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Effect of different sowing dates and row spacing on the growth, seed yield and quality of off-season pea *(Pisum sativum L. Cv. Climax*) under temperate conditions of Rawalakot Azad Jammu and Kashmir

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ABSTRACT

A study was conducted to check the effect of different sowing dates and row spacing on the growth, seed yield and quality of off-season pea (*Pisum sativum* L. cv. Climax). Significant differences were recorded among sowing dates for days to germination while non-significant results were found for row spacing and interaction (A × B). Maximum days to germination were recorded in D_1 (20^{th} April) and minimum were recorded in D_4 (4^{th} June). Germination percentage indicated highly significant differences for sowing dates whereas; non-significant results were found for row spacing and interaction (A × B). Maximum germination percentage was recorded on sowing date D_2 (5^{th} May). Plant height indicated highly significant differences for sowing dates, row spacing and interaction (A × B). Maximum plant height was recorded on D_2 (5^{th} May), S_1 (30 cm) and D_1 x S_3. Number of branches plant^{-1} indicated highly significant differences for sowing dates, row spacing and interaction. Maximum number of branches plant^{-1} were counted in D_1 (20^{th} April), S_3 (50 cm) and D_1 x S_3. Chlorophyll contents showed highly non-significant differences among sowing dates, row spacing and interaction (A × B). Highly significant differences were observed among sowing dates for days

to flowering whereas, non-significant results were found for row spacing and interaction (A × B). Minimum days to flowering were taken by plants sown D_4 (4^{th} June). Days to pod formation showed highly significant differences for sowing dates whereas, non-significant results were found for row spacing and interaction (A × B). Minimum days to pod formation were recorded in D_4 (4^{th} June). A highly significant difference was observed among sowing dates, row spacing and interaction (A × B) for number of pods plant^{-1}. Maximum numbers of pods plant^{-1} were recorded in D_1 (20^{th} April), S_3 (50 cm) and D_1 x S_3. Pod length indicated highly significant differences among sowing dates, row spacing and interaction (A × B). Maximum pod length was recorded in D_1 (20^{th} April), S_3 (50 cm) and D_1 x S_3. Number of seeds pod^{-1} showed highly significant differences among sowing dates, row spacing and interaction. Maximum number of seeds pod^{-1} were recorded in (20^{th} April), S_3 (50 cm) and D_1 x S_3. Highly significant differences were observed among sowing dates, row spacing and interaction for seed yield ha^{-1}. Maximum seed yield ha^{-1} was recorded in D_1 (20^{th} April), S_3 (50 cm) and D_1 x S_3. Protein contents showed highly significant differences among sowing dates while non-significant results were found for row spacing and interaction (A × B). Maximum protein contents (21.10%) were recorded in the plants of D_1 (20^{th} April). The effect of different sowing dates, row spacing and interaction (A × B) on Total sugar, Vitamin C and pH was non-significant.

1. Introduction

Pea (*Pisum sativum* L.) belongs to family Leguminaceae was originated in Ethopia and parts of Europe and Asia. Peas occupy the largest sowing area (6,764,000 ha) after bean, cowpea and chickpea, as well as having the second largest production (12,144,000 t) after bean in the world. Total world dry pea production rose from 8.127 million metric tons in 1979-81 to 14.529 million metric tons in 1994 while acreage varied from 7.488 to 8.060 million hectares for the same years (FAO, 1994). In Pakistan, total area under pea crop during 2008-09 was 12172 hectares and production was 82540 tons with an average yield of 6.78 tons ha^{-1}. (Anonymous, 2008-09).

Pea is a self pollinated crop can be grown at temperature ranges from 10-30˚C. The minimum temperature for germination is about 10˚C and the optimum about 22˚C. It is sensitive to high temperature and drought stress (Baloch, 1994). In plains peas are sown from October to December; whereas in hilly areas they are planted after mid-March to the end of May. However, another important factor determining the sowing time and cultivar is the required product (Gulumser *et al.,* 1994).

