently, in India, a few multinational companies have taken up their production through contract farming through the import of seeds. However, to safeguard the farmers of the country, varieties suitable to specific climatic conditions are needed. Therefore, it is necessary to initiate large-scale production of its seed locally. Keeping this in view, as a public sector initiative, mid-season snow pea genotypes have been developed recently through hybridization between snow pea and garden pea genotypes followed by selection in segregating generations. However, it would be imperative to assess the potential productivity of newly developed cultivars concerning yield and related traits. Edible-pod pea can be grown in varied agroclimatic conditions but optimum yield and quality of produce can be obtained in cool and moist growing conditions. Edible-pod pea requires a temperate climate with optimum temperature of 20-25°C between flowering and harvesting. The pea seeds germinate and grow vigorously at lower temperature but yield is generally affected massively by unfavorable environmental conditions such as drought, frost, and high temperatures. Above 30°C temperature, reduction in yield and rapid deterioration of pod quality has been observed due to hastened pod maturity while growth is adversely affected if temperature falls below 10°C [16]. Occurrence of frost especially at flowering and pod formation stages is quite damaging as it reduces fertility results in no or poor pod formation and also damages the developing pods. Thus, choice of sowing date is an important management option to optimize pod yield under such abnormal environmental conditions [7]. Therefore, the optimum sowing date and a suitable variety are of primary importance for harnessing potential yield.

Sowing time is the major component that needs to be ascertained for the new genotypes as it has direct effect on growth and development of crop plants and ultimately on the total productivity per unit area. It also determines the environmental conditions at planting, flowering, and pod formation stages and accordingly, influences the success in maximizing crop yield (Dapaah et al. 2000). The sowing time has striking effects on the growth and yield of a crop all over the world as a drastic reduction in yield is noticed with delayed

*Corresponding Author: ***Shivanjali Sarswat***

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sowing beyond the optimum time. Sowing at optimum time provides the best yield by affirming harmonization of weather conditions concurrently with different growth stages [12] without involving extra costs. Numerous publications have reported a reduction in yield concerning the sister crop garden pea with delayed sowing after the optimum time [7]; [15]. Precise knowledge of sowing date of a particular variety at a specific location is critical to achieving a high pod yield. Therefore, the positive effect of environmental factors on growth and yield could be harnessed if the information on the optimum time of sowing is made available. Keeping these aspects in view, it would be imperative to study the effect of different sowing dates and genotypes on the performance of edible pod peas under mid-hill conditions of Himachal Pradesh.

