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Effect of Bacterial Inoculation and Different Phosphorus Doses on Yield Components and Yield of Chickpea (*Cicer arietinum* L.)

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ABSTRACT

This research was carried out in 2014-15 to determine yield and yield components of Azkan chickpea (*Cicer arietinum* L.) varieties with four different phosphorus doses and rhizobium bacteria in Van-Gevaş ecological conditions. The experiment was established as a randomized block design with three replications. The results of the research indicated that inoculation and phosphorus doses affected plant height, height of first pods, number of branches per plant, number of pods per plant, number of grain per plant and grain yield significantly. Grain yield averages ranged between 1556.10-1682.30 kg ha^{-1} in the first year and 1628.90-1677.30 kg ha^{-1} in the second year. When the results of inoculation and phosphorus doses were examined, the highest grain yield in both the years (1894.90-1867.70 kg ha^{-1}, respectively) was obtained with 80 kg ha^{-1} phosphorus doses applied to inoculated plots. Increases in inoculation and phosphorus doses increased the grain yield.

Key words: Chickpea, Nitrogen, Phosphorus, Yield components, Yield.

INTRODUCTION

With the increasing population in the world and in our country, the protein malnutrition has become an important problem. Protein-based nutrition plays an important role in the solution of this problem. Two different sources are used to address this problem. The first one is the production of animal foods and the other is the production and consumption of legumes. Legumes are grain crops grown after cereals in field.

Legumes are of great importance as a source of protein. In the world, 22% of plant proteins in human nutrition and 7% of carbohydrates, 38% of proteins in animal nutrition and 5% of carbohydrates are obtained from edible legumes. Chickpea is a rich source of highly digestible dietary protein (17-21 per cent), carbohydrate (61.5 per cent) and fat (4.5 per cent). It is also rich in Ca, Fe, niacin, vitamin-B and vitamin-C (Pingoliya *et al*., 2013).

In addition to the development of high-quality varieties, suitable cultivation techniques in different ecologies should be tried. One of these techniques is undoubtedly fertilizing (Yağmur and Engin, 2005).

The expected benefit from fertilization in terms of yield and quality in plant production depends on applying the right fertilizer source at the right time, with the right methods and in appropriate amounts (Havlin *et al*., 2004). The amount of chemical fertilizer consumed per unit area in Turkey is below the European average and there are important problems in fertilizer consumption. It is not possible to say that the consumption of fertilizers effective per unit area is still at sufficient levels (Adiloğlu and Adiloğlu, 2005; Taban *et al.*, 2005).

Phosphorus is the second macro nutrient that is absolutely essential for optimum growth and development in plants. Phosphorus accounts for about 0.2% of the dry weight of the plant and is involved in numerous physiological and biochemical reactions taking place in the plant (Theodorous and Plaxton, 1993).

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It produces sugar and starch in photosynthesis and energy production by oxidation of sugar and starch in respiration. It promotes flowering, seed binding, early growth and root formation, accelerates ripening and increases seed/fruit production. It is involved in the transport of nutrients and other compounds. In particular, transport of organic compounds to storage organs and seeds requires energy. Organic acids secreted out of plant roots increase the penetration of phosphorus into the cell as $H_2PO_4^{-1}$ by acidifying the root region (Schachtman *et al.,* 1998).

Plants can also absorb soluble organic phosphates containing nucleic acid under certain conditions. Since the phosphorus movement in the soil is limited, root development and activity are extremely important in terms of phosphorus absorption (Lynch, 1995). Almost all of the phosphorus absorbed by the roots is transported to the young leaves by xylem. The concentration of phosphorus in xylem ranges from 1-7 mM (Mimura *et al*., 1990). Sharma *et al*. (1989) and Vadavia *et al*. (1991) reported that the inoculation with rhizobium bacteria significantly affected the grain yield in chickpeas. Rupela *et al.* (1987) reported that rhizobium bacteria are susceptible to drought, salinity and extreme temperatures in the symbiotic relationship. In this study, it was aimed to determine the response to inoculation at different phosphorus doses in order to obtain high grain yield in chickpea in Van province.

MATERIALS AND METHODS

This experiment was carried out in 2014 and 2015 in Van-Gevaş ecological conditions on farmer's land where Chickpea was not cultivated before. The climate conditions prevailed during experimental period is given in Table 1. The soil of the experimental site was collected from 0-20 cm depth and analyzed for physical and chemical properties (Table 2).

