Selcuk Journal of Agriculture and Food Sciences SJAFS
http://sjafs.selcuk.edu.tr/sjafs/index
(2022) 36 (3), 428-437
e-ISSN: 2458-8377
DOI:10.15316/SJAFS.2022.057
Research Article

Effect of Temperature and Storage Time on Germination in Forage Peas**

Cafer TÜRKER[1,*], Ahmet TAMKOÇ[2]
[1]Selçuk University, Faculty of Agriculture, Department of Field Crops, Konya, Türkiye
[2]Ilgaz Directorate of Provincial Agriculture and Forestry, Çankırı, Türkiye

ARTICLE INFO

Article history:
Received date: 01.11.2022
Accepted date: 11.11.2022

Keywords:
Field pea
Germination
Root length
Temperature
Thousand seed weight

ABSTRACT

This research was carried out in 2016 in order to determine the most suitable germination temperatures of the seeds of 4 different forage pea varieties (Furkan, Bilgehan, Özkaynak, Taşkent) stored in paper bags for 7 years and 8 years at room temperature, and the damage that may occur on plants at subzero temperatures after germination were carried out. In the experiment, which was established with 4 replications in the "Random Plots in Factorial Experiment Design" under laboratory conditions; Number of germinated seeds on the 4th, 7th and 10th days at 5°C, 15°C, 25°C and 35°C temperatures, and after the 10th day, frost damage in plants kept at -5°C for 3 days, root length, stem length, root length/stem length ratio was determined. According to the findings of the research, while the best germination took place at 25°C, the most suitable germination temperature was determined between 15°C and 25°C. In addition, it was revealed that the seeds produced in 2008 germinated more than the seeds produced in 2016. On the other hand, among the plants kept at -5°C, it was determined that the varieties named Taşkent and Özkaynak, which were germinated at 15°C and 25°C, suffered the least damage, and the highest average in the comparison of the total height values was found in the Taşkent variety germinated at 25°C.

1. Introduction

With the rapid increase in the world population, animal and vegetable products, which are of great importance in meeting the food needs of people, are of great value for our country's economy. Proteins, which have a very important place in nutrition, should be taken as approximately 1 gram per kilogram of human live weight. About half of this protein can be consumed as vegetable and the other half as animal. At this point, it is known that there are production problems in the consumption of animal protein and consumption problems arise along with it. The basis of these problems is animal production and we can list many sources of this situation.

In Turkey, agricultural areas planted every year are approximately 15.5 million hectares. Forage crops can be produced only in 2.7 million hectares of this. If forage crops are produced and applied to the rotation system every four years, it will be possible to increase the amount of forage crops planted area to approximately 4 million hectares. It may be possible to increase the yield of pastures by 25-50% on average with forage crops breeding and pasture improvement and method. In particular, abandoned agricultural areas are approximately 4 million hectares and should be reintroduced to agriculture through artificial pastures. In addition, artificial meadows and pastures should be encouraged and supported by the Ministry. Forage crops should be encouraged as a secondary crop in irrigated farming areas. Production supports should be given to feed crop producers and livestock enterprises that make contracts with feed producers. Approximately 8 million hectares of forest pastures and bushes, which are considered forest areas, should be transformed into goat pastures that make good use of the bushes. It is a fact that if the increase in our sheep and goat population continues at this rate and our pastures are not rehabilitated, we will face very heavy erosion damage (Tamkoç, 2017).

With this study, it is aimed to prevent our farmers from harming with the data that can minimize the problems experienced in the cultivation of forage crops. In the study, errors in agricultural practices can be minimized by determining the appropriate planting times and temperatures, and the appropriate stem length that can

*Corresponding author email: *caferturker0606@hotmail.com*
**This article is summarized from Cafer TÜRKER's master's thesis ("YÖK" thesis number: 577444).

be caused with the least damage from winter in the results obtained with the seeds of winter forage peas (field pea for feding animals) germinated at different temperatures. In addition, it is aimed to prevent seed waste by evaluating the usability of old seeds by considering the germination status of old and new seeds.

2. Materials and Methods

In this study, Bilgehan, Furkan, Özkaynak and Taşkent registered varieties of forage pea (*Pisum arvense* L.) obtained fromSelcuk University Faculty of Agriculture, Field Crops Department were used as plant material. Furkan, Özkaynak, and Taşkent forage pea seeds are a product of 2008 (old) and 2016 (new), and Bilgehan variety is a product of 2009 (old) and 2015 (new). These seeds were kept in paper bags and at room conditions. Agricultural perlite was used as germination medium. The density of the perlite used is 70-80 kg m3, the grain diameter is 0-6 mm, the melting point is 1200°C, the chemical composition is SiO_2 74%, Al_2O_3 14%, Na_2O 3%, K_2O 5%, MgO 0.5%, CaO 0.05%, Fe_2O_3 1% and pH value between 6.5-7.5. 5%. Sodium hypochlorite (bleach, chlorine-based bleach) was used as disinfectant and commercial packaged water with pH 7.57 was used as water.