2. Materials and methods

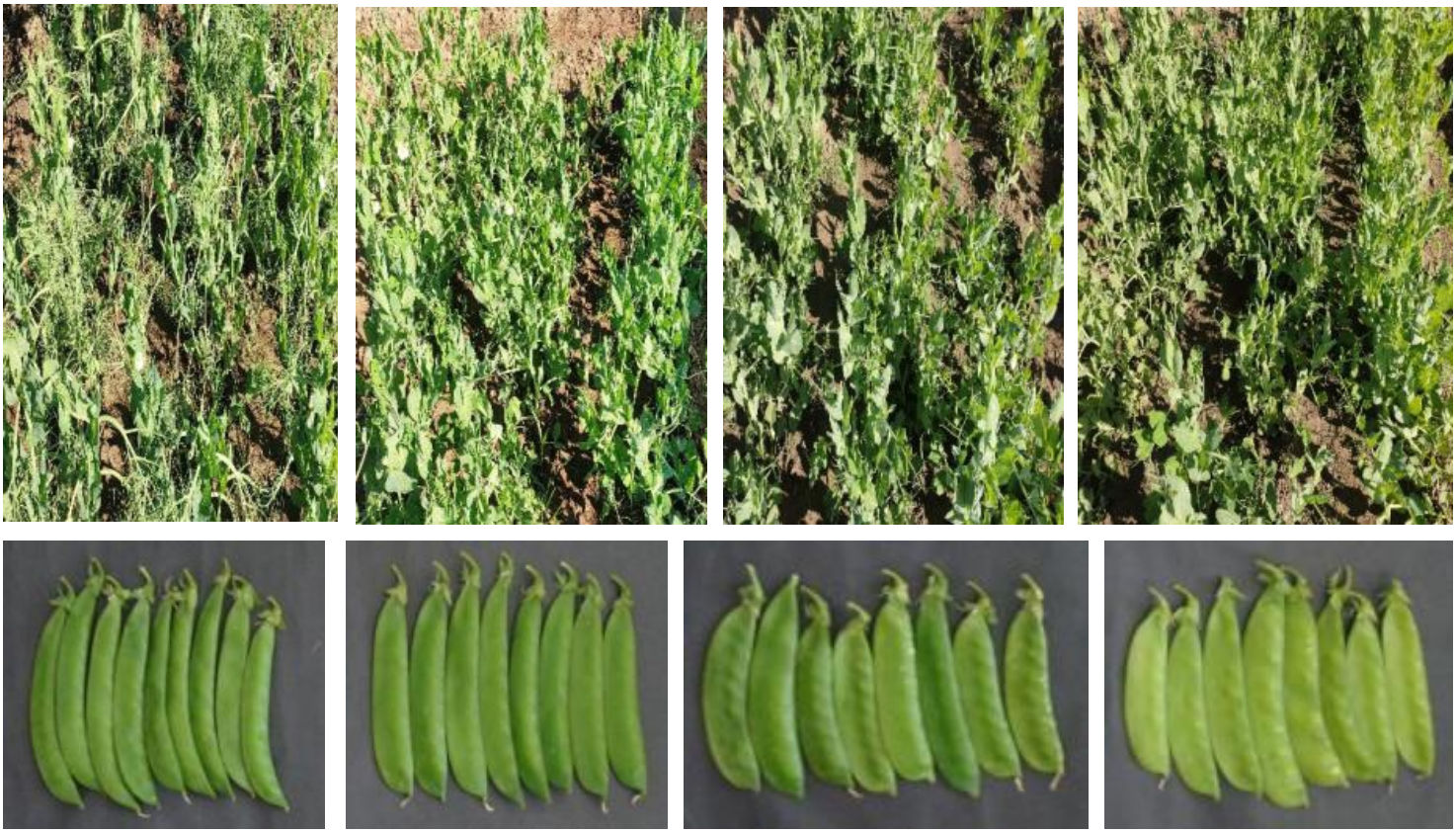
2.1 Location and climatic conditions

The present investigation was carried out at the Experimental Farm of the Department of Vegetable Science and Floriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur [32°6′ N latitude, 76°3′ E longitude and 1290.8 m altitude] during winter seasons of 2018-19 and 2019-20, respectively.

This area represents mid hill sub-humid climatic zone of Himachal Pradesh. It experiences occasional snowfall during winter. The region receives an average annual rainfall of 2332 mm. About 80% of this amount of rainfall is received during June to September. During *rabi* (2018-19) maximum temperature ranged between 25.5 to 31°C (13th and 18th meteorological week, respectively) and during 2019-20 between 13.1 to 27.1 °C (2nd and 20th week, respectively). The minimum temperature ranged between 0 and 7.5°C (52nd and 6th meteorological week, respectively) during 2018-19 and 1.4 and 14.6 °C (52nd and 18th standard week, respectively) during 2019-20. The total amount of rainfall received was 639.6 and 790 mm during 2018-19 and 2019-20, respectively. The soils are clay loam to silty clay loam in texture and are classified as alfisols with typic hapludalf as its sub-order. The reaction of soils is acidic with pH ranging from 5.2 to 6.0 and CEC from 9.0 to 13.0 mg/100 g soils. The status of organic carbon in the soils is medium to high. The soils are medium in available N and P and high in available K.