The soil was slightly alkaline in reaction and moderate in organic matter content. The soil was found to be low in lime, poor in phosphorus and zinc, and rich in potassium.

The experiment was conducted in 2014 and 2015 as per the randomized blocks design. Azkan chickpea variety was used in the experiment. The treatments comprised of 4 phosphorus doses *viz*. 0, 40, 60 and 80 kg ha^{-1} and two bacterial inoculations *viz*. inoculated and uninoculated replicated four times. The distance between the rows was 35 cm and the plot area was 4.5 m^2. Before planting, 100 kg seed was inoculated with 1 kg pith culture (Vincent, 1970). First year plantings were done in early morning and April 17, 2014, 2nd year and April 12, 2015 by hand in order to prevent bacterial damage. After sowing, the rows were determined with a marker and the lines were sown 6-8 cm deep with anchors and planted with 45 seeds per m^2. At harvest, observations on growth and yield parameters were recorded from the net plot area leaving half meter from all sides. The experiment was carried out under arid conditions and watered only once to ensure the emergence of the plants. Cream crushing and weed control were done with hoe as needed. Harvest operations were carried out manually on 24.07.2014 in the first year and 20.07.2015 in the second year. The results obtained were subjected to variance analysis according to randomized block design. Duncan (5%) multiple comparison test (Düzgüneş *et al*., 1987) and Costat and Mstatc package programs were used for analysis of the data.

RESULTS AND DISCUSSION

Number of nodules per plant

At the flowering period of the plants, nodules were counted on 10 plant roots selected randomly from each treatment plots. Active nodules with very few nitrogen binding properties were detected on the roots. In this case, healthy nodule count could not be obtained due to inadequate irrigation water and soil salinity (Yağmur and Engin 2005). However, it is thought that the number of nodules is higher for the research areas due to the difference in rainfall. It is reported that nodule formation was significantly affected from phosphorous and soil salinity (Lal *et al*., 2014; Rupela *et al*., 1987). Islam (1981) reported that chickpea nodule formation is better in winter planting than in summer planting.

Plant height

The effect of inoculation and phosphorus doses on plant height of chickpea was statistically significant in both the years of study. Interactions between applications were found insignificant in both years of the trial (Table 3). Inoculation has been shown to increase plant height. Inoculation recorded 49.80-50.38 cm plant height in the first and second year, respectively. Without inoculation these values were 46.03-46.75 cm (Table 3). Lal *et al*. (2014) reported that the

Table 1: Climate data of the trial site*.

Months	2014					2015				
	Temperature (°C)			Average Moisture (%)	Rain (mm)	Temperature (°C)			Average Moisture (%)	Rain (mm)
	Min	Max	Ave.			Min	Max	Ave.		
May	6.5	24.3	13.6	62.3	48.7	8.6	27.5	14.4	54.7	31.6
June	12.0	34.5	18.0	56.0	15.0	13.0	34.1	18.1	39.0	11.2
July	17.3	37.2	20.7	46.7	3.2	18.0	37.9	21.7	39.2	-
August	17.5	35.9	21.1	42.0	1.8	17.1	36.4	21.5	38.7	0.8
September	13.4	30.4	16.2	45.3	4.6	13.8	32.0	16.9	40.4	-
Average	13.3	32.5	17.9	50.5		14.1	33.6	18.5	42.4	
Total					73.3					43.6

*Van Meteorology Regional Directorate Records.

Table 2: Physico-chemical properties of the test soil at a depth of 0-30 cm*.

Years	Texture	Total Salt (EC)	pH	Calcanty (%)	Available K (K_2O) (kg ha^{-1})	Available P (P_2O_5) (kg ha^{-1})	Organic Matter (%)	Available Zn (kg ha^{-1})
2014	Sandy-Loam-Clay	0.038	7.1	8.22	495.0	33.8	2.47	3.01 (Poor)
2015	Sandy-Loam-Clay	0.044	7.6	8.06	513.0	27.6	2.32	2.86 (Poor)

*Van Commodity Exchange was conducted in soil analysis laboratories, 2015.

effect of inoculation on plant height increased depending on the number of nodules.

The increasing phosphorus doses increased plant height in both the years of study. The highest plant height was obtained with the application of 80 kg ha^{-1} phosphorus. The lowest plant height value was recorded with no phosphorus application. In a similar study, Yağmur and Engin (2005) reported that phosphorus doses did not cause a statistically significant increase in plant height. According to Rethore and Patel (1991), phosphorus doses caused an increase in plant height. This difference between the results is thought to be due to different ecological factors and varieties.