This research was carried out in the Climate Rooms of the Department of Field Crops, Faculty of Agriculture, Selcuk University in 2016.

Seeds of forage pea varieties used as material in the study were divided into two groups as old and new seeds. Each replication of old and new seeds consisted of 25 seeds and was arranged as 4 replications in randomized plots design (Düzgüneş et al., 1987). Forage pea seeds were chosen randomly from healthy seeds. Then, the seeds that would form each replication were kept in 5% sodium hypochlorite solution for 5 minutes and rinsed with commercially packaged water. 100 ml of agricultural perlite and 80 ml of commercially packaged water were added into half-liter glass jars with lids to be planted. The disinfected seeds were sown evenly on the growing medium filled with agricultural perlite and water. 2 drops of 5% sodium hypochlorite were added to each liter of commercially packaged water used to saturate agricultural perlite. The lids of the cultivated jars were closed and placed in the germination cabinet.

Within the scope of the study, the germination test at four different temperatures, 5, 15, 25 and 35°C, and then the frost damage test was applied by applying -5°C and 0°C temperatures in different rows and times. The germination of the seeds left to germinate at 5°C, 15°C, 25°C and 35°C temperatures on the 4th, 7th and 10th days were counted. In germination studies, using materials such as paper and sand, they stated that germinated seeds of Hungarian vetch on the 5th and 10th days at 20°C, and on the 5th and 14th days of vetch and common vetch could be counted (Elçi and Açıkgöz, 1993). Those whose radicula (rootlet) and plumule (stemlet) have come off are considered as germinated (Çuhadar, 1997).

The following processes are applied to the seeds grown at each temperature:

Germination at 5°C: The seeds germinated on the 4th, 7th and 10th days were counted. Seedlings with frost damage after 10 days of storage at 0°C for 2 days, at -5°C for 3 days, at 0°C for 2 days, at 5°C for 3 days and at 15°C for 3 days.

Germination at 15°C: The seeds germinated on the 4th, 7th and 10th days were counted. After day 10 at 5°C for 2 days, at 0°C for 2 days, at -5°C for 3 days, at 0°C for 2 days, at 5°C for 3 days and at 15°C After waiting for 3 days, the seedlings with frost damage were counted.

Germination at 25°C: The seeds germinated on the 4th, 7th and 10th days were counted. After day 10 at 15°C for 2 days, at 5°C for 2 days, at 0°C for 2 days, at -5°C for 3 days, at 0°C for 2 days, at 5°C Seedlings with frost damage were counted after 3 days and 3 days at 15°C.

Germination at 35°C: The seeds germinated on the 4th, 7th and 10th days were counted. After day 10 at 25°C for 2 days, at 15°C for 2 days, at 5°C for 2 days, at 0°C for 2 days, at -5°C for 3 days, at 0°C Seedlings with frost damage were counted after being kept for 2 days, 3 days at 5°C and 3 days at 15°C.

In order to determine the reactions of the plants, which will be formed by keeping them at -5 ° C for 3 days, after the last 2 days at 15 ° C, the plants were taken out of the jars and the damage was evaluated. Root and stem lengths of the plants were also measured.

Frost damage was evaluated with a scale of 1, 3, 5, 7, 9. Accordingly, the scale values are as follows:

1- It is unharmed and has new shoots

3- Leaf tips damaged and mortality less than 5%

5- Damage greater than 25%, death of leaves, branches or roots

7- 50% dead

9- more than 90% dead

Data from observations and measurements were analyzed using the MSTAT-C statistical package program(Anonymous, 1982).

Tthis article is summarized from part of Cafer TURKER's thesis ("YÖK" thesis number: 577444).

3. Results and Discussion

The data of the observations and measurements taken as a result of the effects of different temperatures on the germination of forage pea varieties and the statistical analysis results of these data are given below under the headings.

Number of seeds germinated on the fourth day

It was understood from the examination of Table 1 that the interaction of variety x seed production x temperature was effective on germination at the 4th day count ($P<0.01$). In other words, when the number of seeds germinated on the 4th day was examined in terms

of variety, seed production year and temperature (triple interaction), the changes were not always in the same direction. While the lowest germination in Bilgehan variety was in old seeds at 35°C, it was in new seeds at 25°C in Furkan variety (Table 2). It has been observed that germination values increase relatively from 0°C to 25°C, and decrease at 35°C. According to the 4th day counts, germination did not occur at 5°C. A similar study on some leguminous species revealed a triple interaction (Çuhadar, 1997). No germination occurred at 0°C in the 4th day count. Leaving the plants at temperatures lower than the appropriate germination temperatures slows the growth of the plants (Açıkgöz, 1991).

