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DETERMINATION OF THE YIELD PERFORMANCE AND HARVESTING PERIODS OF FIFTEEN PEA (*PISUM SATIVUM* L.) CULTIVARS SOWN IN AUTUMN AND SPRING

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Abstract

This research was conducted in Samsun, Turkey during 1999-2000 and 2000-2001 to determine the performance of 15 pea cultivars sown in autumn and spring. The study was designed with split plot in randomised complete blocks design with 3 replications. The two sowing times were allocated to main plots and 15 cultivars to subplots. The combined years showed that sowing time was statistically significant for all the observed characteristics (plant height, pods per plant, seeds per pod, 1000 seed weight, seed yield). Autumn sowing showed higher values for all characteristics, except seed number per pod. Dry seed yield was 2124 kg ha^{-1} for autumn sowing compared to 1646 kg ha^{-1} for spring sowings. All the observed characteristics showed statistical difference among cultivars. Dry seed yields varied between 1328 and 2724 kg ha^{-1}. Highest dry seed yield was obtained from Bolero. Bolero, Agromar AG 7306, Feltham First, Jumbo, Sprinter, Sugar Bon and Vilmoren which are recommended for sowing in autumn, particularly for their high seed yield which can be greater than 2000 kg ha^{-1}. Agromar AG 7306, Vilmoren and Jumbo didn't respond to change of sowing time.

Introduction

Peas are important grain legumes. Dry pea cropping has major advantages in sustainable farming systems because of it's low requirement for water, chemicals and fossil energy; ability to symbiotically fix atmospheric nitrogen which precludes the need for N-fertilizer; and reduced emissions of N_2O, NOx and CH_4, which, in addition to CO_2 savings, significantly reduce the greenhouse effect of agricultural activities (Munier-Jolain & Carrouee, 2003). 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 (Anon., 2004)**.** The majority of both sowing area and production of peas is concentrated in the developed countries. Fresh seed and pea pods can be used as a fresh vegetable or as a conserved, frozen product; dry seed as food; hay feed for animals and green fertilizer. In Turkey, peas are sown on 1100 ha and 2500 tons of seed is obtained annually (Anon., 2004). Despite the limited sowing area, there is widespread consumption in Turkey.

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. Cumulative mean temperature requirements for floral initiation varied and this data could be used to decide sowing dates for different cultivars (Roques *et al*., 1992). Dry periods substantially decrease yields (Ozdemir, 2002). Yield can be increased by early sowing and the use of the seeds of early flowering and maturing cultivars in production (Dumolin *et al*., 1996). However, another important factor determining the sowing time and cultivar is the required product. A study carried out in Samsun, Turkey revealed that winter sowing was more suitable for high dry seed yield and early spring sowing for canned food production (Gulumser *et al*., 1994).

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A sowing time study carried out in Konya, Turkey revealed that early sowing increased seed and protein yield. In that study, Jof (147.44 kg da^{-1}), Sprinter (143.45 kg da^{-1}) and Bolero cv. (127.9 kg da^{-1}) produced statistically more than Karina (Ceyhan & Onder, 1999). Belcher (1999) evaluated winter and spring pea cultivars sown in autumn and spring over three years at Thornhaugh in the UK. The winter cultivars produced significantly higher yields when autumn sown but yields were severely reduced by spring sowing. Autumn plantings lead to earlier maturity, but by only 7 days on average over all cultivars and years. Sharma (2002) investigated the effect of sowing date (15 October, 30 October, 15 November and 30 November) on pea seed yield (cv. Arkel) in India during three winters. Sowing on 30 October gave the tallest plants (88.2 cm), the highest pod number per plant (14.0), pod length (7.4 cm), seed number per pod (6.8), seed yield (9.1 q ha^{-1}) and 100-seed weight (20.1 g). During a 3 year study conducted with 71 genotypes in France, 3.71- 7.81 tonnes ha^{-1} yield was obtained. In this study, seed yield and pod number per plant was a highly significantly correlated (Doré *et al*., 1998). Nayak & Baisakh (1990) investigated yield structure in peas during 1987-88 in India. Plant height and number of primary branches/plant had the greatest direct effect on pods/plant and seeds/pod, while all 4 characters had the greatest direct effect on yield.

