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The Effect of Planting Arrangement, Phosphorus and Nitrogen on Physiological Traits and Guar Yield (*Cyamopsis tetragonoloba* L.)

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ABSTRACT

Background: The guar, known as *Cyamopsis tetragonoloba* L., is an annual, summer plant of the legume family and importance of guar as a food, industrial and medicinal product is new in the cultivation pattern.

Methods: This combined experiment was conducted as factorial based on a randomized complete block design with three replications during two consecutive years (2020-2021) under the climatic conditions of Jiroft area (Kerman province, Iran) in the farm of research center and agricultural and natural resources education. Three levels of Nitrogen (20, 60 and 100 kg pure nitrogen per hectare) from a source of urea and phosphorus fertilizer at two levels (zero and 75 kg P_2O_5 source per hectare) and a source of monopotassium phosphate fertilizer and three levels of planting row spacing (30, 45 and 60 cm) equivalent to 47, 31 and 24 plants per square meter, plant density was taken into account.

Result: The highest chlorophyll a (2.69 mg/fresh weight), chlorophyll b (1.97 mg/fresh weight) and carotenoid (2.64 mg/fresh weight) was measured for guar in treatment $N_3P_2D_3$ under application nitrogen 100 kg/ha^{-1} + phosphorus 75 kg/ha^{-1} + planting row distance 60 cm, while the lowest chlorophyll a (1.85 mg/fresh weight), chlorophyll b (1.25 mg/fresh weight) and carotenoid (1.72 mg/fresh weight)was observed in treatment $N_1P_1D_1$ under nitrogen 20 kg/ha^{-1} + phosphorus zero kg/ha^{-1} + planting row distance 30 cm.

Key words: Chlorophyll, Cluster bean, Planting density, Proline.

INTRODUCTION

This plant has a high drought tolerance and is a good crop for semi-arid regions (Grover *et al.,* 2016) and it is called Cluster bean because the pods and flowers appear at the leaf-stem junction (Abidi *et al*., 2015). Mahla *et al.* (2020) reported due to the high industrial value and the sharp jump in demand, the cultivation of guar has also attracted the attention of farmers in the countries of Australia, Bangladesh, Myanmar, the United States of America, South Africa, Brazil, Congo and Sri Lanka. This plant grows in sandy loam soils with good drainage as well as in saline and relatively alkaline soils with a pH of 7.5 to 8.0 (Ghulam Nabi, 2013). This plant has almost deep roots and relatively rough leaves. Some varieties also have smooth leaves. This plant is about 1-2 meters high and has 15-21 seeds in each cluster Sij *et al.* (2002). The field where the guar gum are grown increases crop yields because the guar gum roots coexist with nitrogen-fixing bacteria after plowing and cultivating. Because the ability of plant roots in the soil to access nitrogen is improved (Undersander *et al.,* 1997). Optimum planting density per unit area of the field provides an appropriate nutritional space for a single plant and competitive balance between plants and ultimately achieves maximum yield. Nitrogen is one of the components of many important compounds such as proteins, nucleic acids, some hormones, chlorophyll and other types of primary and secondary constituents of plants (Hopkins, 2004).

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Therefore in rotation with cereals and seed plants. Nitrogen-rich oils are recommended (Lawson, 2009) because nitrogen deficiency reduces dry matter production, crude protein and seed yield (Ashiono *et al.,* 2005). Phosphorus is one of the most consumed and important elements in plant growth and development. It has a key role in the plant, such as participation in energy transfer reactions, plant metabolic processes, photosynthesis, cell division, formation of cell membrane phospholipids and development of reproductive parts (Abdolzadeh *et al.,* 2009).

Yield components are also affected by plant density. The results of researchers' investigations on three planting densities (22, 15 and 33 plants per square meter) of guar showed that the density of 33 plants per square meter increased the percentage of gum (galactomannan), protein, plant height, number of leaves, number of pods, number of seeds per pod, The weight of 100 seeds, pod length, seed yield were compared with other concentrations (Nandini *et al.,* 2017).

Nitrogen application increases the amount of crude protein and fiber, ash content, carbohydrates, leaf area of each plant and dry matter yield of cluster bean varieties (Shaykh *et al.* 2004; Khalid, 2004).