Table 1
Variance analysis table of 4th day germination in forage peas

Sources of Variance	DF	SS	MS	F
Variety	3	207.648	69.216	10.7826**
Year	1	15.820	15.820	2.4645
Variety x Year	3	280.148	93.383	14.5473**
Temperature	3	8762.529	2920.843	455.0116**
Variety x Temperature	9	411.133	45.681	7.1163**
Year x Temperature	3	47.523	15.841	2.4677
Variety x Year x Temperature	9	167.133	18.570	2.8929**
Error	96	616.250	6.419	

**: P<0.01

Table 2
Varieties x seed production year x temperature interaction of forage pea seeds germination on the 4th day (number)

Variety	Year	Temperature							
		35°C		25°C		15°C		5°C	
Furkan	2008	21.5	ABCD	23.8	AB	19.5	BCDE	0.0	J
	2016	15.5	EFGH	16.0	EFGH	12.0	HI	0.0	J
Bilgehan	2009	8.8	I	22.8	ABC	11.3	HI	0.0	J
	2015	14.5	FGH	23.3	ABC	14.5	FGH	0.0	J
Özkaynak	2008	21.3	ABCD	24.0	AB	19.0	CDEF	0.0	J
	2016	20.8	ABCD	22.0	ABC	16.8	DEFG	0.0	J
Taşkent	2008	13.5	GHI	24.8	A	13.0	GHI	0.0	J
	2016	14.0	GH	22.8	ABC	19.8	BCDE	0.0	J

LSD (P<0.01): 4.708; CV (%): 18.65

In the study of Çaçan et al. (2016), mentioned that a temperature of 10°C to 24°C is suitable for adequate germination in 13 forage pea genotypes (lines and varieties). According to the results of this research and the sources, the germination rate of forage pea seeds varies depending on the germination factors.

Number of seeds germinated on the seventh day

In the germination counts made on the seventh day, the effect of the years of production of the seeds was effective on the germination at a significance level of P<0.05 (Table 3). In Table 4, the averages of the cultivar x temperature interaction, which were found to be important as a result of the analysis of variance, are given. As a result of the averages applied to the LSD test, the best germination was obtained from the old seeds with 67.2% in the germination count on the 7th day. This rate was 62.8% in new seeds. According to the results, even if the old seed is old, the germination results of these seeds, which are under the same storage conditions in forage pea germination, are good and this shows that the seeds harvested in the past years can be used economically.

Variety x temperature interaction was effective on the 7th day counts of germination. Varieties differed in response to germination temperatures. In other words, the responses of the cultivars to temperature were not in the same direction. However, it was observed that germination increased as the temperature increased from 5°C to 25°C, whereas germination was observed at a low rate at 35°C (Table 4). At 5°C, none of the cultivars germinated. In a similar study on vetch species, it was stated that the increase in temperature after a certain point causes a decrease in germination (Qin, 1992). It has been reported that there is an optimum temperature range for germination and growth in plants, an increase in temperatures will show a positive reaction in plants to a certain extent, and it may be harmful to plants when the upper limit of the optimum temperature is exceeded (Açıkgöz, 1991).

When it is planned to be cultivated, forage pea varieties to be planted in autumn, the decrease in temperatures in general causes the germination rates to decrease, revealing the possibility that the plant will enter the winter without germination.

Table 3
Variance analysis table of 7th day germination in forage peas

Sources of Variance	DF	SS	MS	F
Variety	3	132.937	44.312	7.4697**
Year	1	34.031	34.031	5.7366*
Variety x Year	3	42.531	14.177	2.3898
Temperature	3	11428.400	3809.467	642.1577**
Variety x Temperature	9	192.750	21.417	3.6102**
Year x Temperature	3	22.656	7.552	1.2730
Variety x Year x Temperature	9	34.031	3.781	0.6374
Error	96	569.500	5.932	

*: P<0.05; **: P<0.01

Table 4
Variety x temperature interaction of 7th day germination of forage pea seeds

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	21.1	BCD	21.3	ABCD	20.3	CD	0.0	F
Bilgehan	16.0	E	24.3	AB	19.1	DE	0.0	F
Özkaynak	21.9	ABCD	24.3	AB	23.4	ABC	0.0	F
Taşkent	20.9	CD	24.4	A	22.8	ABC	0.0	F

LSD (P<0.01): 3.200; CV (%): 15.02

Number of seeds germinated on the tenth day

At the 10th day count on germination, the variety x year interaction was effective at the significance level of P<0.05 (Table 5). Table 6-7 shows the averages of the interactions that were found to be important as a result of the analysis of variance. In other words, the response of the cultivars differed with the old age of the seeds. While old seeds of Furkan variety gave high results on the 10th day germination count, new seeds of Furkan variety gave low results and this difference between them was statistically significant (Table 6).