Generally cereals are sown in winter in Samsun. As the harvesting of the cereal crop continues until July, it delays the harvesting time of the following crop. On the other hand there arise some problems related with the harvesting of this crop out of the shortness of vegetation. Pea is a plant suitable for rotation with cereals in Samsun region. Moreover, as it is a cool-season legume it can be harvested early as a fresh crop or a dry seed crop enabling the sowing of a summer crop afterwards. In addition, pea cultivation can contribute to the development of the agricultural industry because of its wide range of uses. Peas have traditionally been grown in the Black Sea region in small plots for the requirements of farmer families. However, this region has great potential for commercial pea cultivation. To facilitate this process, suitable cultivars and sowing times need to be determined. Taking all these factors under consideration, this study was carried out to determine the compatibility and seed yield performances of 15 pea cultivars sown in autumn and spring.

Materials and Methods

The study was conducted in the experimental area of the Black Sea Agricultural Research Institute in Gelemen, Samsun during the growing seasons of 1999-2000 and 2000-2001. For both years, soil texture was clay, high in posphorus and potassium, medium in organic matter and without lime and salt. The soil was slightly alkaline in the first year and neutral in the second year.

Total rainfall and temperature data for both experiment years and the long term period are shown in Figures 1 and 2. Monthly total rainfall for each year was significantly different from that of the long term. In the first year, through to the end of dry pod harvest, the total precipitation was 563 mm for autumn sowings and 183.2 mm for spring sowings. In the second year, these values were 354.6 and 154.9 mm, respectively. In the first year of the experiment, rainfall was higher in the first three months of the year than in same period of the second year. In the growing period, average monthly temperature was 11ºC in the first year and 15ºC in the second. The average monthly temperature was similar for the two years, except for January.

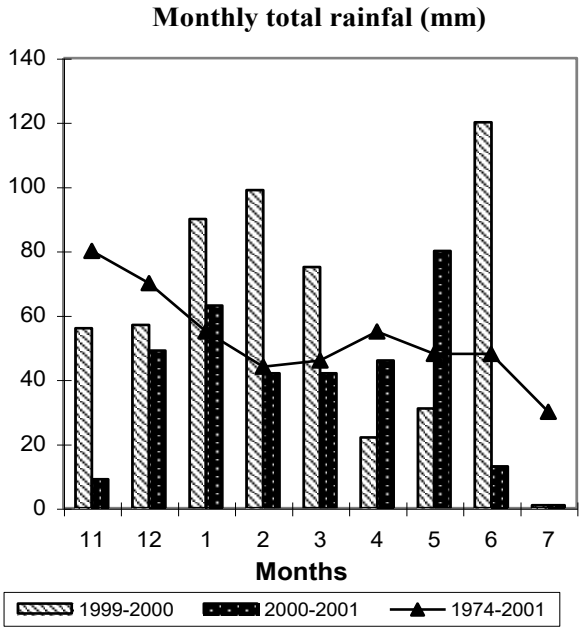

Fig. 1. Monthly total rainfall (mm) in experimental area.