The production of vegetables in the country is currently limited to certain time periods during the year. However, due to the invention of modern Agriculture production and storage techniques, there is an opportunity for providing a variety of vegetables in off-season as well. In this regard, two options can be considered. First to store vegetable under an artificially created environment while the second would be to grow them off-season. Vegetable growing in off-season is a better option for fresh supply round the year. These off-season vegetable productions would change the food habits of consumers and increase the annual profit of farmers as well. But this can only be possible by creating awareness amongst vegetable growers. The production of vegetables all round the year enables the growers to fully utilize their resources and supplement income from vegetable growing as compared to others normal agricultural crops (Zhihao *et al*., 2000).

Rawalakot Valley lies altitude of 1800-2000 m and at latitude of 33-36^0 in Northern Pakistan, under the foot hills of Himalaya. The climate of the area is temperate, sub-humid with annual rainfall ranging from about 500-2000 mm, most of which is irregular, with intensive storms during moon-soon and winter. The mean annual

temperature ranges from a minimum of 0 ^{0}C to maximum of 30 ^{0}C accompanied by severe cold and snowfall in winter (Abbasi and Khan, 2004).

The climatic conditions of Rawalakot are temperate and are best for of off-season vegetable production. Pea is a winter vegetable and can be grown as off-season in summer in temperate/hilly areas. In our country it is generally grown in autumn season (October-November) and remained available in market for a short period. So, off-season pea can fetch more prices in the market. Keeping in view the importance of peas as off-season crop, first time an experiment was conducted to determine the effect of different sowing dates and row spacing on the growth, seed yield and quality of off-season pea (*Pisum sativum* L.) cv. Climax under temperate conditions of Rawalakot Azad Jammu and Kashmir for further recommendations to farming community. Objective of current study were:

1. To check the best sowing time and row spacing for cultivation of off-season peas under temperate/cool conditions of Rawalakot.
2. To boost up off-season pea cultivation in local farming community.
3. To get high yield and more income per unit area and supply of fresh peas in market during off-season.

2. Materials and methods

The present research work was carried out at village Kharick Rawalakot, Azad Jammu and Kashmir to study the effect of different sowing dates and row spacing on the growth, seed yield and quality of off-season pea cv. Climax during the year 2010. Seeds of pea cv. Climax were collected from Awan Nursery and Seed Store, Rawalpindi. Sowing was done on the following dates:

2.1. Sowing dates

D_1 20th April
D_2 5th May
D_3 20th May
D_4 4th June

Different row spacing were allotted to sub plots and considered as treatment. These spacing was arranged as under:

2.2. Row spacing

S_1 30 cm
S_2 40 cm
S_3 50 cm
S_4 60 cm

The experiment was laid out as Randomized Complete Block Design (RCBD) with 3 replications. Different sowing dates were allotted to main plot and row spacing to sub plot. The area for experiment use was 132.22 m^2. There were 48 sub plots. The size of sub plot was 1.60m^2. Seeds were sown at distance of 8 cm. A fertilizer dose of 45-90-90 kg ha^{-1}of N, P_2O_5 and K_2O was given for getting better yield. Data collected were statistically analyzed for analysis of variance (ANOVA), which reflected the level of significance of treatments. The treatments which indicate statistical differences were further studied by comparing there performance. Results exhibiting significant differences were subjected to Least Significant Difference (LSD) Test for comparison of their means (Steel *et al*., 1997).

3. Results and discussion

The effect of different sowing dates and row spacing on the growth, seed yield and quality of off-season pea (*Pisum sativum* L.) was studied at village Kharick Rawalakot, Azad Jammu & Kashmir during the year 2010. The results collected on different parameters are presented in the Tables 1-15 for discussion. Before discussion we have to know how about temperature during the entire period of growth, because it is an important factor for off-season pea production. The average temperature in Rawalakot from April to August is given below.

Table 1
Average temperature in Rawalakot from April to August.

Month	Temperature
April	21.13 °C
May	25.91 °C
June	29.10 °C
July	27.50 °C
August	25.82 °C

3.1. Days to germination

The effect of different sowing dates on days to germination was significant. The maximum (15.90) days to germination were recorded in D_1 (20th April), while minimum (11.30) days to germination were taken in D_4 (4th June). Days to germination is an important factor for successful production of any crop including peas, which is affected by various factors including temperature etc. Pea is a cool season crop, can be grown at temperature ranges from 10-30˚C but prefers cooler temperature for its planting and germination, the minimum temperature for germination is about 10˚C and the optimum about 22˚C. It is sensitive to high temperature and drought stress (Baloch, 1994). While it shows non significant results for row spacing and interaction.