As a result of the averages obtained as a result of the LSD test, while the old seeds of Özkaynak variety achieved high germination results in the 10th day germination, the new seeds of Bilgehan variety gave a lower germination average and the difference between them shows statistical significance. On the other hand, the differences between the germination of old and new seeds of Özkaynak and Taşkent cultivars and the germination of old seeds of Furkan cultivar were not found significant (Table 6).

Table 5
Variance analysis table of 10th day germination in forage peas

Sources of Variance	DF	SS	MS	F
Variety	3	98.531	32.844	5.6229**
Year	1	20.324	20.324	3.4794
Variety x Year	3	50.269	16.756	2.8687*
Temperature	3	11139.753	3713.251	635.7144**
Variety x Temperature	9	262.421	29.158	4.9919**
Year x Temperature	3	32.830	10.943	1.8735
Variety x Year x Temperature	9	23.445	2.605	0.4460
Error	96	560.743	5.841	

*: P<0.05; **: P<0.01

Table 6
Variety x seed production year interaction of 10th day germination of forage pea seeds

Variety	Year	
Furkan	2008	17.2 AB
	2016	14.6 C
Bilgehan	2009	15.2 C
	2015	16.1 BC
Özkaynak	2008	18.2 A
	2016	17.1 AB
Taşkent	2008	17.6 AB
	2016	17.1 AB

LSD (P<0.05): 1.696; CV (%): 14.52

Table 7
Variety x temperature interaction of 10th day germination of forage pea seeds (number)

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	21.1	CD	21.4	BCD	21.1	CD	0.0	F
Bilgehan	16.1	E	24.3	AB	19.9	D	2.4	F
Özkaynak	22.3	ABCD	24.4	AB	23.9	ABC	0.1	F
Taşkent	21.5	ABCD	24.6	A	23.4	ABC	0.0	F

LSD (P<0.01): 3.176; CV (%): 14.52

In the analysis of variance, the difference between cultivars and germination temperatures on the 10th day germination was effective at P<0.01 significance level (Table 7). In other words, the reactions of the varieties to the temperatures were in different directions.

In a study, the importance of temperature in germination for field agriculture was mentioned and appropriate temperature ranges for seed germination were mentioned even if there is sufficient moisture in the soil (Ashby and Hellmers, 1955).

When the 10th day count variety x temperature interaction was examined in the LSD test, the relatively best germination average was determined at 25°C. Although the best results were obtained at 25°C, the difference between the number of seeds germinated at 25°C on the 10th day, and the number of seeds germinated on the 10th day of the Özkaynak cultivar and Bilgehan cultivar at 25°C were statistically insignificant (Table 7) . The difference between the number of germination of Taşkent variety at 25°C and the 10th day counts of Furkan variety germinated at 25°C was statistically significant.

As a result of the study, we can say that among the applied germination temperatures, the best germination temperature of forage peas is between 15°C and 25°C. It was observed that at 35°C, some of the seeds deteriorated without germination and at this high temperature, the seeds lost their seed properties and melted. It has been stated that at high temperatures, the enzyme and protein structures of plants deteriorate, cell divisions slow down at plant development points, thus growth slows down, and the nutrients produced are rapidly consumed (Açıkgöz, 1991). It was found that there was very little germination at 5°C and the germination differences between varieties at 5°C were not statistically significant. It was determined that the seeds that did not germinate remained viable. In the examinations made, since it was accepted that the complete germination count was the radicle and plumule exit, only the seeds that had grown rootlets were not considered to be germinated. In a germination study on peas and broad beans in Poland, germination was carried out at different temperatures, and it was found that low temperature greatly reduced the germination percentage and reduced the chance of survival of the seedlings (Gorecki et al., 1990). It has been reported that the germination temperature of forage legumes planted in winter is 1-4°C at the minimum level and 20°C at the optimum level (Açıkgöz, 1991). In another study, the lowest average germination at 5°C; It was observed that some pea and bean seeds grown in cold soil showed abnormal germination and produced multiple shoots (Gorecki et al., 1990).

Number of seeds germinated before -5°C

This observation was made for the detection of seeds that re-germinated before switching to -5°C after 2 days at 0°C. According to the analysis of variance, the difference between the seed production years was effective at the P<0.05 significance level in the germination count made when the temperature of all replications was reduced to -5°C (Table 8). In Table 9, the averages of the cultivar x temperature interaction, which were found to be important as a result of the analysis of variance, are given. As a result of the LSD test applied averages, the best germination was obtained from the old seeds with 70% in the germination count made when the temperature was reduced to -5°C. Germination of new seeds was determined as 66.5%.

