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Effect of Phosphorous Fertilizer and Bacterial Applications on Seed Yield of Morphologically Different Forage Pea (*Pisum sativum L.*) Varieties

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Abstract

As a result of today's modern agricultural practices, many negative consequences have been encountered due to the use of intense, inaccurate and excessive chemical fertilizers and pesticides. In particular, chemical fertilizers have reached fresh water sources as a result of washing, causing environmental pollution and this has become a threat to human, domestic and wildlife. Therefore, one of the alternatives created by experts in terms of prevention of environmental pollution and agricultural sustainability has been the use of useful bacteria instead of chemical input.

In this study, carried out in Erzurum, was aimed to determine the effects of different phosphorous rates (0, 30 and 60 kg/ha P_2O_5) and bacteria genotypes (control, nitrogen fixing and *phosphate solvent*) on agricultural and morphological characteristics of some fodder pea cultivars. The experiment was established in Randomized Split Blocks Trial Design with three replications. In the study, were used Kirazli (semi-leafless) and Urunlu (leafed) pea cultivars, *Rhizobium leguminasorum* and *Arthrobacter agilis* bacteria and triple superphosphate 0-45-0 fertilizer. According to the results, number of pods per plant 6.5-7.7, number of seeds per pod 5.6-6.2, 1000 seed weight 187.5-198.9 g, seed yield 1087-1663 kg/ha, seed crude protein content 30.6-31.6 % were investigated. As a result; no response was observed for phosphate fertilization since the soils of experiment plots were rich of this nutrient. Yet, *Rhizobium* inoculation yielded positive and significant results.

Keywords: Bacteria inoculation, environmental pollution, forage pea, phosphate rates, variety, yield components

Research article
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INTRODUCTION

As a result of today's modern agricultural practices dense, incorrect and excessive chemical fertilizers and pesticides use as a result of various negative consequences. Especially chemical fertilizers reach to fresh water sources as a result of washing and cause environmental pollution.This situation negatively affects people and the environment in which they live. Environmental pollution should be prevented and agricultural sustainability ensured natural resources must be protected. Environmental and life-friendly techniques and applications should be developed and investigated as an alternative to the use of chemicals.

Recently, studies to increase the availability of phosphorus with different bacteria have gained momentum. Plant growth, nitrogen fixation, phosphorus to become bioavailable, some minerals taken by plants, production of some hormones that promote the growth of bacteria can be used in the plant. In this study, the effects of phosphorous bacteria and phosphorus solvent bacteria (*A. agilis*) and nitrogen fixation (*R. leguminasorum*) on seed yield and yield components in different morphology (semi-leaf and normal leaf) varieties were investigated.

MATERIAL AND METHODS

As material; two different types of feed peas Type of half-leaf (semi-leafless) (Kirazli) Type of full-leaf (leafed) (Urunlu) nitrogen fixative (*Rhizobium leguminosarum*) phosphorus solvent bacteria (*Arthrobacter agilis*) three doses of phosphate fertilizer (0, 3 and 6 kg / da P_2O_5) were used. Research; in Erzurum, Eastern Anatolia Agricultural Research Institute was conducted with three replicates according to the Randomized Split Blocks Trial Design with three replications. In the experiment, the plantings were made in 5 rows of 5 m in row spacing of 20 cm. While the varieties (2) were placed in the main parcel, 3 (0, 3 and 6 kg / da P_2O_5) and bacteria 2 (inoculated-noninoculated) were placed in the sub-parcel. The plantings were made by hand on May 5 each year. A few hours before planting, the seeds were wetted with sugar water and then mixed with the bacteria culture (*Rhizobium leguminosarum* (RL). *Arthrobacter agilis* (AA) inoculation was done before planting in the Department of Plant Protection, Faculty of Agriculture, and Ataturk University. Half of the parcels were harvested for the weed and half for the seed. The data obtained in the study were used by SPSS computer package program. Analyzes of the variance of years divided parcels, the combined analysis was made according to the split plot design, significant factor averages were grouped by Duncan test.