Since the south of Kerman is a hot and dry region in Iran, it is necessary to identify and cultivate plants specific to those regions by virtue of their existing conditions. In addition the drug can be included in the summer cultivation pattern. Therefore, the present study was designed and conducted to investigate the effect of planting arrangement, phosphorus and nitrogen on physiological traits and Guar yield to achieve the best treatment composition (planting row spacing, nitrogen and phosphorus) in southern Kerman province, Iran (Jiroft area).

MATERIALS AND METHODS

This study was performed to check the effect of planting arrangement, phosphorus and nitrogen on physiological traits and guar yield in the two cropping years of 2019-2020 and 2020-2021 in the Center for Agricultural Research and Education and Natural Resources of South Kerman province, Iran (Jiroft area).

The research center is in Jiroft city with a longitude of 57°41′N and latitude of 28°37′E. 627 meters above sea level with mild winters and hot and dry summers. The average monthly rainfall is 64 mm, the greatest temperature is 48°C and minimum temperature is 4°C and the relative humidity is zero to 65% (Table 1).

The experiment was performed as a factorial experiment in a randomized complete block design with three replications, n which nitrogen was applied at three levels (20, 60 and 100 kg/ha) from urea and phosphorus fertilizers at two levels (0 and 75 kg/ha). P_2O_5 base from the source of monopotassium phosphate fertilizer and planting row spacing at three levels (30, 45 and 60 cm) equivalent to 47, 31 and 24 plants per square meter, plant density. The experimental treatments are shown in Table 2.

In both years, after selecting the location of the project, in order to determine the physical and chemical properties of the soil before starting the land preparation operation, samples were taken from a depth of 0 to 30 cm from different parts of the field, soil analysis included the measurement of pH, EC, potassium percentage, nitrogen percentage, phosphorus percentage and soil texture class (Table 3).

Each plot consisted of four streams and ridges with intervals and sizes according to the levels of planting spacing treatments. The distances between the plants were 7 cm and the distance between each replication was two meters. Planting was done in the second half of July and irrigation was done in drops with tape. Nitrogen levels were applied twice (4 to 6 leaf stage and flowering stage) and phosphorus levels were applied in the 4 to 6 leaf stage. Height of the bush, number of leaves, dry weight of the bush and fresh bush weight of 5 plants were measured and recorded in each plot. The product was measured in two middle rows after removing the margin and pounding the samples to measure seed yield. The measured morphological and agronomic traits included leaf number, fresh bush weight, bush dry weight, seed yield and seed gum content and harvest index.

Measurement of physiological traits

The method of Bates *et al*. (1973) was used to measure the proline content was calculated from the procedure of Grieve and Grattan (Grieve and Grattan, 1983). Hiscox and Israels tam, (1979) was used to measure the number of carotenoids and chlorophyll a and b in leaf samples.

Table 1: Mean, maximum and minimum temperature and total monthly rainfall registered 2020 in Kerman South (Jiroft area).

Month	Temperature			Total monthly rainfall (mm)
	Average °C	Maximum °C	Minimum °C	
March	20.2	30.8	11	64.1
April	29.1	39.8	14.4	2.9
May	33.8	46.4	21	6.1
June	37.8	48.2	26.8	0
July	38.1	46.2	28.6	0.8
August	37.2	44.4	27	2
September	33.6	43	22	0
October	29.2	39.4	17.8	0
November	20.9	33.6	9.6	6
December	15.3	38	4	0
January	13.5	18	9	10
February	19.5	24	15	22

Statistical analysis

The data were normalized after collection and then analyzed using SAS software and the averages were compared with the LSD test.