According to the variance analysis, the response of the cultivars differed with temperature in the germination count made when all replications were reduced to -5°C by the 10th day count (Table 8). The variety x temperature interaction was effective at the P<0.01 significance level.

Table 8
Analysis of variance of germination in forage peas when the temperature decreases to -5°C

Sources of Variance	DF	SS	MS	F
Variety	3	51.530	17.177	2.9185*
Year	1	26.283	26.283	4.4658*
Variety x Year	3	37.032	12.344	2.0974
Temperature	3	9922.616	3307.539	561.9909**
Variety x Temperature	9	618.824	68.758	11.6828**
Year x Temperature	3	22.654	7.551	1.2830
Variety x Year x Temperature	9	16.531	1.837	0.3121
Error	96	564.998	5.885	

*: P<0.05; **: P<0.01

Table 9
Variety x temperature interaction of the germination status of forage pea seeds at -5°C (number)

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	21.1	BC	21.8	ABC	21.5	ABC	0.0	F
Bilgehan	16.1	D	24.3	A	19.9	C	7.6	E
Özkaynak	22.4	ABC	24.4	A	24.0	AB	0.3	F
Taşkent	21.9	ABC	24.6	A	23.5	AB	0.0	F

LSD (P<0.01): 3.188; CV (%): 14.21

When the interaction between cultivar and temperature was examined as a result of the LSD test, the reactions of cultivars to temperatures to -5°C were realized in different directions. The difference between the germination of Özkaynak variety germinated at 35°C when descending to -5°C and the germination of Bilgehan variety germinated at 35°C showed statistical significance. As a matter of fact, the difference between the reaction of the seeds of the Taşkent variety left to germinate at 25°C and the germination response of the seeds of the Bilgehan variety left to germinate at 15°C when descending to -5 °C was found to be statistically significant (Table 9).

Number of seeds germinated after the last temperature (15°C)

Before data on the number of germinated seeds after the final temperature were obtained, the seeds removed from -5°C were counted after being kept at 0°C for 2 days, at 5°C for 3 days, and at 15°C for 3 days, respectively. In the last germination count, the effect of the production year of the seeds on germination was found to be significant at P<0.05. The difference between the old seeds germinating with a rate of 73.2% and the new seeds germinating with a rate of 67.2% as a result of the LSD test averages is statistically significant. According to the analysis of variance performed in the last germination count, the variety x temperature interaction was effective at P<0.01 importance (Table 10).

Table 10
Variance analysis table of germination in forage peas from -5°C to 15°C

Sources of Variance	DF	SS	MS	F
Variety	3	319.653	106.551	8.3588**
Year	1	76.569	76.569	6.0067*
Variety x Year	3	29.335	9.778	0.7671
Temperature	3	6423.515	2141.172	167.9728**
Variety x Temperature	9	1075.496	119.500	9.3746**
Year x Temperature	3	5.274	1.758	0.1379
Variety x Year x Temperature	9	43.945	4.883	0.3831
Error	96	1223.725	12.747	

*: P<0.05; **: P<0.01

Table 11
Variety x temperature interaction of germination of forage pea seeds from -5°C to 15°C

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	21.1	A	22.4	A	21.5	A	6.9	B
Bilgehan	7.8	B	24.1	A	20.0	A	7.6	B
Özkaynak	22.6	A	24.3	A	23.6	A	3.5	B
Taşkent	21.9	A	24.5	A	24.0	A	5.1	B

LSD (P<0.01): 4.691; CV (%): 20.34

According to the LSD test, when the averages of germination taking place from -5°C to 15°C are examined, the difference between the number of germinated seeds in the last count of Bilgehan variety germinated at 35°C and the number of germinated seeds of Furkan, Özkaynak and Taşkent varieties germinated at 35°C statistically significant (Table 11).

According to the results obtained from the study, it was observed that the seeds that started to germinate at 5°C kept their vitality and it was determined that they germinated in the last count carried out after 15°C. The difference between varieties in this germination at 5°C was found to be statistically insignificant (Table 11).

Damage status at -5°C ("1-9" scale)

When the damage scale values were examined in the analysis of variance in determining the damage status of all replications at -5°C, it was determined that the interaction of cultivar and temperature was significant at P<0.01 (Table 12). In a similar study carried out in field conditions, it was determined that the effect of the variety factor on the overwintering rate of forage peas at -8°C was found to be effective at P<0.01 significance level to determine the winter hardiness of forage peas (Homer and Groose, 2016).

As a result of the averages obtained from the LSD test, when examining the damage situation at -5°C, the varieties gave different responses with the difference be-

tween germination temperatures. The difference between the damage status of the seeds of the Bilgehan variety germinated at 35°C and the damage status of the Taşkent variety at 25°C was found to be statistically significant. On the other hand, the difference between the damage conditions of Özkaynak and Taşkent cultivars germinated at 15°C and 25°C at -5°C is not statistically significant (Table 12).