2.2 Plant material

Four edible-pod pea genotypes used in this study are 'DPEPP-10-1', 'DPEPP-15-1', 'Mithi Phali', and 'Arka Apoorva' (Figure 1) as described in Table 1.



DPEPP-10-1 DPEPP-15-1 Arka Apoorva Meethi Phali

Figure 1: Four edible pod pea genotypes

Table 1: Description of the plant material of snow peas used in the study

Plant material	Description	Source
DPEPP-10-1	A sweet, high-yielding variety developed for hilly regions. Known for its adaptability and disease resistance.	CSKHPKV, Himachal Pradesh, India
DPEPP-15-1	High pod yield variety for hilly regions, moderately resistant to powdery mildew disease and low incidence of leaf miner.	CSKHPKV, Himachal Pradesh, India
Arka Apoorva	A hybrid variety with uniform pod development, adaptable to various climates, and resistant to rust and powdery mildew.	IIHR, Bangalore, India
Meethi Phali	An open-pollinated variety known for its sweetness, tenderness, and reliable yield in cooler climates.	PAU, Ludhiana, India

CSKHPKV - Chaudhary Sarwan Kumar Himachal Pradesh Agricultural University, IIHR - Indian Institute of Horticultural Research, PAU - Punjab Agricultural University

2.3 Experimental method

Four edible-pod pea genotypes viz. 'DPEPP-10-1', 'DPEPP-15-1', 'Mithi Phali' and 'Arka Apoorva' were sown at three dates viz. 21st October, 5th November and 20th November. Thus, a total of 12 treatments were evaluated in split plot design with four replications in the respective years in a plot size of 2.7 m × 1.8 m at spacing of 45 cm between rows and 7.5 cm within row at 60 kg ha^{-1} seed rate manually. The dates of sowing were placed in main plots and four varieties in subplots. 40 kg N, 60 kg P_2O_5 and 30 kg K_2O per ha^{-1} were applied as basal dose through urea, single super phosphate and muriate of potash, respectively. Two to three irrigations were applied uniformly in all the treatments. Power operated knapsack backpack sprayer fitted with a flat fan nozzle (WFN 40) was used for spraying the herbicides pendimethalin 1.2 kg/ha. The herbicides were sprayed using a spray volume of 600 litres of water ha^{-1}. Hand weeding was also superimposed to take care of rest of the weeds. Standard plant protection and other cultural practices were followed to maintain uniform experimental conditions. The observations were recorded for seed yield (q/ha) and related parameters namely, plant height (cm), pod length (cm), pods/plant, straw yield (q/ha), biological yield (q/ha), harvest index (%) and 100 seed weight (g). Seed, straw and biological yields were recorded on plot basis and were converted to tonnes/ha. Economics of treatments was worked out based on the prevalent prices.

2.4 Statistical analysis

The data obtained were subjected to statistical analysis by analysis of variance (ANOVA) for the split plot design to test the significance of the overall differences among the treatments by the "F" test and a conclusion was drawn at 5% probability level. Standard error of mean was calculated in each case. When the 'F' value from analysis of variance tables was found to be significant, the critical difference (LSD) was computed to test the significance of the difference between the two treatments. The average values over the replications in the respective years and on pooled basis were analyzed as per the procedure described for split plot design [4].

3. Results and Discussion

3.1 Emergence count (No./m^2)

The data on the effect of various treatments on emergence count have been presented in Table 2. A cursory glance at the data revealed that sowing dates significantly influenced the emergence count in edible-podded pea during 2018-19 and on pooled basis. Emergence count in crop sown on 5th and 20th November was significantly higher than early sown crop. Significant differences were recorded for emergence count among the varieties of edible podded pea during both the years and on pooled basis. 'DPEPP-10-1' and 'DPEPP-15-1' had significantly more emergence count as compared to 'Arka Apoorva' and 'Mithi Phali' during 2018-19, 2019-20 and on a pooled basis. The interaction effects between varieties and dates of sowing on emergence count were found to be non-significant.