RESULTS AND DISCUSSION

The mean comparison results showed (Table 4) that the $N_3P_2D_3$ treatment with the highest amount of chlorophyll at 2.69 mg/gr and the $N_1P_1D_1$ treatment had the lowest chlorophyll at 1.85 mg/gr. In general, the amount of cluster bean chlorophyll increased with the row spacing and the application of nitrogen and phosphorus. Phosphorus and nitrogen high levels on the one hand and a suitable space between rows lead to improved vegetative growth, increasing the number of leaves, light absorption level, chlorophyll and photosynthesis level in plants (Ajeng *et al.,* 2020). According to the property research of Maleki Narg *et al.* (2013), the consumption of nitrogen fertilizer increased the content of photosynthetic pigments in sweet corn. By increasing the plant density of maize per surface unit, the chloroplast is disturbed and the thylakoid structure is destroyed, which provides the basis for reducing the chlorophyll content per unit area (Ren *et al.,* 2017). In fact, it seems that the increase in seed yield is caused by using fertilizer, the essential role of nitrogen in the structure of chlorophyll and the synthesis of proteins and enzymes and leaf surface development and thus increases photosynthetic material. Nitrogen increases the yield of different varieties of guar by increasing the yield components (Behera *et al.,* 2000), but it has a significant impact on dry matter percentage Modaihsh *et al.* (2007). The mean comparison results showed (Table 4) that $N_3P_2D_3$ treatment had the highest amount of chlorophyll b at 1.97 mg/g and $N_1P_1D_1$ treatment had the lowest amount of chlorophyll b at 1.25 mg/gr. In general, the amount of cluster bean chlorophyll b increased with the row spacing and the application of nitrogen and phosphorus. At high levels of nitrogen and phosphorus, the spacing of rows has a more decisive role in the amount of chlorophyll b, so that in $N_3P_2D_2$ treatments the lowest and $N_3P_2D_1$ in the following category $N_3P_2D_3$ has the highest amount of chlorophyll b. Koochekzadeh *et al.* (2018) reported that chlorophyll b decreased at high densities of safflower. Meena *et al.* (2006) reported on the effect of phosphorus and zinc fertilizers on the growth and quality of guar gum. Phosphorus fertilizer consumption at the rate of 40 kg per hectare, all tested traits including plant height, the number of branches per plant, amount of dry matter, leaf area index at 45 days after planting, chlorophyll content at 30, 45 and 60 days after planting, protein and gum content of bean cluster increased. The mean comparison results showed (Table 4) that $N_3P_2D_3$ treatment had the highest amount of carotenoids at

Table 2: Treatments description.

Treatment	Summary
$N_1P_1D_1$	Nitrogen 20 kg/ha + phosphorus zero kg/ha + planting row distance 30 cm
$N_1P_1D_2$	Nitrogen 20 kg/ha + phosphorus zero kg/ha + planting row distance 45 cm
$N_1P_1D_3$	Nitrogen 20 kg/ha + phosphorus zero kg/ha + planting row distance 60 cm
$N_1P_2D_1$	Nitrogen 20 kg/ha + phosphorus 75 kg/ha + planting row distance 30 cm
$N_1P_2D_2$	Nitrogen 20 kg/ha + phosphorus 75 kg/ha + planting row distance 45 cm
$N_1P_2D_3$	Nitrogen 20 kg/ha + phosphorus 75 kg/ha + planting row distance 60 cm
$N_2P_1D_1$	Nitrogen 60 kg/ha + phosphorus zero kg/ha + planting row distance 30 cm
$N_2P_1D_2$	Nitrogen 60 kg/ha + phosphorus zero kg/ha + planting row distance 45 cm
$N_2P_1D_3$	Nitrogen 60 kg/ha + phosphorus zero kg/ha + planting row distance 60 cm
$N_2P_2D_1$	Nitrogen 60 kg/ha + phosphorus 75 kg/ha + planting row distance 30 cm
$N_2P_2D_2$	Nitrogen 60 kg/ha + phosphorus 75 kg/ha + planting row distance 45 cm
$N_2P_2D_3$	Nitrogen 60 kg/ha + phosphorus 75 kg/ha + planting row distance 60 cm
$N_3P_1D_1$	Nitrogen 100 kg/ha + phosphorus zero kg/ha + planting row distance 30 cm
$N_3P_1D_2$	Nitrogen 100 kg/ha + phosphorus zero kg/ha + planting row distance 45 cm
$N_3P_1D_3$	Nitrogen 100 kg/ha + phosphorus zero kg/ha + planting row distance 60 cm
$N_3P_2D_1$	Nitrogen 100 kg/ha + phosphorus 75 kg/ha + planting row distance 30 cm
$N_3P_2D_2$	Nitrogen 100 kg/ha + phosphorus 75 kg/ha + planting row distance 45 cm
$N_3P_2D_3$	Nitrogen 100 kg/ha + phosphorus 75 kg/ha + planting row distance 60 cm

Table 3: Physical and chemical properties of the soil.