Soil properties of the research area; soil samples taken from the first year research area; clay loam, slightly alkaline reaction, organic matter content less, moderately salty, rich in potassium and phosphorus level was determined to be sufficient. In the second year analysis results; clay loam, mild acid reaction, poor organic matter, limy, without salt, ıt has been found to be rich in potassium and phosphorus.

In the first year of the study, the temperature value (12.6^{o}C) in vegetation period is lower than the average. In the second year it was slightly higher than the average (14^{o}C) for 14 years with 14.8^{o}C. The second year was hot in the summer months (Figure 1).

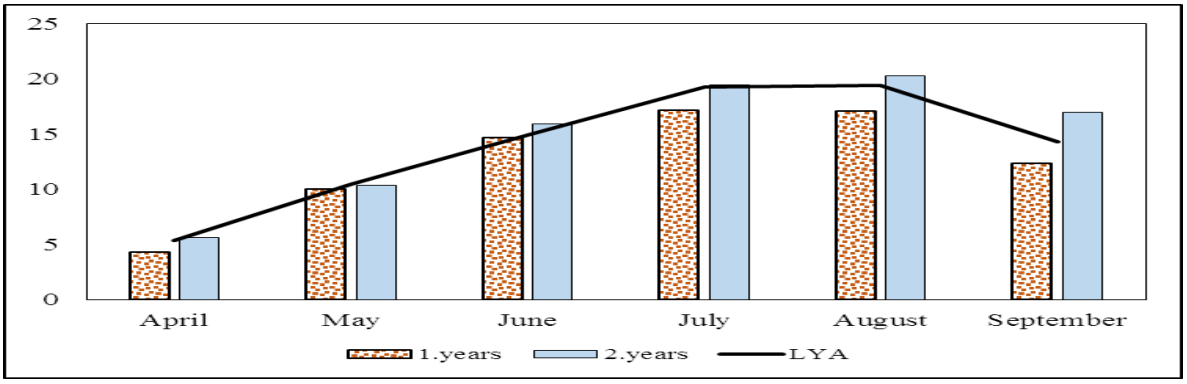

Figure 1.Temperature of research years and long years average

In the first year of the survey, the total amount of precipitation was above the average of 257.8 mm. In the second year, the total amount of precipitation was above the average of many years (241.6). The first year of June 22 and the second year of June 16 and July 18 there was heavy rain and hail. The first year was quite a lot of rainfall in June (Figure 2).