First pod height

The effect of inoculation, phosphorus doses and their interactions on the number of first pod height in the plant was statistically insignificant (Table 4). Genotype and environmental factors significantly influence the first pod height (Fehr, 1987).

Number of branches per plant

The effect of inoculation and phosphorus doses on the number of branches in chickpea was found to be statistically significant. However, their interactions were found non-significant (Table 5).

It was observed that inoculation increased the number of branches in the plant. The number of branches per plant in both the years was 8.52-8.05, respectively, the number of branches in uninoculated applications were 6.86-7.46 (Table 5).

Increased phosphorus doses were found to increase the number of branches in the plant. The highest number of branches was 8.24-8.76 in 80 kg ha^{-1} phosphorus applications, respectively. The lowest number of branches

Table 3: Groups and average values of chickpea plant length*.

Bacterium	2014					2015				
	Phosphorus Doses (kg ha^{-1})					Phosphorus Doses (kg ha^{-1})				
	00.0	40.0	60.0	80.0	Avg.	00.0	40.0	60.0	80.0	Avg.
Uninoculated	43.76	45.89	46.21	48.26	46.03 B	45.38	46.19	46.81	48.62	46.75B
Inoculated	48.44	48.71	50.81	51.26	49.80A	48.72	49.06	51.76	52.01	50.38A
Average	46.10B	47.30AB	48.51AB	49.76A		47.05B	47.64B	49.28AB	50.31A	
Years Avg.			47.91B					48.56A		
$LSD_{0.05}$			2.7012					2.3745		
C.V (%)			6.91					5.55		

*Values shown in uppercase are significant at 1% (P <0.01) and values shown in lowercase at 5% (P <0.05) are significant.

Table 4: Groups and average values of the first pod in chickpea*.

Bacterium	2014					2015				
	Phosphorus Doses (kg ha^{-1})					Phosphorus Doses (kg ha^{-1})				
	00.0	40.0	60.0	80.0	Avg.	00.0	40.0	60.0	80.0	Avg.
Uninoculated	31.08	33.09	33.14	31.44	32.18	32.71	32.49	30.58	33.95	32.43
Inoculated	34.93	33.39	32.87	34.42	33.90	33.64	32.17	33.12	34.81	33.43
Average	33.00	33.24	33.00	32.93		33.17	32.33	31.85	34.38	
Years Avg.			33.04					32.93		
$LSD_{0.05}$			2.6625					1.9233		
C.V (%)			9.16					6.55		

*Values shown in uppercase are significant at 1% (P <0.01) and values shown in lowercase at 5% (P <0.05) are significant.

Table 5: Number of branches and average values of the number of branches in chickpea plant*.

Bacterium	2014					2015				
	Phosphorus Doses (kg ha^{-1})					Phosphorus Doses (kg ha^{-1})				
	00.0	40.0	60.0	80.0	Avg.	00.0	40.0	60.0	80.0	Avg.
Uninoculated	5.64	6.92	7.40	7.51	6.86B	5.80	7.40	8.10	8.56	7.46B
Inoculated	8.00	8.32	8.81	8.97	8.52A	7.25	8.00	8.01	8.97	8.05A
Average	6.70C	7.62B	8.10AB	8.24A		6.52C	7.70B	8.05AB	8.76A	
Years Avg.			7.69					7.75		
$LSD_{0.05}$			0.8743					0.7028		
C.V (%)			12.96					10.34		

*Values shown in uppercase are significant at 1% (P <0.01) and values shown in lowercase at 5% (P <0.05) are significant.

(6.70-6.52) was obtained from the control (Table 5). The most important action of phosphorus in plants is to promote cell division as well as being an effective element in the formation of new tissue. Dahiya *et al.* (1993) and Vadavia *et al.* (1991) reported that phosphorus applied to the seed enhanced the branching of the plant.

Number of pods per plant

The inoculation and phosphorus doses and their interactions had significant effect on the number of pods per plant, in both years (Table 6).

The numbers of pods per plant (23.83-22.81) were increased by inoculation as compared to uninoculated (20.48-21.71). In terms of number of pods per plant, higher values were found in inoculated than in uninoculated treatments. This finding was similar to those of Hernandez and Hill (1983) and Akdağ (1990).