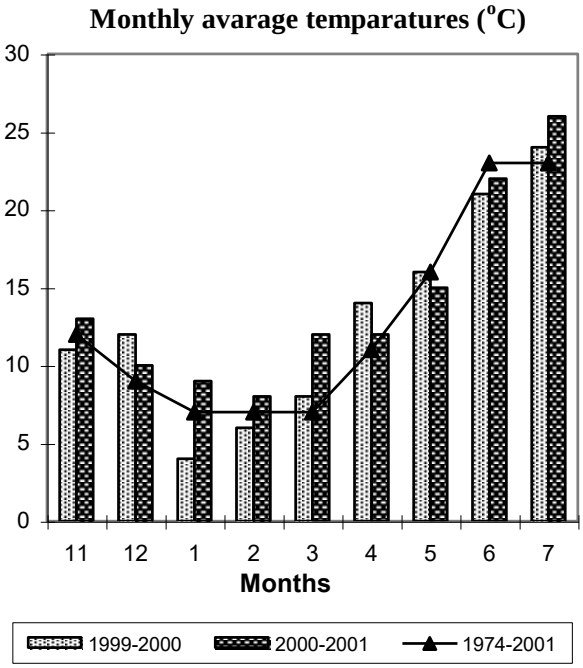

Fig. 2. Monthly average temperature (°C) in experimental area.

Seven pea cultivars (Lancet, Progress No.9, Klein Rheinlanderin, Sugar Bon, Karina, Erbse Norli, Kelvedon Wonder) obtained from abroad and 8 pea cultivars (Sprinter, Agromar AG 7306, Green Pearly, Vilmoren, Bolero, Feltham First, Jumbo, Jof) from local seed firm were evaluated.

Experiments were laid in a split plot design in randomized complete blocks with 3 replications. Autumn and early spring sowing was allocated to the main plots and pea cultivars to the subplots. The first year autumn sowings were on November 12, 1999 and spring sowings were on March 28, 2000. For the second year, these dates were November 11, 2000 and March 12, 2001 respectively. Row spacing was 40 cm, with 5 cm between plants and five rows per plot. The complete experiment area was fertilized at the time of sowing with 60 kg of P_2O_5 ha^{-1} and 40 kg of N ha^{-1}. Weeds were removed with a hoe during the cultivation period. Fifteen plants were chosen randomly from each plot for analysis. For both years, harvesting was done on different dates to coincide with the maturation time of the plants. Analysis of correlation and variance using the MSTATC program was performed after the data was combined over the years. Duncan's multiple range test was used in the grouping of characteristics that were found to be significant.

Results and Discussion

Average values of plant height, number of pods per plant and seeds per pod are shown in Table 1. The effect of sowing time on plant height was highly significant ($p<0.01$). Average plant height of autumn sowing (56.4 cm) was greater than for the spring sowing (50.6 cm). Between autumn and spring sowing dates, there were 135 days in the first year and 120 days in the second year. This much longer growing period contributed to greater plant height in autumn sowing such similar results have been reported by Sharma (2002).

Differences among the pea cultivars in terms of plant height were significant ($p<0.01$). The greatest plant heights were measured in the Vilmoren (64.7 cm) and Agromar (64.5 cm) cultivars. On the contrary, Progress No.9 (44.9 cm), G. Pearly (45.0 cm) and Karina, E. Norli and K. Rheinlanderin (45.1 cm) cultivars constituted the shortest group. Sehirali (1988) reported variation of plant height from 20 to greater than 200 cm. In another study to determine the effect of different planting dates on growth and yield of different pea cultivars in Pakistan, maximum height was obtained at earlier sowing (Tyagi & Srivastava, 2002).

For most of the cultivars, height of plants sown in autumn was greater than in spring. Plants suppressed as seedlings through the winter entered a rapid growth period with the beginning of spring. On the other hand, plants sown in spring suffered a relative loss of time during these early months for germination and seedling growth. Towards the end of spring, increased day length and temperature initiates the generative period. This causes a slowing down of plant growth. Therefore the plants, that come through winter in a healthy condition, grow better than those sown in spring. Thus positive and significant correlations were found between plant height and pods per plant ($r=0.554^{**}$), seeds per pod ($r=0.281^{*}$) and seed yield ($r=0.538^{**}$).