3.2 Dry matter accumulation

The sowing dates significantly influenced the edible-pod pea crop dry weight during both the years and on pooled basis. A cursory glance at Table 2 revealed that early sowing on 21st October produced significantly higher crop dry weight during 2018-19, 2019-20 and on pooled basis, respectively with average increase of 20.6 and 46.8% on pooled basis as compared to 5th November and 20th November sowing dates, respectively. Similarly, sowing on 5th November produced significantly higher crop dry weight over late sowing (20th November) with average advantage of 21.7% over the years. This gradual decrease in dry matter accumulation with delayed sowing could be attributed to low vegetative growth, low ambient temperature and decrease in crop duration. The highest dry matter accumulation under early crop sown on 21st October might be the result of optimum environmental conditions for crop growth and the crop got more time to attain different phenophases. [8] have also recorded high dry matter accumulation in garden pea. Among varieties, 'DPEPP-15-1' significantly produced higher dry matter accumulation followed by 'DPEPP-10-1' as compared to 'Arka Apoorva' with 'Mithi Phali'. Interaction effects (Figure 2) revealed that early sowing of 'DPEPP-15-1' and 'DPEPP-10-1' on 21st October, resulted in significantly higher dry matter accumulation over the other two varieties sown on all the three dates as well as late sowing of the two test varieties on 5th and 20th November during both the years and on pooled basis. There was incremental decline in the performance of varieties with delay in sowing on 5th November to 20th November. The significantly lowest dry matter accumulation was recorded in 'Mithi Phali' sown on 20th November during both the years.

3.3 100-seed weight

The 100 seed weight/test weight is an important yield attribute that determines the yield contribution of individual seed as well as quality appearance of seed. The data presented in Table 1 revealed that this trait was not significantly affected by different dates of sowing during both the years. In contrary, [9] had reported high test weight in early sown pea crop than late sown crop. On the other hand, varieties showed significant variation for 100 seed weight during both the years and on pooled basis. On the pooled basis, significantly higher test weight was recorded for 'DPEPP-15-1' over years followed by 'DPEPP-10-1', 'Arka Apoorva' and 'Mithi Phali' and each variety differing significantly from one another.[5],[6] and [14] had also reported variations among varieties for test weight in garden pea. Interaction effects on 100 seed weight were found to be non-significant. In contrary to the present findings, [1] and [11] had recorded significant effects of interaction between sowing dates and varieties on 100 seed weight.

3.4 Yield

The sowing dates significantly influenced the seed and straw yield during both the years and on pooled basis. A cursory glance at Table 1 revealed that early sowing on 21st October produced significantly higher seed yield to the extent of 26.32, 35.47 and 30.89 q/ha, respectively during 2018-19, 2019-20 and on pooled basis, respectively. The average increase was to the extent of 17 and 57% on pooled basis as compared to 5th November and 20th November sowing dates, respectively. Similarly, sowing on 5th November produced significantly higher seed yield over late sowing (20th November) with average advantage of 34% over the years. Similar trend was recorded for straw yield with significant advantage in early crop sown on 21st October. There was significant incremental decrease to the extent of 23 and 40% in straw yield on pooled basis when sown on 5th and 20th November, respectively as compared to early sown crop on the 21st October. This gradual decrease with delayed sowing could be attributed to low vegetative growth, low dry matter accumulation and decrease in crop duration.

The highest yield in early crop sown on 21st October might be the result of optimum environmental conditions for crop growth and the crop got more time to attain different phenophases. [8] also recorded the better performance of genotypes in early sown garden pea.