Özkaynak variety gave the best results in terms of cold resistance among forage pea lines and varieties, whose winter resistance was examined in Erzurum conditions (Aslan, 2017). In a similar study, the wintering rate was determined as Özkaynak among other forage pea varieties and lines (Kadıoğlu and Tan, 2018).

Table 12
Variance analysis table of damage to forage peas at -5°C

Sources of Variance	DF	SS	MS	F
Variety	3	57.125	19.042	19.8696**
Year	1	1.125	1.125	1.1739
Variety x Year	3	3.625	1.208	1.2609
Temperature	3	101.125	33.708	35.1739**
Variety x Temperature	9	124.625	13.847	14.4493**
Year x Temperature	3	1.625	0.542	0.5652
Variety x Year x Temperature	9	8.625	0.958	1.000
Error	96	92.000	0.958	

**: P<0.01

Table 13
Variety x temperature interaction of damage to forage peas at -5°C

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	1.3	BC	1.5	BC	1.5	BC	1.0	C
Bilgehan	7.3	A	1.5	BC	1.8	BC	1.0	C
Özkaynak	2.3	B	1.0	C	1.0	C	1.3	BC
Taşkent	2.3	B	1.0	C	1.0	C	1.0	C

LSD (P<0.01): 1.286; CV (%): 56.96

As a result of studies on vetch and pea species, it has been determined that plants with short stature andslow growth and smaller leaf areas are more resistant to cold (Açıkgöz, 1982). It has been determined in the study that the plants germinated in the optimum temperature range are less damaged by cold. It has been determined that the plants germinated above the optimum germination temperature suffer the most damage when kept at -5°C due to the weak tissue structure, development status and chlorophyll status. It has been observed that the seeds left to germinate at 5°C are not damaged at -5°C and maintain their vitality. In a study conducted in field conditions, it was determined that pea plants exposed to cold with less or more leaves than 4-5 leaves were more damaged by cold (Alan and Geren, 2012).

Stem length (cm)

The response of the cultivars to the stem lengths of the germinating forage peas differed with the germination temperatures. This difference was effective at the P<0.01 significance level according to the analysis of variance (Table 14).

In the germination study carried out on vetch species at different temperatures, the highest stem length was determined at 20°C and it was observed that the stem lengths of the plants decreased after 25°C (Çuhadar, 1997).

When the stem lengths of forage peas were examined, the responses of the varieties to the germination temperatures were different as a result of the LSD test. The difference between the stem length of Özkaynak variety germinated at 25°C and the stem length of Furkan variety germinated at 25°C was statistically significant. Although the Taşkent variety germinated at 25°C gave the highest average stem length, the difference between the average height of the Taşkent variety germinated at 25°C and the average stem length of Özkaynak and Bilgehan cultivars germinated at 25°C was found to be insignificant (Table 15).

Table 14
Analysis of variance of forage pea stem length

Sources of Variance	DF	SS	MS	F
Variety	3	49.5817	16.5272	7.8238**
Year	1	5.0880	5.0880	2.4086
Variety x Year	3	0.6802	0.2267	0.1073
Temperature	3	768.7097	256.2365	121.2990**
Variety x Temperature	9	72.2758	8.0306	3.8016**
Year x Temperature	3	5.8122	1.9374	0.9171
Variety x Year x Temperature	9	8.4050	0.9338	0.4421
Error	96	202.7939	2.1124	

**: P<0.01

Table 15
Variety x temperature interaction of forage pea stem length (cm)

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	3.4	EF	5.2	CDE	4.8	DE	0.2	I
Bilgehan	1.0	GHI	6.8	ABC	2.8	FG	0.3	I
Özkaynak	3.6	EF	7.4	AB	5.2	CDE	0.3	I
Taşkent	2.4	FGH	8.3	A	6.2	BCD	0.5	HI

LSD (P<0.01): 1.910; CV (%): 39.83

Root length (cm)

The response of the cultivars to the root lengths of the germinating forage peas differed with the germination temperatures. According to the analysis of variance, this difference was effective at the significance level of P<0.01 (Table 16).

In a study with peas, the root development of plants was investigated between 12°C and 36°C, and it was found that root growth increased at temperatures up to 30°C and a decrease in root length occurred after 30°C (Leopold and Kriedemann, 1975).

When the root length averages were examined in the LSD test, the response of the cultivars to the germination temperatures occurred in different directions. The difference in root length averages of Taşkent and Özkaynak varieties germinated at 5°C was statistically insignificant (Table 17).

According to the results obtained from seeds germinated at 5, 15, 20, 25 and 30°C, the best germination temperature range was between 18°C and 23°C, but 20°C and 25°C. range was determined as the temperature range with the best root growth (Mosjidis and Zhang, 1995).