There was a significant difference ($p<0.05$) in cultivar x sowing time interaction with plant height. Agromar (74.4 cm) and Vilmoren (73.9 cm) were the highest for the autumn sowings. Jumbo (56.5 cm) was the highest for the spring sowing, followed by Vilmoren (55.4 cm), Agromar (54.5 cm) and Jof (54.4 cm). Karina, F. First, Kelvedon and Progress no.9 cultivars' were higher in spring sowing than autumn sowing (Table 1). Despite autumn sowing's longer growing period, these cultivars were negatively effected by low temperature (Fig. 2) from sowing date to early spring and their growth was permanently slowed.

Table 1. Average values of plant height, pods per plant and seeds per pod of pea cultivars sown in autumn and spring.

Cultivars	Plant height (cm)		Mean**	Pods per plant		Mean**	Seeds per pod		Mean**
	Autumn*	Spring		Autumn**	Spring		Autumn*	Spring	
Agromar	74.4 a	54.5 b-h	64.5 a	10.5 cde	6.4 g-k	8.4 c	5.59 h-k	6.78 a-f	6.18 bcd
Bolero	61.7 bcd	53.6 b-h	57.6 bc	16.3 a	9.0 d-h	12.7 a	6.43 b-i	6.95 a-e	6.69 ab
Karina	43.1 i-l	47.0 f-l	45.1 e	8.5 d-j	7.0 f-k	7.8 cd	5.95 e-k	6.27 b-j	6.11 bcd
E. Norli	48.7 f-l	41.4 jkl	45.1 e	9.4 d-g	6.5 f-k	9.3 cd	5.58 h-k	5.33 jk	5.46 d
F.First	48.1 f-l	52.4 c-i	50.3 de	12.9 bc	8.5 d-j	7.9 ab	6.48 b-h	7.18 ab	6.83 ab
G. Pearly	49.1 f-l	40.9 kl	45.0 e	7.2 e-k	5.0 k	6.1 de	5.11 k	6.48 b-h	5.79 cd
Kelvedon	51.5 f-l	52.5 c-i	51.9 cd	5.8 h-k	5.1 jk	5.5 e	5.67 g-k	5.27 j-k	5.47 d
Kleine R.	45.9 g-l	44.2 h-l	45.1 e	9.1 d-h	5.2 ijk	7.2 cde	6.09 d-k	6.17 c-j	6.13 bcd
Lancet	60.9 bcd	52.8 c-i	56.9 bcd	15.2 ab	7.4 d-k	11.3 a	6.43 b-i	6.80 a-f	6.62 abc
Jof	63.6 b	54.4 b-h	58.9 ab	10.7 cd	6.6 f-k	8.7 bc	7.05 a-d	7.73 a	7.39 a
Jumbo	61.8 bc	56.5 b-f	59.1 ab	9.8 def	6.4 d-k	8.1 cd	5.55 h-k	6.63 b-g	6.09 bcd
Progress	39.3 l	50.5 e-k	44.9 e	7.5 d-k	5.8 h-k	6.6 cde	5.12 k	5.82 f-k	5.47 d
Sprinter	60.1 b-e	53.4 c-h	56.7 bcd	13.9 ab	8.6 d-i	11.3 a	7.18 abc	7.13 abc	7.15 a
Sugar Bon	63.6 b	49.2 f-l	56.4 bcd	15.9 ab	6.3 g-k	11.1 a	6.92 a-e	6.78 a-f	6.85 ab
Vilmoren	73.9 a	55.4 b-g	64.7 a	12.9 bc	8.2 d-k	10.6 ab	5.94 e-k	5.43 ijk	5.69 d
Mean	**56.38 a****	**50.59 b**		**11.05 a****	**6.82 b**		**6.07 b**	**6.45 a***	