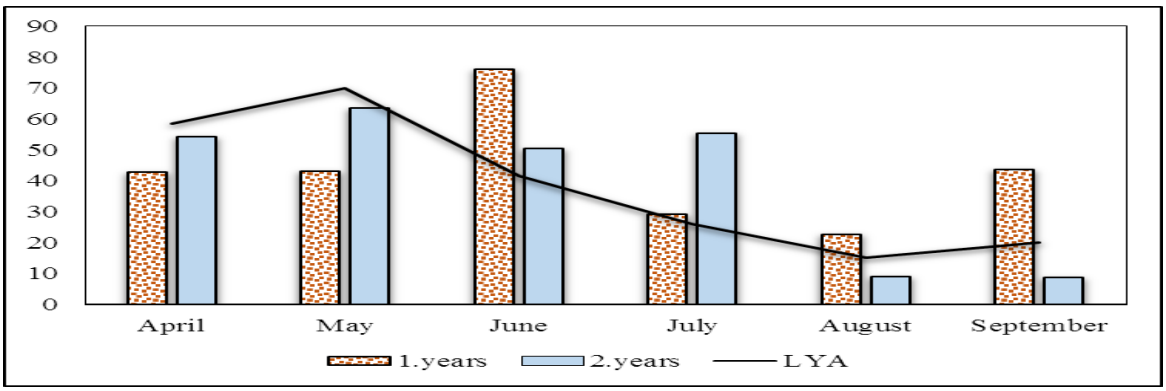

Figure 2. Rainfall values for years of research and long years average

Research Findings and Discussion

According to the results of this research; There were no significant differences between the number of grains in bean, the weight of one thousand grains and the rate of crude protein. In the first year in terms of the number of pods in the plant phosphorus and bacterial applications with the effect of phosphorus x bacteria, phosphorus x variety, bacteria x variety and variety x phosphorus x bacterial interactions were statistically significant at 1% level. In the second year, application of bacteria was 1% and phosphorus application was significant at 5% level. Interactions of the variety x phosphorus interaction was found to be significant at 5%. It was noted that phosphorus and bacterial applications were very important in the combined analysis of years ($p<0.01$). Variety diversity was significant at 5% level. In the study the yield components examined;

Number of pods in the plant

In the first year of the experiment, the average number of pods per plant was 7.0 for Kirazli and 7.2 for Urunlu. Pea plants in the parcels containing phosphol solvent bacteria produced more pods than the plants in the parcels where RL inoculated was performed. In the first year of the experiment, the number of pods in the plant has not been affected by bacterial applications. In applications where phosphorus is applied, especially in *A. agilis*, there is a significant increase compared to control. In the first year in the non-phosphorus parcels less per plant per plant (6.4) was determined, while phosphorus applied in the more pods were identified (Table 1).

Varieties in the first year of the experiment showed different results against bacterial applications. Kirazli variety is the highest value of AA application, while the Urunlu type RL + AA application has reached. In the second year of the experiment, the average number of pods in the plant was 7.4 and the number of beans was 7.3 and 7.2, respectively. The plants in the phosphorus applied parcels have a higher number of pods per plant than the ones without phosphorus (Table 1). The difference between phosphorus applications was significant ($p < 0.05$). Kirazli varieties of 3 kg P_2O_5 applied to the parcels more varieties per plant than the varieties of varieties, while In other phosphorus applications, the Urunlu type has similar or higher values. In bacterial applications, the plants in the parcels where RL and AA bacteria were applied alone produced more pods than in control and RL + AA parcels. In the combined analysis, there was no significant difference in the production of pods per plant. The number of pods per plant, which was 7.0-7.4. The number of pods per plant was 7.1 in Kirazli cultivar and 7.4 in Urunlu cultivar. The plants in the phosphorus applied parcels produced more pods than the ones without phosphorus. A significant difference ($p < 0.01$) between phosphorus doses was found in the combined analyzes.

Table 1. The average number of pods per plant for the peas applied to bacteria and phosphorus fertilizers (number)[1]

Varieties	Years	P_2O_5	K	RL	AA	RL+AA	Average
Kirazli	1.year		6.4	6.4	7.8	6.5	6.8
	2.year		6.3	7.6	8.0	7.2	7.3
	Two years	P0	6.1	6.1	7.5	6.1	6.5
		P1	6.4	7.7	7.4	8	7.4
		P2	6.7	7.1	8.9	6.6	7.3
		Average	6.4	7	7.9	6.9	7.1 b
Urunlu	1.year		6.3	7.2	7.0	8.2	7.2
	2.year		7.1	7.9	7.9	7.3	7.6
	Two years	P0	6.7	7.1	7.6	6.5	7
		P1	6.7	7.6	7.7	8.2	7.6
		P2	6.8	8	7.2	8.7	7.7
		Average	6.7	7.6	7.5	7.8	7.4 a
Two years	Average	P0	6.4	6.6	7.6	6.3	6.7 B
		P1	6.6	7.7	7.6	8.1	7.5 A
		P2	6.8	7.6	8.1	7.7	7.5 A
	Average	Average	6.6 B	7.2 A	7.7 A	7.4 A	7.2

[1] The averages marked with different uppercase and lowercase letters are important at 1% and 5% respectively.