Table 16
Variance analysis table of root length of forage pea

Sources of Variance	DF	SS	MS	F
Variety	3	21.1406	7.0468	8.3757**
Year	1	0.0569	0.0569	0.0677
Variety x Year	3	0.9333	0.3111	0.3698
Temperature	3	192.4707	64.1569	76.2550**
Variety x Temperature	9	37.5308	4.1700	4.9565**
Year x Temperature	3	0.7385	0.2461	0.2926
Variety x Year x Temperature	9	10.7949	1.1994	1.4256
Error	96	80.7693	0.8413	

**: P<0.01

Table 17
Variety x temperature interaction of root length of forage pea (cm)

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	3.2	CDEF	3.6	BCDE	4.3	ABCD	1.6	H
Bilgehan	1.3	H	5.5	A	3.1	DEF	1.6	H
Özkaynak	3.7	BCDE	5.5	A	4.4	ABC	1.8	GH
Taşkent	2.9	EFG	5.3	A	4.8	AB	2.1	FGH

LSD (P<0.01): 1.205; CV (%): 26.86

Total length (cm)

The response of cultivars to total plant length of forage peas differed with germination temperatures. According to the analysis of variance, this difference was effective at the P<0.01 significance level.

When the interaction between the difference in the total heights of the genotypes and the germination temperatures was examined, the difference between the total height averages of the Taşkent variety germinated at 25°C and the total height averages of the Özkaynak variety germinated at 25°C was found to be statistically insignificant. However, the difference between the Tashkent variety germinated at 35°C and the Tashkent variety germinated at 25°C was significant (Table 19).

Table 18
Variance analysis table of total length of forage peas

Sources of Variance	DF	SS	MS	F
Variety	3	133.585	44.528	9.403**
Year	1	4.068	4.068	0.859
Variety x Year	3	1.815	0.605	0.128
Temperature	3	1726.936	575.645	121.555**
Variety x Temperature	9	201.680	22.409	4.732**
Year x Temperature	3	6.137	2.046	0.432
Variety x Year x Temperature	9	34.150	3.794	0.801
Error	96	454.623	4.736	

**: P<0.01

Table 19
Variety x temperature interaction of total length of forage peas (cm)

Variety	Temperature							
	35°C		25°C		15°C		5°C	
Furkan	6.7	EF	8.8	CDE	9.1	CDE	1.9	H
Bilgehan	2.3	H	12.3	AB	5.9	F	1.9	H
Özkaynak	7.2	DEF	12.9	A	9.6	BCD	2.2	H
Taşkent	5.3	FG	13.5	A	11.0	ABC	2.5	GH

LSD (P<0.01): 2.859; CV (%): 30.81

Root length/Stem length

The difference between cultivars in the root/stem ratios of the germinated forage peas was effective at the significance level of P<0.05 (Table 20). The difference between Furkan variety with 4.0% root/stem ratio and Bilgehan variety with 3.2% root/stem ratio as a result of LSD test averages is statistically significant.

Table 20
Variance analysis table of Root length/Stem length ratio of forage pea

Sources of Variance	DF	SS	MS	DF
Variety	3	0.971	0.324	2.8262*
Year	1	0.468	0.468	4.0864*
Variety x Year	3	0.345	0.115	1.0035
Temperature	3	28.527	9.509	83.0245**
Variety x Temperature	9	1.105	0.123	1.0718
Year x Temperature	3	0,809	0.270	2.3559
Variety x Year x Temperature	9	0.844	0.094	0.8181
Error	96	10.995	0.115	

*: P<0.05; **: P<0.01

Table 21
Averages of root length/stem length ratio of forage peas (cm)

Means of Variety							
Furkan		Bilgehan		Özkaynak		Taşkent	
0,97	A	0,76	B	0,90	AB	0,98	A
Means of Temperature							
35°C		25°C		15°C		5°C	
0,80	C	1,50	A	1,10	B	0,90	BC
Means of Year							
Old Seed (2008-2009)				New Seed (2015-2016)			
0,80				0,90			

LSD (Variety: P<0.05) :0.1683; LSD (Temperature: P<0.05): 0.2228; CV (%): 37.32

The difference between the seed production years in the root/stem ratios of the plants was effective at the P<0.05 significance level (Table 20). The difference between the old seeds with 3.2% root/stem ratio and the new seeds with 3.6% root/stem ratio as a result of the LSD test averages was found to be statistically significant (Table 21).

Germination temperatures were effective on the root/stem ratios of the germinating forage pea plants at the significance level of P<0.01 (Table 20). The difference between the root/stem ratio of the plants germinated at 4.4% and 25°C and the root/stem ratio of the plants germinated at 6.0% and 15°C, as a result of the LSD test averages, is statistically significant.