* = Significant at 0.05 level and ** = Significant at 0.01 level

The effect of sowing time on pods per plant was significant ($p<0.01$). Pods per plant in autumn sowing (11.0) was greater than that in spring sowing (6.8). There was a significant difference ($p<0.01$) among cultivars for pod numbers. Pods per plant ranged from 5.5 to 12.7. Bolero (12.7), Lancet and Sprinter (11.3) and Sugar Bon (11.1) were highest and Kelvedon (5.5) was the lowest. In studies carried out in different ecological regions of the world, the highest number of pods per plant was 14 (Sharma, 2002) and 15.1 (Peksen *et al*., 2004). Peksen *et al*., (2004) recommended autumn sowing in the Samsun region because it gave greater yields than spring sowing. For the number of pods per plant, a highly significant interaction was established between cultivar and sowing time. Bolero was ranked first with 16.3 pods per plant for autumn sowing. For the spring sowing, Bolero was again the first, followed by Sprinter (8.6), further. First (8.5) and Vilmoren (8.2), respectively. G.Pearly (5.0) formed the least pods per plant. Number of pods per plant, which has a positive and very significant relationship with yield in the grain legumes (Nayak & Baisakh 1990; Dore *et al*., 1998; Tyagi & Srivastava 2002), varies between cultivars because of genetic effects. However, cultivation conditions and environment can also influence characteristics. The greater number of pods per plant in autumn sowing was direct related to plant height. A positive and significant correlation ($r=0.554$**) was established between plant height and pods per plant. In a similar study conducted in Samsun, pods per plant varied between 10.2 and 15.5 (Gulumser *et al*., 1994). Pods per plant for spring sowing decreased to 12-61% among cultivars when compared to autumn sowing in this study.

Kelvedon and K. Rheinlanderin, having lower number of pods per plant, showed the least response to the change of sowing time for pods per plant. On the other hand, cultivars having a greater number of pods per plant exhibited a difference in pods per plant attributable to the change in sowing time. Peas sown in autumn have a long growing period and extending the growing period allows better vegetative growth and increases the total dry matter production (Peksen *et al*., 2004). Temperature exceed 10^{o}C for flowering initiation in two years and well distrubuted rainfall caused to an increase in pod setting. Peksen *et al*., (2002), in a study in the Samsun region, found that autumn sowing significantly affected some characters compared to spring sowing. This study produced a similar results.

There were more seeds per pod (6.4) in spring sowing than in autumn sowing (6.1). The effect of sowing time on seeds per pod was significant ($p<0.05$). There was also a highly significant difference ($p<0.01$) among cultivars. Seeds per pod ranged from 7.4 (Jof) to 5.5 (E. Norli, Kelvedon and Progress No.9). The interaction between cultivar and sowing time was significant ($p<0.05$) for seeds per pod. Sprinter with (7.2) in autumn sowing and Jof (7.7) in spring sowing were ranked first. Seeds per pod is highly heritable, but is subject to the effects of environmental factors during the fertilisation and pod setting period. The fact that climate and growing conditions were appropriate for pea cultivation in both years allowed the cultivars to demostrate their genetic potential. Seeds per pod were fewer in autumn sowing than spring sowing. The greater number of flowers in autumn sowing makes it more difficult for all of them to be pod setting and seed formation. This gives rise to a relatively smaller number of well developed seeds. Similar results have been obtained in studies conducted in the same region (Gulumser *et al*., 1994; Peksen *et al*., 2002, 2004), hence confirming the current results. This was so for the correlation between seeds per pod and seed yield ($r=0.227$). On the other hand, a negative and very significant relationship between number of seeds per pod and 1000-seed weight was found ($r= -0.277*$).

Average values of seed yield, 1000-seed weight and harvesting time of the 15 pea cultivars sown in autumn and spring are shown in Table 2. The effect of sowing time on seed yield was highly significant ($p<0.01$). Seed yield from autumn sowing (2124 kg ha^{-1}) was higher than for spring sowing (1646 kg ha^{-1}) (Table 2). Seed yield was considerably less in spring sowing when compared with autumn sowing. Similar results have been obtained in studies from different regions of the world (Silim *et al*., 1985; Dumolin *et al*., 1996; Gulumser *et al*., 1999; Belcher 1999; Peksen *et al*., 2002).