Among varieties, 'DPEPP-15-1' significantly produced higher seed and straw yield as compared to other varieties followed by 'DPEPP-10-1', 'Arka Apoorva' and 'Mithi Phali' in that order, each variety differing significantly from each other. 'DPEPP-15-1' and 'DPEPP-10-1' had mean seed yield advantage of 53 and 45% over variety 'Arka Apoorva' on pooled basis, respectively. [6] and [14] had also reported significant differences for these traits in garden pea. Interaction effects (Figure 1) revealed that early sowing of 'DPEPP-15-1' and 'DPEPP-10-1' on 21st October significantly outyielded the other two varieties sown on other dates as well as late sowing of the two test varieties on 5th November and 20th November during both the years and on pooled basis for seed and straw yield. There was incremental decline in the performance of varieties with a delay in sowing on 5th November to 20th November.

3.5 Harvest index

The data presented in Table 1 revealed that harvest index varied significantly in sowing environments during 2019-20 and on pooled basis. During 2019-20 and pooled years, significantly higher harvest index was observed in 5th November and 21st October sown crop. Low harvest index with delayed sowing had also been recorded by Sirwaiya and Kushwah (2018). Amongst varieties, significant differences were recorded for harvest index over the years with highest in 'DPEPP-15-1' (38.03%) followed by 'DPEPP-10-1' (37.33%) and 'Arka Apoorva' (36.94%) during 2018-19, significantly outperformed 'Mithi Phali' (33.52%). However, 'DPEPP-15-1' (46.29%, 42.16%) and 'DPEPP-10-1' (46.0%, 41.86%) had significantly high harvest index than the other varieties *viz.* 'Arka Apoorva' (40.51%, 38.73%) and 'Mithi Phali' (38.51%, 36.02%), respectively during 2019-20 and on pooled basis. Differences among varieties for harvest index had also been represented by [13], [6] and [15] in pea.

3.6 Days to seed maturity

Analysis of the data presented in Table 1 revealed that 21st October sown crop took significantly more numbers of days to seed maturity followed by 5th November and 20th November sown crop. A declining trend was observed for seed maturity with delay in sowing from 21st October to 20th November and the difference of about 5 to 6 days between first and second sowing date was further reduced to about 4 weeks in late sown crop as compared to early sown crop. This indicated that late-sown crop matured about 4 weeks earlier than early sown crop over the years and ultimately led to seed harvest almost parallel to other sowing dates in the same month that is April. The reduction in number of days was due to availability of shorter cool growing period for the delayed sown crop and simultaneous rise in temperature which accelerated the developmental stages of the crop and thereby caused senescence almost in the same month of April in all sowing dates. A perusal of data revealed that variety 'DPEPP-15-1' (164.33, 172.67 and 168.50 days) took maximum number of days to physiological maturity followed by 'DPEPP-10-1' (162.33, 170.89 and 166.61 days) during 2018-19, 2019-20 and on pooled basis, respectively while the other varieties matured significantly earlier than the above captioned varieties over the years.

Table 1: Effect of dates of sowing on seed yield and related parameters of different varieties of edible-pod pea