Increased phosphorus doses increased the number of pods per plant. The highest number of pods per plant was obtained from the phosphorus dose of 60 kg ha^{-1} *viz*. 23.80-23.86 in both the years, respectively. The lowest number of pods was obtained from the control plots (Table 6). Vadavia *et al*. (1991) and Rathore and Patel (1991) reported that nitrogenous and phosphorus fertilization increased the total number of pods.

The interaction effect inoculation and phosphorus dose on the number of pods per plant was found to be significant. In both the years of experiment, the highest numbers of pods were obtained from 60 kg ha^{-1} phosphorus application along with inoculation. The lowest value was obtained in the un-inoculated with no phosphorus application (Table 6). The number of pods and the numbers of grains in the pods are important features that directly affect the grain yield.

Table 6: Number of pods in chickpea plant groups and average values*.

Bacterium	2014					2015				
	Phosphorus Doses (kg ha^{-1})					Phosphorus Doses (kg ha^{-1})				
	00.0	40.0	60.0	80.0	Avg.	00.0	40.0	60.0	80.0	Avg.
Uninoculated	19.05d	19.54d	21.85b	21.49b	20.48B	17.74d	21.85c	25.06b	22.19a	21.71B
Inoculated	20.67c	25.06a	25.75a	23.86a	23.83A	19.73c	21.89c	25.83b	23.80a	22.81A
Average	19.86B	22.30B	23.80A	22.67B						
Years Avg.			22.15					22.26		
$LSD_{0.05}$			1.6825					1.4638		
C.V (%)			8.64					7.46		

*Values shown in uppercase are significant at 1% (P <0.01) and values shown in lowercase at 5% (P <0.05) are significant.

Table 7: Groups and average values of the number of seeds in chickpea plants*.

Bacterium	2014					2015				
	Phosphorus Doses (kg ha^{-1})					Phosphorus Doses (kg ha^{-1})				
	00.0	40.0	60.0	80.0	Avg.	00.0	40.0	60.0	80.0	Avg.
Uninoculated	15.71c	20.04b	20.64b	24.44a	20.20B	14.02d	24.61b	20.64c	24.44b	20.92B
Inoculated	15.91c	23.51ab	24.61a	25.14a	22.29A	16.53d	24.80b	21.19c	28.14a	22.64A
Average	15.81C	21.77BC	22.62AB	24.29A		15.27C	24.70A	20.91B	26.29A	
Years Avg.			21.62					21.78		
$LSD_{0.05}$			1.8538					1.4878		
C.V (%)			9.77					7.79		

*Values shown in uppercase are significant at 1% (P <0.01) and values shown in lowercase at 5% (P <0.05) are significant.

Table 8: Groups and average values of chickpea grain yield*.

Bacterium	2014					2015				
	Phosphorus Doses (kg ha^{-1})					Phosphorus Doses (kg ha^{-1})				
	00.0	40.0	60.0	80.0	Avg.	00.0	40.0	60.0	80.0	Avg.
Uninoculated	1376.6	1526.9	1579.5	1741.6	1556.1B	1402.1	1603.9	1718.3	1791.6	1628.9B
Inoculated	1441.6	1622.7	1770.3	1894.8	1682.3A	1465.5	1605.7	1770.3	1867.7	1677.3A
Average	1409.1D	1574.8C	1674.9B	1818.2A		1433.8C	1604.8B	1744.3A	1829.6A	
Years Avg.			1619.2B					1653.1A		
$LSD_{0.05}$			5.2848					4.4432		
C.V (%)			7.50					6.25		

*Values shown in uppercase are significant at 1% (P <0.01) and values shown in lowercase at 5% (P <0.05) are significant.

Especially environmental factors and cultural practices can be determinative of this number. Increases in the number of pods occur in plants, especially as the phosphorus intake is encouraged in the years when rainfall is high and the temperature values are at optimum levels. The low soil temperature is an important environmental factor that restricts phosphorus uptake in plants (Connor *et al*. 2011). It has been reported by different researchers that the number of pods in pulses increase due to increased phosphorus uptake (Çetin and Öztürk, 2012).

Number of grain per plant

In both the years of study, the effect of inoculation, phosphorus doses and their interactions on the number of grains in chickpea was found to be statistically significant (Table 3). Inoculation has been shown to increase the number of grains in the plant. As a result of inoculation, the maximum number of grains was 22.29-22.64 in the first and second year, respectively. These values were 20.20-20.92 in uninoculated application. In similar studies, a higher number of grains were obtained in the inoculated treatments (Hernandez and Hill, 1983).