Seed yield was also affected by the different cultivars ($p<0.01$). Bolero had the highest yield with 2724 kg ha^{-1}, followed by Vilmeron with 2614 kg and Agromar with 2239 kg ha^{-1}. Lowest seed yields were from E. Norli (1328 kg), Karina (1387 kg ha^{-1}), G.Pearly (1402 kg ha^{-1}) and Kelvedon (1426 kg ha^{-1}) (Table 2). The results obtained by Ceyhan and Onder (1999) for seed yield of Jof, Bolero and Karina were similar to this study. There was a highly significant ($p<0.01$) interaction between cultivar and sowing time. The highest seed yield was obtained from Bolero (3922 kg) and Vilmoren (3027 kg) when sown in autumn. Vilmoren (2201 kg), Bolero (2157 kg) and Agromar (2095 kg) exhibited the highest yield for spring sowing. Yield, which is the most important characteristic for the breeder and the producer, is evaluated under the categories of fresh pod and fresh seed, dry seed and stem yield for plants like pea. Correlation analysis showed positive relationships as follows: seed yield and plant height ($r=0.538**$), seed yield and pods per plant ($r=0.655**$), seed yield and seeds per pod ($r=0.227$) and seed yield and weight of 1000 seeds ($r=0.179$). Tiwari et al. (2001) generated similar results. Seed yield/plant exhibited a significant and positive correlation with plant height, number of pods/plant, 1000-seed weight, number of seeds/pod and harvest index. Autumn sowing increased yield in comparison with spring sowing. For the average seed yield for the two years and all pea cultivars, a decrease of 478 kg ha^{-1} (2124 kg ha^{-1} to 1646 kg ha^{-1}) in spring sowing compared to autumn was observed. This result arises from the fact that plants sown in autumn have a longer vegetative period. As can also be seen for maturation period, plants maturing over a longer period perform better for yield than those maturing in a shorter period. The results obtained by Belcher (1999), Ceyhan & Onder (1999), Gulumser *et al*., (1994), Peksen *et al*., (2002), Sharma (2002) for seed yield are in agreement with this study.

There was no significant difference between sowing times for 1000 seed weight. The average weight for autumn sowing was 212.9 g, while this value was 214.7 g for the spring sowing (Table 2). Highly significant differences ($p<0.01$) were observed among the cultivars for this character. The 1000-seed weight ranged from Jof (290.0 g) to Sugar Bon (149.6 g). Progress no: 9, G.Pearly, Vilmoren and Agromar were statistically grouped with Jof (Table 2).

A shorter maturation period and productivity of a crop in a region are important factors for early presentation to the market and leaving sufficient time for the sowing of another crop. Peas reach the generative period and harvest maturity early because they tolerate lower temperatures. Under Canadian conditions, peas needed a total temperature of 1200-1500ºC for full maturity (Zanstra & Squire, 2000). The ideal temperature for the accumulation of dry material in seed was 21-23ºC (Sehirali, 1988). This temperature coincides with late spring or the beginning of summer in the Samsun area (Fig. 2). Time to harvest, which was 223.8 days for autumn sowing, fell to 96.5 days for spring sowing. This difference in time to dry seed harvesting was statistically significant ($p<0.01$). There was difference of 23 days among cultivars in harvesting period. The average growing period for the cultivars varied between 149.7 and 172.9 days (Table 2). The shortest harvest period belonged to Karina, whereas Vilmoren had the longest. The harvesting time for spring sowing lasted until the third week of June while harvest was completed made in the second week of June for autumn sowing. In effect, there was a time differential of 10 days between the two sowing times. Cervato (1984) in experiment on different sowing of pea in Italy that the autumn sowing of certain pea cv. showed that harvesting can take place 8-10 days earlier from spring sowing. This difference may be attributed to climatic conditions and cultivars.