3.2. Plant height (cm)

The results showed that time of sowing had a significant effect on height of plants. The 5th May 2010 (D_2) attained maximum plant height (101.7cm) while 4th June 2010 (D_4) remained at the bottom with 70.88cm plant height. Height of plant depends on the plant vigor, period of development and temperature. It is obvious from the results that D_1 and D_2 showed maximum plant height. The plant height in early sowing was more due to more growing period and favorable temperature, in late sowing the growth period was short which affect the plant growth and hence minimum plant height was observed. It was reported that a delay in sowing from 10th May to 20th May or 10th June decreased plant height (Shaharia, 1992).

In row spacing significantly maximum plant height (93.8 cm) was in 30 cm row spacing while minimum (83.3 cm) in 60 cm row spacing. S_3 stood at par with S_4 because they are statistically non-significant with each other. In row spacing the space for plant spread was less and hence plant height increased. These results were also obtained by the earlier studies that the tallest plants from closer row spacing (Sharma, 2002).

Observation of the above Table showed that maximum plant height (101.6 cm) was observed in plants sown on 20th April at a distance of 50 cm (D_1 x S_3) while minimum plant height (70.83 cm) was measured in the plants of (D_4 x S_1) 4th June at 30 cm row spacing.

3.3. Number of branches plant^{-1}

Maximum number of branches plant^{-1} (2.306) were recorded in D_1 (20th April) while minimum number of branches plant^{-1} (1.111) in D_4 (4th June). Observation of results for various sowing dates showed that almost all sowing dates under study responded positively for number of branches plant^{-1}. Number of branches is usually dependent on vigor of the plants. The fact that D_1 presented great number of branches plant^{-1} reflected upon the findings that same treatment might have given better vigor. This has been also found by the data on height of plant. D_1 represented the 20th April of planting date. This is usual time for germination under Rawalakot conditions. Maximum branches in early sowing may be due to favorable temperature for growth. The growth of pea plant in early sowing was more due to more growing season and favorable temperature which may have helped in branching. These results were also in line with the earlier studies that reduced number of branches per plant with delay in sowing (Singh and Srivastava, 2002).

Results of table 2 revealed that maximum (2.728) number of branches per plant were counted in S_3 (50 cm) while at closer spacing S_1 (30 cm) less (1.169) number of branches per plant were recorded. The increase in number of branches in wider row spacing may be due to more space availability to plants to spread more rather to go straight due to which less number of branches per plant were counted in S_1 (30 cm). It is the reason that plant height in wider spacing was less and hence produced more branches while plant height in close spacing was more and produced less branches. Our results are supported by investigations that the 30 cm spacing resulted lowest number of branches per plant (Mondal *et al.*, 1993).

Maximum numbers of branches plant^{-1} (2.833) were counted in D_1 x S_3. Minimum numbers of branches plant^{-1} (1.090) were in D_3 x S_1. Number of branches depends upon the efficiency of plant to develop vegetative initials or primordias in the plant. Furthermore, it is the rate of development of these primordias that will determine the number of branches. Temperature plays an important role for bud initiation and development. That is why D_1 x S_3 produced more primordias which in turn developed more branches as compared to other interactions (sowing dates x row spacing).

3.4. Days to flowering

The maximum days to flowering (54.88) were recorded in D_1 (20th April) and minimum days to flowering (42.15) were in D_4 (4th June). There was no significant difference between D_1 and D_2 for days to flowering. Days to flowering are an important factor for seed yield of peas which are affected by various factors like temperature etc. "Pea cultivation is widespread in areas having a mild and warm climate, because relatively high or low temperatures are the most important factors limiting pea cultivation. A dry climate is also unsuitable for the plant, particularly during flowering and pod development" (Roques *et al.,* 1992), while, row spacing and interaction between row spacing and different dates of sowing shows non significant differences.