Plants in the P2 applied parcels produced 7.2 to 7.7 pods per plant. While phosphorus applications in control plots did not affect the number of pods in the plant, phosphorus fertilization increased the number of bacteria in RL and AA applied parcels. Bacterial applications have led to the production of more pods in feed peas. There was no significant difference between varieties. This situation can be explained by the fact that there is no significant difference in the number of pods among the varieties. Similar results were obtained in similar studies (Tamkoc, 2007). Phosphorous fertilizer application caused a significant increase in the number of pods per plant in both year and unified analysis. A similar situation occurred in phosphorus-soluble bacteria. Although the soil of the trial area is sufficient for the phosphorus suitable for the plant, the phosphorus and phosphorus solvent bacteria have been reacted in terms of the number of pods. Here, phosphorus can promote the generative development of the plant (Yildiz, 2008). Since the activity of microorganism is low at the beginning of development, soil temperature may have played a role in the emergence of reaction to additional phosphorus or phosphorus solvent bacteria.

Number of seeds in the pods

In both years of the experiment, there was no significant difference between the varieties in terms of number of beans. In the first year, the number of beans in the varieties of Kirazli 6.6 pieces of the Urunlu has been 6.3 in number. These values in the second year of the trial Kirazli varieties of 5.4 and 5 was the Urunlu variety. In the second year, the Urunlu variety reached only the highest number of beans in the parcels (6.3) and the Kirazli variety reached the control parcels (Table 2).

In the second year of the experiment, the number of grains in the pod may have been in the drought of effective (Figure 3). In several studies, the number of pods and number of pods in the plant decreased due to drought (Ney et al. 1994; Guilioni et al. 2003). In the combined analysis, the genetic potential of the varieties has been influential in the variation in the number of seed in the pea among varieties (Table 2). According to the varieties, the number of seed in the number of pea changes (Tamkoc, 2007) was recorded by. The sufficiency of soils in the phosphorus direction may be effective in the reaction of phosphorus to the number of grains. On the other hand, the basic determinant in the presence of enough nutrients to determine the number of pea in plants is the drought (Davies et al. 1985; Biarnes-Dumoulin et al. 1996; Kocacaliskan, 2004; Uzun et al. 2005). In the second year, the decrease in the number of pea in the bean has been important because of the more drought of the generative period. Varieties have reacted differently against bacterial applications. The varieties with the highest number of varieties in the parcels applied to the AA, Kirazli RL + AA in the parcels were applied together. Bacterial response to the plant species, and even the same type of reaction to cause a different response (Lucy et al. 2004; Khalid et al. 2004) was effective in this regard.

Table 2. The average number of seeds per pod for the peas applied to bacteria and phosphorus fertilizers (number)[1]

Varieties	Years	P_2O_5	K	RL	AA	RL+AA	Average
Kirazli	1.year		6.5	6.9	6.4	6.9	6.6
	2.year		5.8	5.4	5.0	5.4	5.4
	Two years	P0	6.5	6.1	6	6.1	6.2
		P1	6	6.5	5.8	5.7	6
	Average	P2	6.1	5.8	5.4	6.7	6
		Average	6.2	6.1	5.7	6.2	6.1 A
Urunlu	1.year		5.9	6.4	6.5	6.5	6.3
	2.year		4.5	4.8	5.5	5.2	5.0
	Two years	P0	5.2	5.6	6.3	5.7	5.7
		P1	5.2	5.5	5.7	6	5.6
		P2	5.4	5.8	6	5.9	5.8
		Average	5.3	5.6	6	5.9	5.7 B
Two years	Average	P0	5.9	5.9	6.2	5.9	5.9
		P1	5.6	6	5.8	5.9	5.8
		P2	5.8	5.8	5.7	6.3	5.9
	Average	Average	5.7	5.9	5.9	6	5.9

[1] The averages marked with different uppercase and lowercase letters are important at 1% and 5% respectively.