Treatment	Emergence count (No. /m²)			Crop dry weight (g/m²)			1000-seed weight (g)			Seed yield (kg/ha)			Straw yield (kg/ha)			Harvest index (%)			Days to seed maturity		
	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool	2018-19	2019-20	Pool
Year																					
Date of sowing (D)																					
21st October	25.17	26.33	25.75	543.9	629.5	586.7	202.5	208.3	205.4	2632	3547	3089	4342	4523	4432	37.48	43.36	40.42	173.25	179.67	176.46
5th November	26.92	27.25	27.08	425.9	547.4	486.6	215.0	204.2	209.6	2082	3192	2637	3378	3827	3603	37.38	44.78	41.08	167.00	175.00	171.00
20th November	26.50	28.00	27.25	353.3	446.0	399.7	201.4	190.0	195.7	1600	2337	1968	2930	3382	3156	34.81	40.34	37.57	144.25	154.17	149.21
CD (P=0.05)	1.17	NS	0.78	33.9	34.3	20.0	NS	NS	NS	177	101	85	271	351	184	NS	1.62	1.17	1.91	3.92	1.81
Variety (V)																					
DPEPP-15-1	26.67	27.89	27.28	541.6	645.8	593.7	238.8	224.4	231.6	2653	3851	3252	4291	4429	4360	38.03	46.29	42.16	164.33	172.67	168.50
DPEPP-10-1	26.89	28.11	27.50	506.5	624.2	565.3	205.4	212.2	208.8	2478	3700	3089	4016	4302	4159	37.73	46.00	41.86	162.33	170.89	166.61
Mithi Phali	25.67	26.11	25.89	342.2	419.3	380.7	185.4	175.6	180.5	1496	2080	1788	2891	3296	3093	33.52	38.51	36.02	158.67	168.33	163.50
Arka Apoorva	25.56	26.67	26.11	373.9	474.6	424.2	195.6	191.1	193.3	1791	2469	2130	3002	3616	3309	36.94	40.51	38.73	160.67	166.56	163.61
CD (P=0.05)	0.94	0.56	0.53	22.6	8.7	11.7	10.9	12.5	8.0	113	107	75	206	67	104	1.47	1.16	0.90	2.93	2.03	1.72
Interaction (D × V)	NS	NS	NS	S	S	S	NS	NS	NS	S	S	S	S	S	S	NS	NS	NS	NS	NS	NS

3.7 Economics

Both seeding time and variety are generally considered non-monetary inputs. However, prices/cost on seed and planting varied many a times due to quality and prevalent environmental conditions. Also, one may expect similar cost of cultivation due to variety and seeding time but it varied due to the quantity of the output realized. Gross returns are directly proportional to the amount of output produced in terms of seed and haulm yield under the present investigation and were, therefore, significantly affected (Figure 2). Early sowing of 'DPEPP-15-1' and 'DPEPP-10-1' on 21st October, resulted in significantly higher gross and net returns over the other two varieties irrespective of other dates on 5th November and 20th November during both the years and on pooled basis.

4. Conclusion

It can be concluded that early sowing on 21st October of 'DPEPP-15-1' followed by 'DPEPP-10-1' produced significantly high seed yield as well as net returns as compared to other varieties irrespective of sowing dates besides having higher 100-seed weight and harvest index. Thus, it is recommended to use these two varieties in hilly regions at the optimal time to ensure profitable returns for farmers.