3.5. Days to pod formation

It is evident from the Table 7.1 that maximum day to pod formation (8.967) were recorded in D_1 (20th April) while minimum days to pod formation (5.358) were in D_4 (4th June). Observation of results for various sowing dates showed that almost all sowing dates under study responded positively for days to pod formation. D_1 stood at par with D_2 and are statistically alike. The days to pod formation is an important factor for successful seed production of peas which is affected by various factors including temperature etc. "Temperatures above 27°C shorten the growing period and adversely affect pollination. Peas can be grown successfully during midsummer and early fall in those areas having relatively low temperatures and a good rainfall, or where irrigation is practiced (Duke, 1981). Pea is a cool-season crop and grows best in cool weather with ample moisture. They don't do well in dry, hot weather. Hot weather interferes with the seed set and lowers the quality of pods (Baloch, 1994). That is why D_1 and D_2 were found to be better for days to pod formation. Whereas row spacing and interaction between row spacing and different dates of sowing shows no significant differences for days to pod formation.

3.6. Number of pods plant^{-1}

Above results showed that maximum number of pods plant^{-1} (13.55) were recorded in D_1 (20th April) while minimum numbers of pods plant^{-1} (7.767) were recorded in D_4 (4th June). Observation of results for various sowing dates showed that almost all sowing dates under study responded positively for number of pods plant^{-1}. D_1 stood at par with D_2 because they are statistically alike. The number of pods plant^{-1} depends on the vegetative growth, temperature and duration of development. Temperature was optimum for the plants sown on D_1 (20th April) and D_2 (5th May) due to which there was best vegetative and reproductive growth, that is why more number of pods plant^{-1} were recorded for these sowing dates. During the period of D_4 (4th June) temperature was high that is why it resulted in low production of pods. Same results have been reported (Bhat *et al.,* 2002; Shaharia, 1992) who found less number of pods per plant with delay in sowing.

Table 2 revealed that highest (12.28) number of pods per plant were obtained from the pea plants sown at 50 cm row spacing and number of pods decreased with decrease in row spacing and the minimum pods (9.320) per plant were obtained at 30 cm row spacing. This increase in number of pods per plant in wider row spacing may be due to vigorous plants, as in wider space, plant grew vigorously and produce more branches which resulted in high number of pods per plant. These results are in agreement with the results (Sharma, 2002) who reported highest pod number per plant in wider row spacing. With decrease in row spacing, the plant growth was also decreased which resulted in low pods production.

Interaction of sowing dates and row spacing also had a highly significant effect on number of pods per plant and the highest (13.43) number of pod per plant were obtained from the plants sown on 20th April at 50cm row spacing whereas minimum (5.338) number of pods per plant were obtained from plants sown on 4th June at 30cm row spacing.

3.7. Pod length (cm)

Table showed maximum (9.225 cm) pod length in D_1 (20th April) while minimum pod length (6.400) was in D_4 (4th June). Observation of results for various sowing dates showed that almost all sowing dates under study responded positively for Pod length (cm). The maximum pod length in early sowing may be due to favorable temperature for pod development, more number of ovules fertilized and also due to more vegetative growth as compared to late sowing where less number of ovules fertilized and plants were not vigorous. The arguments sponsored on the height of the plant can also be sponsored on the length of pods. These results are similar to the results that early sowing gave the longest pods (Sharma, 2002).

Means of table 2 shows that maximum pod length (8.478 cm) was recorded in S_3 (50 cm) while minimum pod length (6.298 cm) was measured in S_1 (30 cm). S_3 stood at par with S_4 because they are statistically alike. In wider spacing, the increase in pod length may be due to more vegetative growth of the plants. In closer row spacing vegetative growth was less which obviously affect the reproductive growth of the plants due to which minimum pod length was measured at 30 cm row spacing. Our results are supported by the investigations that the 30 cm spacing resulted lowest pod length per plant (Mondal *et al.,* 1993).

The interaction (sowing dates x row spacing) also showed the variation in pod length. The maximum (9.332 cm) pod length was measured by the peas sown on 20th April at a distance of 50 cm (D_1 x S_3). The minimum (6.165 cm) pod length was measured by the plants sown on 4th June at 30 cm row spacing (D_4 x S_1).