Seed Yield

In the first year of the experiment, Kirazli cultivar yielded 216.9 kg of seed yield and 154.8 kg of seed yield. Although the seed yield in the range of 179.1-192.2 kg/da against phosphorous fertilizer applications was not statistically significant, similar results were obtained against bacterial applications. Although the highest seed yield was found in RL with 196.0 kg / da, it was not statistically significant. Kirazli variety in terms of seed yield was more efficient than the Urunlu variety.

The seed yield in the leaf-reduced varieties is the main selection criterion. In this study to, the genetic structure of this type has been effective in producing of semi-leaf Kirazli variety. Temperature and hail precipitation values recorded in the second year of the experiment caused a significant decrease in seed yield. High temperatures in the generative period cause a serious decrease in seed yield.

Seed yield per decare was 109.5 kg in Kirazli varietes. In the second year, the average seed yield of 90.9 kg ranged from 88.1 to 95.4 kg/da according to phosphorus applications. When the effect of PGPR applications is examined, it is seen that the highest seed yield occurs in RL vaccinated parcels (104.0 kg/da) and the seed yield is 99.4 kg/da in seed parcels (77.9 kg/da). It is seen In the second year of the trial, Kirazli variety produced more seeds than the control with RL application. On the other hand, seed yield per unit area in AA applications led to a faster decrease in the Urunlu variety. This situation led to a significant interaction of bacterial-type interaction. In the first year of the experiment, seed yield of 185.9 kg/da decreased rapidly in the second year to 90,9 kg/da. This decrease was statistically significant on a yearly basis ($p < 0.01$). In the combined analysis, the average seed yield was 138.3 kg/da. In Kirazli variates, 163.2 kg / da in the variates and 113.4 kg/da (Table 3).This has made the difference between the varieties statistically very important.

Table 3. The average seed yield for the peas applied to bacteria and phosphorus fertilizers (kg/da)[1]

Varieties		P_2O_5	K	RL	AA	RL+AA	Average
Kirazli	1.year		173.5	240.7	210.2	243.3	216.9
	2.year		108.9	119.8	110.5	98.9	109.5
	Two years	P0	139.9	178.8	152.4	162.9	158.5
		P1	139.2	181.0	172.2	172.7	166.3
		P2	144.6	180.9	156.3	177.7	164.9
		Average	141.2	180.2	160.3	171.1	163.2 A
Urunlu	1. year		166.0	151.2	168.0	133.9	154.8
	2. year		89.8	88.3	45.4	65.4	72.2
	Two years	P0	132.3	108.5	107.9	86	108.7
		P1	127.9	131.9	108.5	116.9	121.3
		P2	123.4	118.7	103.5	95.8	110.4
		Average	127.9	119.7	106.6	99.6	113.4 B
Two Years	Average	P0	136.1	143.7	130.2	124.5	133.6
		P1	133.6	156.5	140.4	144.8	143.8
		P2	134	149.8	129.9	136.8	137.6
	Average	Average	134.6	150	133.5	135.3	138.3

[1]The averages marked with different uppercase and lowercase letters are important at 1% and 5% respectively.

In both varieties, seed yield decreased in the second year of the experiment compared to the first year. However, the decrease in the Urunlu variety was more pronounced compared to the decrease in the Kirazli variety. In general, pea seed yield is reported to vary between 150-200 kg/da (Bayraktar, 1981; Gençkan, 1983; Alan, 1984). Seed yield in the first year of the trial is observed to be very good in the second year. However, it is observed that seed yields are consistent with the literature as the average of both years (Tosun, 1974; Alan, 1984; Altın, 1991; Acikgoz, 2001; Sayar et al. 2009; Tan et al. 2009).