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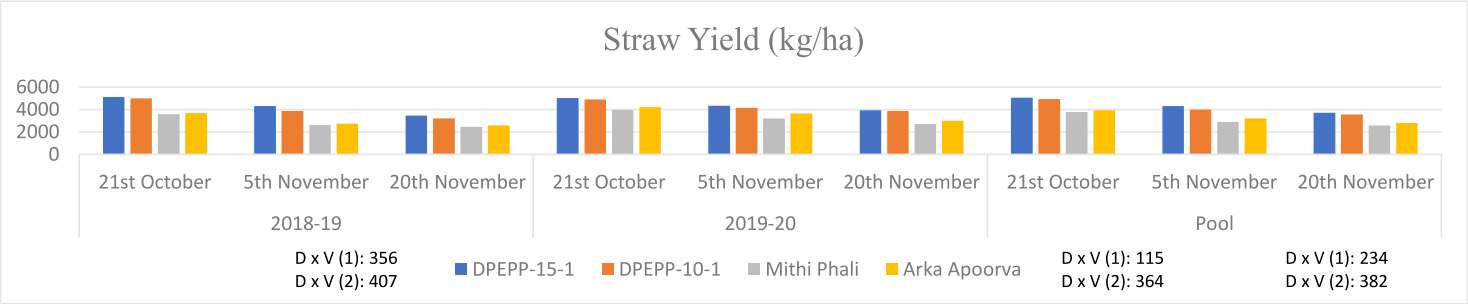
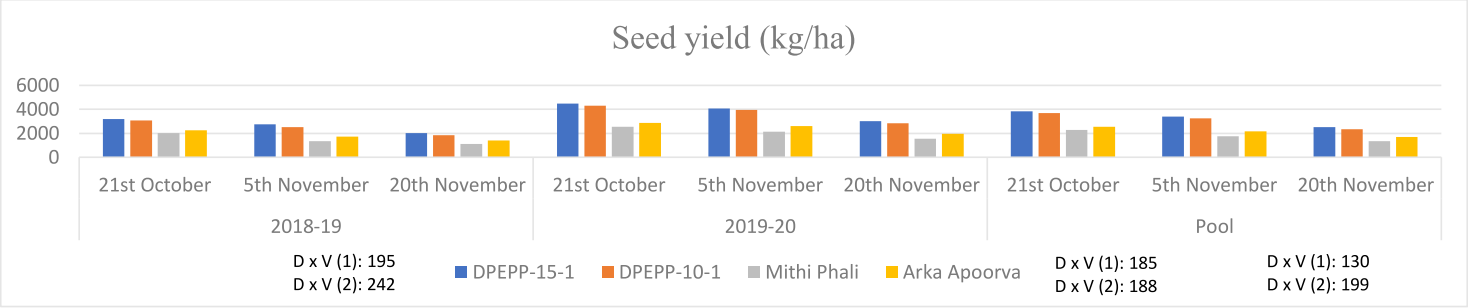
Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

***Figure 1**: Interaction effects of dates of sowing on seed yield and related parameters of different edible-pod pea varieties*
CD (P=0.05) D x V (1), For comparison of varieties at same date; D x V (2), For comparison of dates at same or different varieties