3.8. Number of seeds pod^{-1}

Observation of table showed that maximum number of seeds pod^{-1} (9.050) were in D_1 (20th April). Minimum number of seeds pod^{-1} (5.217) was in D_4 (4th June). “Pea plants may tolerate some high temperatures during vegetative growth, but flowering is initiated when plants are smaller. Pod and seed development is so rapid that quality and yield are reduced by high temperatures” (Duke, 1981). In early sowing of the plants temperature was optimum resulted in vigorous plants with long pods due to which more number of seeds pod^{-1} were observed in D_1 (20th April).

The different row spacing also showed variations in total number of seeds pod^{-1}. The maximum number of seeds pod^{-1}(9.00) were produced by the peas sown at 50 cm row spacing while less number of seed pod^{-1}(5.379) was recorded from the peas sown at 30 cm distance between rows. In wider rows plants have more space to grow vigorously and produced lengthy pods, which contained more seeds. The similar results shown that the number of seeds per plant decreased with increasing plant density (Aziz and Abdul, 1989).

Results of table 3 depicted that maximum numbers of seeds pod^{-1} (9.400) were recorded in D_1 x S_3 while minimum numbers of seeds pod^{-1} (6.067) were in D_4 x S_1. Observation of results for interaction showed that almost all (sowing dates x row spacing) interaction under study responded positively for number of seeds pod^{-1}. Same results have been reported that early sowing gave the highest number of seeds pod^{-1} (Bhat *et al.,* 2002).

3.9. Seed yield ha^{-1}

The maximum seed yield ha^{-1} (5.606 t) was recorded in D_1 (20th April) and minimum seed yield ha^{-1} (1.005 t) was in D_4 (4th June). This indicated that date of sowing had a significant effect on pea yield. D_1 stood at par with D_2 because they are statistically alike. On the basis of these findings it is recommended that the optimum or the best time of sowing for pea under Rawalakot conditions is D_1 (20th April) and D_2 (5th May). “As temperature rises during growing season, yield drops off rapidly. In New York, yields are highest when seeds are planted during first 2 weeks of April; for each 2-week delay in planting, yield of shelled peas decreased about 400 kg/ha" (Duke, 1981).

Maximum seed yield ha^{-1} (3.878 t) was recorded in S_3 (50 cm). Minimum seed yield ha^{-1} (3.321) was in S_4 (60 cm). S_2 stood at par with S_3 because they are statistically alike. In closer row, the number of plants per unit land was more but vigor of the plant was poor which resulted less number of pods and less seeds per pod. Though closer rows have more number of plants per plot but due to less space the plants can not grow vigorously and produce less number of pods and small size seed. Shaharia (1992) in his report also stated that a delay in sowing from 10th May to 20th May or 10th June decreased seed yield ha^{-1}.

Maximum seed yield ha^{-1} (6.220 t) was in recorded in the plants sown on 20th April at 50 cm distance between rows (D_1 x S_3). The minimum seed yield ha^{-1} (0.9600 t) was observed in the plants which were sown on 4th June at 30 cm row spacing (D_4 x S_1). Observation of results for interaction showed that almost all the study responded positively for seed yield ha^{-1}.

3.10. Protein contents (%)

The maximum protein contents (21.10%) were recorded in D_1 (20^{th} April). Minimum protein contents (18.13%) were found in D_4 (4^{th} June). Observation of results for various sowing dates showed that almost all sowing dates under study responded positively for protein contents. D_1 stood at par with D_2 because they are statistically alike similarly D_3 stood at par with D_4. Temperature for the plants sown on D_1 (20^{th} April) and D_2 (5^{th} May) was optimum which helped out in getting good quality of pea seeds with maximum protein contents. Temperature was high for the growth and development of D_3 and D_4 plant due to which their period of development was shorten which resulted in the reduction of protein contents. While non-significant results were found for row spacing and interaction.

3.11. Total sugar (%)

Observations for total sugar percentage show non-significant differences among sowing dates, row spacing and interaction.

3.12. Vitamin C (mg/100ml)

Observations for Vitamin C (mg/100ml) content show non-significant differences among sowing dates, row spacing and interaction.

3.13. pH

Observations for pH show non-significant differences among sowing dates, row spacing and interaction.

Table 1.1
Means of sowing dates.