Table 2. Mean of 1000-seed weight, seed yield and harvesting time of pea cultivars sown in autumn and spring.

Cultivars	1000-Seed weight (g)		Mean**	Seed yield (kg ha^{-1})		Mean**	Harvesting time (day)		Mean**
	Autumn	Spring		Autumn**	Spring		Autumn**	Spring	
Agromar	271.4	257.6	264.5 a	2385 bc	2095 b-f	2239 abc	230.5 bc	108.0 g	169.2 b
Bolero	179.8	168.3	174.1 cd	3922 a	2157 b-e	2724 a	225.0 d	97.5 h	161.2 cd
Karina	176.5	175.7	176.1 cd	1444 h-k	1330 ijk	1387 e	213.2 f	86.1 j	149.7 f
E. Norli	176.6	174.8	175.2 cd	1649 d-j	1006 k	1328 e	216.7 ef	86.3 j	151.5 ef
F.First	178.9	183.4	181.2 c	2352 bc	1828 c-i	2089 cd	226.3 cd	98.5 h	162.4 c
G. Pearly	288.2	268.0	278.1a	1308 ijk	1495 f-k	1402 e	224.5 d	97.0 h	160.8 cd
Kelvedon	198.8	219.2	209.0 b	1718d-j	1135 jk	1426 e	218.0 e	90.2 ij	154.1 e
Kleine R.	213.9	222.9	218.4 b	1884 b-i	1301 ijk	1592 de	215.2 ef	87.7 ij	151.4 ef
Lancet	173.6	174.8	174.2 cd	2070 b-g	1656 d-j	1863 cde	227.0 cd	99.3 h	163.2 c
Jof	171.9	182.8	177.4 cd	2036 b-h	1676 d-j	1856 cde	217.5 ef	91.0 i	154.2 e
Jumbo	295.5	286.2	290.9 a	2358 bc	2027b-h	2193 bc	233.0 ab	105.8 g	169.4 b
Progress	275.9	291.4	283.7 a	1461 g-k	1562 e-k	1511 e	222.7 d	95.2 h	158.9 d
Sprinter	174.4	179.9	177.2 cd	2483 b	1896 b-i	2189 bc	224.8 d	97.8 h	161.3 cd
Sugar Bon	136.0	163.1	149.6 d	2403 bc	1321 ijk	1862 cde	225.7 d	98.3 h	162.0 cd
Vilmoren	281.9	271.9	276.9 a	3027 a	2201bcd	2614 ab	236.8 a	109.0 g	172.9 a
Mean	**212.9**	**214.7**		**2124 a****	**1646 b**		**223.8 a****	**96.5 b**	

* = Significant at 0.05 level and ** = Significant at 0.01 level

Conclusions

In the Samsun region, peas are traditionally grown on small areas to satisfy family needs. This study highlighted autumn sowing advantages and suitable cultivars for Samsun conditions. It can also contribute to increased pea sowing in this region if economic conditions are conducive.

According to the results, autumn sowing increased seed yield significantly and provided earlier harvest. Therefore, autumun sowing is indicated for this region for dry seed cultivation. Bolero and Vilmoren cultivars had the highest yield and are therefore reccommended. Agromar, F. First, Jumbo and Sprinter can also be recommended because their dry seed yields are over 2000 kg ha^{-1} in autumn sowing. Agromar, Jumbo and Vilmoren did not exhibit much difference in yield between sowing times. They appeared to have stability against changing environmental parameters. If sowing date is not critical, these cultivars can be grown.

Taking into consideration the higher level of humidity due to precipitation, choosing cultivars like Agromar and Jumbo which grow vertically may reduce the risk of disease for autumn sowing. Further studies are recommended to determine the best agronomic practices and the economic viability of pea growing as a commercial crop in the Samsun region. A commercially viable industry may be dependent on both fresh product and preserved product markets. Processing facilities would increase the confidence of growers to invest in the opening of industry and support for its long term viability.

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