It has been reported that the increase in temperatures after the optimum degree will decrease the root/stem ratio in plants (Akçin, 1981). Based on this, it was determined that although the root/stem ratio of forage peas germinated at relatively 25°C was good, the root/stem ratio decreased at 35°C.

4. Conclusions

As an example of the study supporting this, it was seen that summer sowing gave better results in forage peas planted in winter and summer in Konya conditions. The reason is that due to late winter planting, the plants were exposed to winter cold before reaching sufficient seedling height (Konuk and Tamkoç, 2018).

Since this study was carried out in germination environments, it was carried out with constant temperature applications, and the temperatures were gradually lowered and increased in order to determine the cold damage. However, since environmental conditions are constantly changing, these studies can be supported by conducting them in parallel with field studies. In the results obtained, it can be found that the most suitable germination temperature in winter forage pea varieties, as well as how much the forage pea seedlings growing at the appropriate germination temperature are affected by cold damage. Based on this, for the forage peas to be cultivated commercially, they can spend the winter in a

healthy way only by sowing at the appropriate time in winter sowing and the products can be harvested without losing their yield. Otherwise, failures may occur in winter planting.

5. References

Açıkgöz E (1982). Cold tolarance and its association with seedling marphology and chemical composition in annual forage legumes 1. field peas, *Z.Pflanzenzüchtung* 88: 118-126.

Açıkgöz E (1991). Yem Bitkileri Tarımı. Uludağ Üniversitesi Yayınevi, Bursa.

Akçin A (1981). Genel Tarla Ziraatı. Atatürk Üniversitesi Tarla Bitkileri Bölümü, Ankara.

Alan Ö, Geren H (2012). Bezelye'de (*Pisum sativum* L.) farklı ekim zamanlarının tane verimi ve diğer bazı tarımsal özellikler üzerine etkisi. *Ege Üniversitesi Ziraat Fakültesi Dergisi* 49 (2): 127-134.

Anonymous (1982). Mstat-C statistical program.

Ashby WC, Hellmers H 1(955). Temperature requirements for germination in relation to wild-land seeding. *Journal of Range Management* 8 (2): 80-83.

Aslan B (2017). Erzurum şartlarında kışlık yem bezelyesi geliştirme çalışmaları. Yüksek Lisans Tezi, Atatürk Üniversitesi Fen Bilimleri Enstitüsü, Erzurum.

Çaçan E, Kökten K, Özbay N (2016). Bazı yem bezelyesi hat ve çeşitlerinin farklı sıcaklıklarda çimlenme ve çıkış performanslarının belirlenmesi. *Nevşehir Bilim ve Teknoloji Dergisi TARGİD*, Özel Sayı 62-68.

Çuhadar B (1997). Fiğ tohumlarının çimlenmesi üzerine sıcaklığın etkisi. Yüksek Lisans Tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü, Konya.

Düzgüneş O, Kesici T, Kavuncu O, Gürbüz F (1987). Araştırma ve deneme metotları. Ankara Üniversitesi, Ziraat Fakültesi Yayınları, Ankara.

Elçi Ş, Açıkgöz E (1993). Baklagil ve buğdaygil yem bitkileri tanıtma kılavuzu. TİGEM Yayınları, Afşaroğlu Matbaası, Ankara.

Gorecki R, Fordoński G, Bieniaszewski T, Jacuński K (1990). Comparative studies on chilling sensitivity in some legume seeds. *Acta Physiologiae Plantarum* 12 (2): 149-158.

Homer A, Groose RW (2016). Using an "index of merit" to evaluate winterhardy pea lines. *J. Agric. Sci.* 8: 45-53.

Kadıoğlu S, Tan M (2018). Erzurum şartlarında bazı yem bezelyesi hat ve çeşitlerinin tohum verimleri ile bazı özelliklerinin belirlenmesi. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi* 49 (2): 143-149.

Konuk A, Tamkoç A (2018). Yem bezelyesinde kışlık ve yazlık ekimin bazı tarımsal özellikler üzerine etkisi. *Bahri Dağdaş Bitkisel Araştırma Dergisi* 7 (1): 39-50.

Leopold AC, Kriedemann PE (1975). Plant Growth and Development, 2. Edition, Mc Graq-Hill, New York.

Mosjidis J, Zhang X (1995). Seed germination and root growth of several Vicia species at different temperatures. *Seed Science and Technology (Switzerland)* 23 (3): 749-759..

Qin DH (1992). Effect of temperature on seed characters of common vetch [*Vicia sativa*] and hairy vetch [*Vicia villosa*]. *Grassland of China* 5: 18-22.

Tamkoç A (2017). Türkiye'de yem bitkileri ve hayvansal protein üretimi. Hanhana Kalecik Kültür Dergisi, 3.