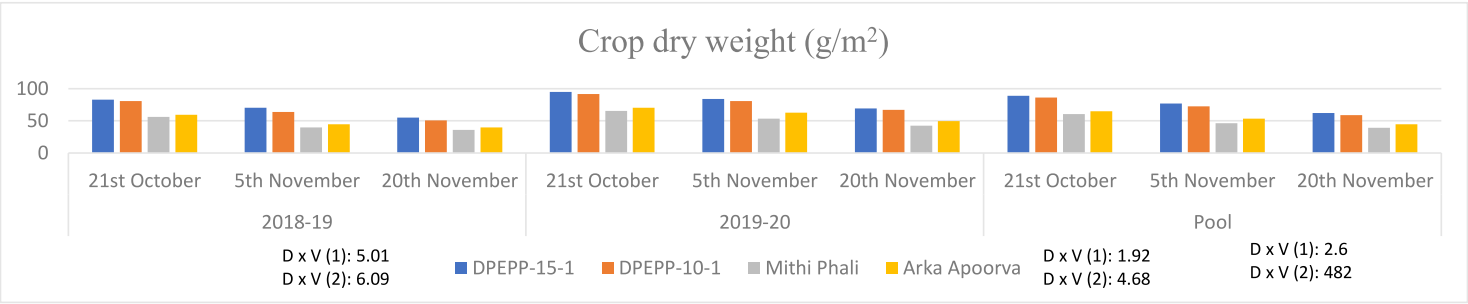
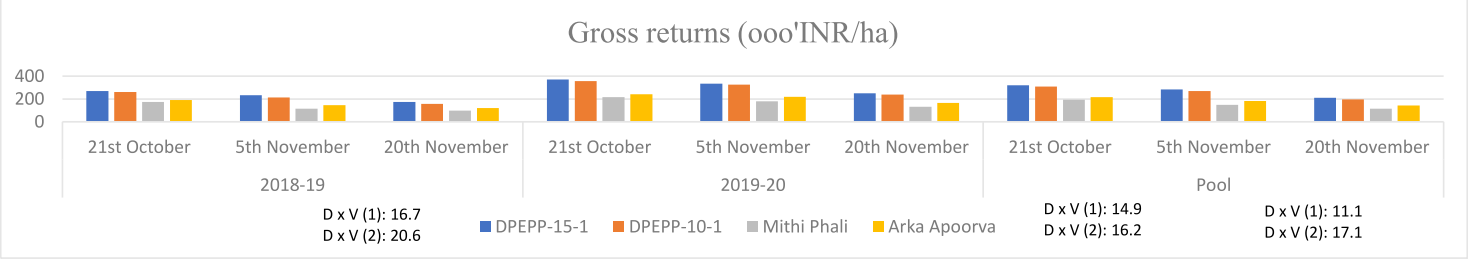
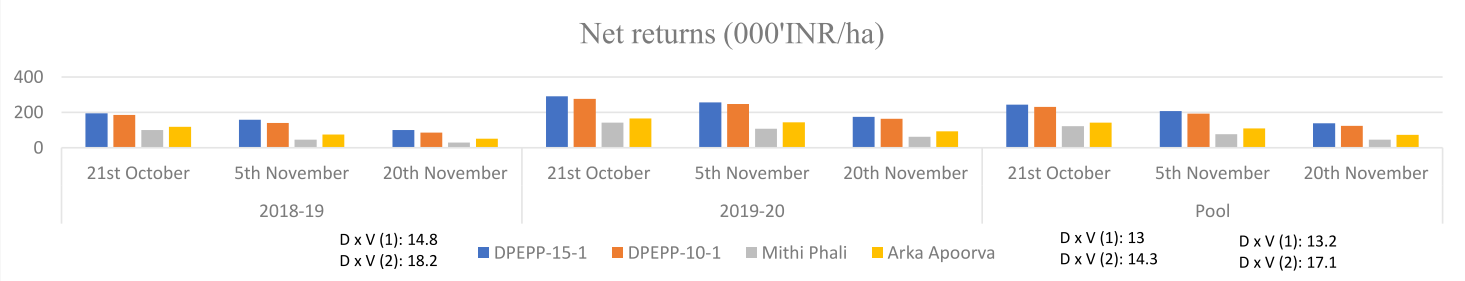
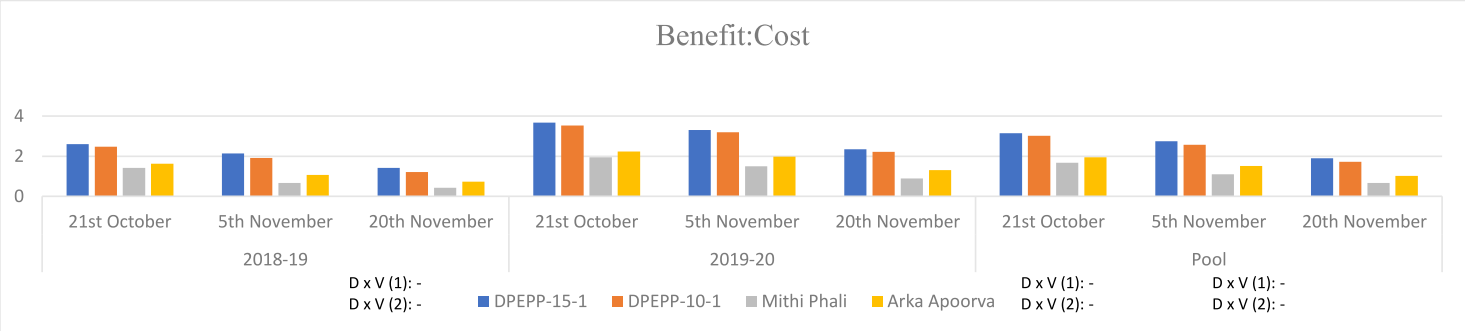


***Figure 2:** Interaction effects of dates of sowing on economics of different edible-pod pea varieties*







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