In the first year of the experiment, a positive response was recorded in the Kirazli cultivar in terms of seed yield. In the second year of the experiment, the lowest seed yield in Kirazli variety was recorded in RL + AA application, while the lowest value was 45.4 kg/da in AA application (Table 3). According to the results of the combined analysis, Kirazli variety showed a positive increase in seed yield in response to the RL application and a significant increase compared to the control parcels.

In general, bacterial applications showed a markedly reducing effect on the Urunlu variety. Kirazli varieties in terms of varieties in terms of seed yield was more efficient than the Urunlu variety. The seed yield in the leaf-reduced varieties is the main selection criterion (Snoad, 1974; Heath and Hebblethwaite, 1985). In this study, the genetic structure of this type has been effective in producing more seeds of semi-leaf Kirazli variety. Indeed, Acikgoz and Uzun (1997); Long (2001) researchers have obtained similar results.

Temperature and hail precipitation values recorded in the second year of the experiment caused a significant decrease in seed yield. Because the high temperatures in pea pea in the cool season plant cause a serious decrease in seed yield (Ney et al. 1994). In the trial there was no significant difference in seed fertilizer application in terms of seed yield. This result was effective in the area of the test area soils phosphorus. Combined analysis of the seed yield in the yield of the year x varieties of varieties in the generative period of high temperature and drought caused by the more affected than kirazli varieties. The yield of the rainfall during the year and the temperature in the growing period (Smith and Goeging, 1999) and the effects of the genotypes together yield. The higher temperatures compared to the previous year, especially in the late July and August, the sudden rise of air temperatures and also the heavy precipitation in the period of full grain formation was effective in low seed yield (Figure 1).

Although the response to bacterial applications in the combined analysis was different, RL administration with its general lines showed an effect of increasing the seed yield (Table 3). Some researchers have also stated that *Rhizobium* significantly affects grain yield (Sharma et al. 1989; Vadavia et al. 1991; Khan et al. 1992).In *Arthrobacter agilis* applications, negative reaction has emerged. Sufficient phosphorus content of soils can be effective in this bacterium. However, the reaction in the first year in the Urunlu type is negligible. Therefore, it can be stated that *Rhizobium* vaccination is necessary in Erzurum and similar ecologies especially in seed pea cultivation. Phosphorus solvent bacteria appears to be useful under favorable conditions. This effect can be more pronounced especially in cooler years.

1000 Seeds Weight

In the first year of the experiment, the average weight of a thousand seeds was 200.7 g. In the application of phosphorus between 197.0 and 205.0 g. In bacteria applications between 196.5 and 210.3 g. In the second year of the experiment, the average weight of 1000 seeds was 180.7 g. In this year, the seeds of the seeds of Kirazli was 175.6 g and the weight of the seeds of the Urunlu varieties was 185.8 g. This difference between the thousand-weight of varieties was not significant. One thousand seeds weight is an indication of the seed size of the plant. The seeds of the two pea varieties (Kirazli ve Urunlu) were found to be similar in this study. There are similarities in terms of seed size, which are already recorded by the breeding institution (Anonymous, 2004). In the combined analysis of years, this difference in the weight of thousands of thousand weights ranging from 188.1 to 95.4 g as a result of phosphorus fertilizer applications did not show statistical significance. The difference between the weight of thousands of grain in the second year in the second year during the filling period of hot and dry weather was effective. Since the drought is shortened by the grain filling period, the decrease in the amount of assimilate to be reduced to the grain is expected to be a result (Kacar, 1996; Kocacaliskan, 2004). As a matter of fact, this situation was effective in the decrease of one thousand seeds weight in the second year. The fact that the phosphorus content of the soils is not sufficient to record the reaction of phosphorus fertilizer in terms of thousand weight has been effective. The values recorded in terms of one thousand grain weight were similar to the studies on this subject (Uzun and Acikgoz, 1998; Anlarsal et al. 2001; Uzun et al. 2005).