Treatments	Days to germination	Plant height (cm)	Number of branches plant^{-1}	Days to flowering	Days to pod formation	Number of pods plant^{-1}
D_1 (20^{th} April)	15.90^{a}	99.63^{a}	2.306^{a}	54.88^{a}	8.967 ^{a}	13.55^{a}
D_2 (5^{th} May)	15.43^{a}	101.7^{a}	1.433^{b}	53.24^{a}	8.783 ^{a}	12.32^{ab}
D_3 (20^{th} May)	13.66^{b}	83.80^{b}	1.392^{b}	46.01^{b}	6.984 ^{b}	11.00^{b}
D_4 (4^{th} June)	11.30^{c}	70.88^{c}	1.111^{c}	42.15^{c}	5.358 ^{c}	7.767^{c}

Table 1.2
Means of sowing dates.

Treatments	Pod length (cm)	Number of seeds pod^{-1}	Seed yield ha^{-1} (tons)	Protein contents (%)
D_1 (20^{th} April)	9.225 a	9.050 a	5.606 a	21.10 a
D_2 (5^{th} May)	8.689 b	9.042 a	5.592 a	20.96 a
D_3 (20^{th} May)	7.033 c	7.175 b	2.409 b	19.59 b
D_4 (4^{th} June)	6.400 d	5.217 c	1.005 c	18.13 c

Table 2
Means of row spacing.

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	Seed yield ha^{-1} (tons)
S_1 (30 cm)	93.8 a	1.169 c	9.320 c	6.298 c	5.379 c	3.321 b
S_2 (40 cm)	89.1 b	1.467 b	11.18 b	7.003 b	6.213 b	3.348 b
S_3 (50 cm)	84.6 c	2.767 a	12.28 a	8.478 a	9.000 a	3.878 a
S_4 (60 cm)	83.3 c	2.628 a	12.18 a	8.335 a	8.998 a	3.764 a

Table 3
Means of Interaction (A x B)

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	Seed yield ha^{-1} (tons)
$D_1 S_1$	90.73 d	1.400 ef	9.44 cd	7.001 e	8.333 d	5.037 f
$D_1 S_2$	94.33 c	1.923 c	10.40 c	8.633 d	8.701 c	4.957 e
$D_1 S_3$	101.6 a	2.833 a	13.43 a	9.332 a	9.400 a	6.220 a
$D_1 S_4$	98.13 b	2.267 b	12.84 a	9.321 a	9.033 c	6.130 ab
$D_2 S_1$	91.17 d	1.100 g	9.920 c	8.113 c	8.317 d	5.200 d
$D_2 S_2$	94.09 c	1.500 de	9.280 cd	7.538 d	9.000 c	5.517 c
$D_2 S_3$	98.16 b	2.789 a	13.34 a	9.332 a	9.067 b	5.897 b
$D_2 S_4$	98.23 b	2.253 b	11.93 b	8.711 b	9.033 b	5.833 b
$D_3 S_1$	84.05 f	1.090 g	6.006 e	7.131 e	7.537 f	2.267 h
$D_3 S_2$	78.67 h	1.120 g	6.889 e	6.660 f	7.910 e	2.560 g
$D_3 S_3$	81.33 g	1.133 g	5.778 ef	7.122 e	7.133 g	2.420 gh
$D_3 S_4$	87.31 e	1.100 g	5.738 ef	7.163 f	7.933 g	2.390 gh
$D_4 S_1$	70.83 j	1.433 f	5.338 f	6.165 g	6.067 i	0.9600 i
$D_4 S_2$	75.35 i	1.400 ef	5.531 f	7.047 e	6.730 h	1.047 i
$D_4 S_3$	81.01 g	1.400 ef	5.433 f	7.167 f	6.639 h	0.9767 i
$D_4 S_4$	84.67 f	1.600 d	5.420 f	7.123 e	7.167 g	1.37 i

- In sowing dates D_1 (20th April) and D_2 (5th May) gave best results for germination percentage, plant height, number of branches plant^{-1}, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, seed yield ha^{-1} and protein contents.
- In row spacing S_3 (50 cm) gave more number of branches plant^{-1}, number of pods plant^{-1}, pod length, number of seeds pod^{-1} and seed yield ha^{-1}.

Therefore, the best time for off-season pea production under Rawalakot condition is the last week of April to 1st week of May at 50 cm row spacing. However, it is recommended that further studies should be carried to check the findings during the late June to July.

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