Increasing phosphorus doses increased the number of grains per plant in both years of the study. The highest number of grains per plant was with 80 kg ha^{-1} phosphorus along with the inoculation. The lowest grain numbers were recorded with no phosphorus application (Table 7). Yağmur and Engin (2005) reported that increased doses of phosphorus increased the number of grains per plant.

Phosphorus is one of the basic elements limiting plant growth. Since it is usually in insoluble form in soil, its availability in general is in sufficient. A large part of the inorganic phosphorus applied as fertilizer is transformed into unavailable form by plants after application. Intensive use of fertilizers to meet phosphorus deficiency causes high costs and environmental problems. In order to reduce the use of chemical fertilizers in agriculture, the use of P-solvent microorganisms is important. Erdin and Kulaz (2014) reported positive effect of phosphorus on grains per plant in chickpea.

Grain yield

The effect of inoculation and phosphorus doses on grain yield was found to be statistically significant. However, the interactions between them were found insignificant (Table 8).

The effect of inoculation on seed yield of chickpea was found to be important. It recorded 1682.30-1677.30 kg ha^{-1} in the first and second years, respectively. In uninoculated applications, these values were lower (1556.10-1628.90 $kgha^{-1}$) (Table 8). Similar results were also reported by Akdağ(1990).

The increasing phosphorus doses increased grain yield in both the years of research. The highest grain yield was obtained from the application of 80 kg ha^{-1} phosphorous (1894.80-1867.70 kg ha^{-1}) and the lowest grain yield was observed with no phosphorus application (1376.60-1402.10 kg ha^{-1}). It is reported that the effect of irrigation and correct and adequate fertilizer applications is important for the increase in grain yield (Dahiya *et al.,* 1993 and Yağmur and Engin, 2005). The application of phosphorus 60 kg P_2O_5 / ha has been reported result in a statistically significant growth, yield characteristics and increase in seed yield compared to formal levels (Meena *et al*. 2006).

CONCLUSION

On the basis of this study it may be concluded that phosphorus is an important factor determining the yield of chickpea and along with optimum dose of phosphorus seed inoculation with appropriate strains rhizobium and phosphorus soluble bacteria enhance the availability nutrients and increase the seed yield.

REFERENCES

Adiloğlu, A. and Adiloğlu S. (2005). An Invertigation on nutritional problems of hazelnut (*Corylus avellana*) grown in acid soils. Communications in Soil Science and Plant Analysis. 36: 2219-2226.

Akdağ, C. (1990). Bakteri (*Rhizobium* ssp.) aşılama, azot dozları ve ekim sıklığının nohut (*Cicer arietinum* L.)'un verim ve verim unsurlarına etkileri. *Ankara Üniversitesi Fen Bilimleri Enstitüsü*, Doktora Tezi, Türkiye.

Connor, D.J., Loomis, R.S., Cassman, K.G. (2011). Crop ecology productivity and management in agricultural systems second edition, Cambridge, pp. 562.

Çetin, S. H. and Öztürk, Ö. (2012). Soyada farklı fosfor dozlarının verim ve verim unsurları üzerine etkisi. Tarım Bilimleri Araştırma Dergisi. 5: 157-161.

Dahiya, S., Singh, M., Singh, M. (1993). Relative growth performance of chickpea genotypes to irrigation and fertilizers application. Haryana Journal of Agronomy. 9: 172-175.

Düzgüneş, O., Kesici, T., Koyuncu, O., Gürbüz, F. (1987). Araştırma ve deneme metotları. AÜ, Ziraat Fak. Yayınları: 1021 Ders Kitabı. 295: 381.

Erdin, F. and Kulaz, H. (2014). Van-Gevaş ekolojik koşullarında bazı nohut (*Cicer arietinum* L.) çeşitlerinin ikinci ürün olarak yetiştirilmesi. Turkish Journal of Agricultural and Natural Science. 1: 910- 914.

Fehr, W.R. (1987). Genotyp x enviroment interaction. principles of cultivar development, Vol: I. Theory and Tecnique (Ed. W.R. Fehr). Macmillan Publishing Company, New York. 1: 247-260.

Havlin, J.L., Tisdale, S.L., Nelson, L.N., Beaton, J.D. (2004). Soil fertility and fertilizers: an introduction to nutrient management, 7th Edition. Prentice Hall. pp 528, ISBN:10-013027824.