Crude Protein Ratio in Seeds

In the first year of the experiment, there was no significant difference between the varieties of the crude protein ratio of 29.0%.The seeds of Kirazli have 29.1% crude protein and 29.2% crude protein. In the first year, the rate of crude protein in the seed, which is 29.1% against phosphorous fertilizer applications and does not change according to the doses, has changed between 28.4% and 29.6% depending on the bacterial applications. Bacterial applications showed an effect of increasing the rate of seed crude protein in Kirazli type, while decreasing effect on the Urunlu type.

In the second year of the experiment, the seeds of Kirazli were 32.7% and the seeds of the Urunlu were 33.5% of crude protein. In the second year, the application of phosphorous fertilizer showed a decreasing effect on the ratio of grain crude protein. The rate of seed crude protein in bacterial applications ranged from 32.8 to 33.4%.The resulting change was not statistically effective. As the second year of the experiment has been drilled, less asimylate has been transported to the grain since it shortens the filling period. As a result, the proportion of crude protein is proportionally increased as carbohydrate decreases proportionally. As a matter of fact, the rate of crude protein in the grain due to drought increased in Ozturk and Caglar (1999) and Mut et al. (2007) by wheat, Dwivedi et al. (1996) by peanuts.

In the combined analysis, the effect of phosphorus fertilizer application on the grain protein ratio was not recorded. The rate of grain crude protein, which was 31.2% on average, ranged from 30.8% to 31.6%, depending on the applications. Although phosphorus application causes an increase in the grain protein content in legumes (Erman et al. 2009), the phosphorus level of the test area soils has prevented this result. The ratio of the crude protein ratio in the bacterial applications ranged from 30.8% to 31.6%, which was 31.2%, and therefore the bacterial applications did not affect the protein content of the peas.

In this study, a significant increase in crude protein ratio was observed in RL and Kirazli varieties seeds. The decrease in Urunlu is probably due to the effect of bacteria on plant physiology. In many studies, the effect of the bacteria on the year and the environment and changed to according to the variety of plants (Şahin et al. 2004; Lucy et al. 2004; Khalid et al. 2004; Çakmakçı et al. 2006). As a result, the Kirazli variety, which can produce satisfactory seeds in the region, has around 30% grain protein content. With this aspect can be a good alternative protein source for the concentrated feed industry. Inoculation of the plant with RL yields positive results both in terms of seed yield and crude protein content.

Conclusion and Suggestions

As a result of today's modern agricultural practices, intense, inaccurate and excessive chemical fertilizers and pesticides are used. In particular, chemical fertilizers are washed to reach fresh water sources and cause environmental pollution. This situation negatively affects people and the environment in which they live. Prevention of environmental pollution, agricultural sustainability and natural resources need to be protected. Therefore, the use of chemical inputs should be reduced or the applications should be expanded by using environmentally friendly techniques and necessary research should be carried out.

When the results are evaluated as a whole, it can be stated that Kirazlı variety is more suitable for seed production in the region. Because the yield differences were not much compared to years and seed yield was significantly higher than the Urunlu variety. With this aspect, it is a good alternative for seed feed production. When the reaction areas of phosphorous fertilizers were not sufficient, the phosphorus content of the soil was effective. Before sowing in the area to be planted in the pea, soil analysis should be done to determine whether or not to give phosphorus fertilizer. If the test area is poor in terms of phosphorus, phosphorus should be added.

It is not correct to make a clear judgment on the results of this experiment on phosphorus-soluble bacteria. Some characteristics showed a good response for one year, the next year the opposite situation has arisen. This is due to the change of bacteria response to changing environmental conditions. Based on these results, it can be said that it would be beneficial to develop bacterial strains that will have a positive effect on the wider environmental range and to try to obtain a more healthy result in poor soil in terms of phosphorus. Rhizobium inoculation has responded positively to the trial. This response is more pronounced in the insufficient soils of Rhizobium. Based on soil analysis, it would be more appropriate to decide on inoculation.

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