Hernandez, L.G. and Hill, G.D. (1983). Effect of plant population and inoculation on yield and yield components of chickpea (*Cicer arietinum* L.). Proceedings. Agronomy Society of New Zealand. 13: 75-79.

Islam, R. (1981). Nodulation aspects of winter-planted chickpeas. Proceedings of the Workshop on Ascochyta Blight and Winter Sowing of Chickpeas. Aleppo (Syria). 4-7 May 1981.

Kumbhare, N.V., Dubey, S.K., Nain, M. S., Bahal, R. (2014). Micro analysis of yield gap and profitability in pulses and cereals. Legume Research-An International Journal. 37: 532-536.

Lal, B., Rana, K.S., Rana, D.S., Gautam, P., Shivay, Y.S., Ansari, M.A. and Kumar, K. (2014). Influence of intercropping, moisture conservation practice and P and S levels on growth, nodulation and yield of chickpea (*Cicer arietinum* L.) under rainfed condition. Legume Research. 37: 300-305.

Lynch, J. (1995). Root architecture and plant productivity. Plant Physiol. 109:7-13.

Meena, L.R., Singh, R.K., Gautam, R.C. (2006). Effect of moisture conservation practices, phosphorus levels and bacterial inoculation on growth, yield and economics of chickpea (*Cicer arietinum* L.). Legume Research. 29: 68-72.

Mimura, T., Dietz, K.J., Kaiser, W., Schramm, M., Kaiser, G., Heber, U. (1990). Phosphate transport across biomembranes and cytosolic phosphate homeostasis in barley leaves. Planta. 180: 139–146.

Pingoliya, K.K., Mathur, A.K., Dotaniya, M.L., Jajoria, D.K., Narolia, G.P. (2013). Effect of phosphorus and iron levels on growth and yield attributes of chickpea (*Cicer arietinum* L.) under agroclimatic zone IV a of Rajasthan, India. Legume Research. 37: 537-541.

Rathore, A.L. and Patel, S.L. (1991). Response of late sown chickpea to method of sowing, seed rate and fertilizer. Indian J. of Agron. 36: 180-183, India.

Rupela, O.P. and Rao, J.V.D. (1987). Effects of drought, temperature and salinity on symbiotic nitrogen fixation in legumes, with emphasis on chickpea and pigeonpea. Adaptation of Chickpea and Pigeonpea to Abiotic Stresses: Proceedings of the Consultants Workshop. Patancheru, A.P. (India). ICRISAT. pp. 123-131.

Sharma, A.K., Haribendra, S., Sushil., S., Singh,. H., Singh, S. (1989). Response of *Cicer arietinum* L. to rhizobial and N fertilization. Indian J. of Agron. 34: 381-383.

Schachtman, D.P., Reid, R.J., Ayling, S. M. (1998). Phosphorus uptake by plants: from soil to cell. Plant Physiol. 116:447-453.

Taban, S., İbrikçi, H., Ortaş, İ., Karaman, M. R., Orhan, Y., Güneri, A. (2005). Türkiye' de gübre üretimi ve kullanımı. Türkiye Ziraat Mühendisliği Kongresi Bildiri Kitabı, Ankara. 2: 847-867.

Theodorous, M. and Plaxton, W. (1993). Metabolic adaptations of plant respiration to nutritional phosphate deprivation. Plant Physiol. 101: 339-344.

Yağmur, M. and Engin, M. (2005). Nohut (*Cicer arietinum* L.)'ta fosfor ve azot dozları ile bakteri (*Rhizobium ciceri*) aşılamanın bazı morfolojik özellikler ile tane verimi üzerine etkileri ve bazı bitkisel özellikler arasındaki ilişkiler. Yüzüncü Yıl Üniversitesi, Ziraat Fakültesi, Tarım Bilimleri Dergisi (J. Agric. Sci.). 15: 103-112.

Varoglu, H. and Abak, K. (2019). Effect of sowing dates on yield and quality characteristics of chickpea varieties under Mediterranean climate conditions. Legume Research-An International Journal. 42: 360-364.

Vadavia, A.T., Kalaria, K.K., Patel, J.C., Baldha,. N.M. (1991). Influence of organic, inorganic and biofertilizers on growth yield on nodulation of chickpea. Indian Journal of Agronomy. 36: 263-264.

Vincent, J.M. (1970). Manual for the Practical Study of the Root-nodule Bacteria. I.B.P. Handbook No 15. Blackwell Scientific Pub. Oxfort: pp.164.