Physical properties					
Clay (%)	Silt (%)	Fine sand (%)		Soil texture	
12	18.5	69.5		Sandy loam	
Chemical properties					
pH	EC (ds/m)	Organic matter (%)	N (%)	P (ppm)	K (ppm)
7.4	2.23	0.48	0.48	7.5	2.1

2.64 mg/g and $N_3P_2D_2$, $N_3P_2D_1$ and $N_3P_1D_1$ treatments were in the next category and $N_1P_1D_1$ treatment had the lowest carotenoid content of 1.72 mg/g. High levels of nitrogen appear to have the greatest effect on carotenoids. The results showed that using nitrogen fertilizers has significant effects on the biochemical traits of cluster bean gum, causing a considerable increase in carotenoids, soluble sugar and seed protein (Gill and Tuteja, 2010; Xu *et al*. (2020).

The results of the average comparison showed (Table 4) the $N_2P_2D_3$ treatment with the highest proline content of 2.84 mg/g and the $N_3P_2D_1$ treatment had the lowest amount of proline of 1.52 mg/gr. In general, the amount of cluster bean proline increased with increasing the row spacing. Drought stress is obtained at long row intervals (60 cm) compared to short row distances due to the lack of canopy overlap and light penetration between the rows. The statements of Gao *et al.* (2020) indicate an increase in compatible osmolytes of proline and carbohydrates, enzymatic activities and secondary metabolites under drought stress conditions.

The highest seed yield-related to $N_2P_2D_2$ treatment at 4300 kg was not different from $N_1P_1D_2$, $N_3P_2D_2$ and $N_3P_1D_2$ treatments (Table 4).

Therefore, it can be concluded that the yield of guar is affected by planting intervals and nitrogen and phosphorus fertilizer levels have less effect on seed yield. Optimal application of 60 and 75 kg of nitrogen and phosphorus can produce maximum performance. With regard to planting tervals (density), it can be concluded that high densities (plant spacing with a short row, 30 cm) and more than desirable seed yield types reduce due to increased competition. Low densities of large row spacing (60 cm) reduce seed yield due to the reduction in the number of plants per unit area and yield components. Therefore, the optimal and desirable density, *i.e*., the distances between rows of 45 cm, is the best density for this plant and it is recommended that the results of Patel *et al.* (2002), who showed the highest yield in the row spacing of 45 cm be consistent. The results of researchers' studies on three planting densities (22, 15 and 33 plants per square meter) of guar gum showed that the density of 33 plants per square meter increased the percentage of gum (galactomannan) protein, the height of bush, the number of leaves, the number of pods, the number of seeds per pod, 100 seed weight, pod length, seed yield compared to other densities (Nandini *et al.,* 2017). The results showed that the application of the full recommended dose of fertilizers (15 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1}) significantly increased the seed and straw yields of cluster beans (guar gum) by 55.7 and 60.9 per cent over control, respectively Kumawat *et al.* (2006). Deka *et al*. (2015), in the study of the effect of planting date and distance on the growth and yield of cluster beans in the subtropical climate of India, stated that the planting date of July 1 at plant intervals of 30 × 45 cm, the highest pod yield was related to cluster bean. In studying the response of new cluster bean strains to different row

Table 4: Comparison of the means of physiological traits evaluated in guar under the effect of planting arrangement, phosphorus and nitrogen during 2019-2020. (pooled data of 2 years).

Treatment	Chlorophyll a mg/fresh weight	Chlorophyll b mg/fresh weight	Leaf carotenoid mg/fresh weight	Leaf proline mg/dry weight	Seed yield Kg/ha^{-1}
$N_1P_1D_1$	1.85h	1.25j	1.72h	2.39cd	2373 egf
$N_1P_1D_2$	2.05fg	1.29i	1.78gh	2.59b	3633bac
$N_1P_1D_3$	2.24bd	1.33h	1.83fh	1.9gh	1767g
$N_1P_2D_1$	2.28bd	1.39ef	1.92dg	2.57b	2460egdf
$N_1P_2D_2$	2.22ce	1.4e	1.97df	2.17e	2193egf
$N_1P_2D_3$	2.23bd	1.38eg	1.8gh	1.99fg	1850gf
$N_2P_1D_1$	2.32bc	1.46d	1.92dg	2.37d	2700edf
$N_2P_1D_2$	2.14df	1.37fg	1.93dg	1.83h	2420egdf
$N_2P_1D_3$	2.16df	1.39eg	1.96df	2.56b	2210egf
$N_2P_2D_1$	2.38b	1.33h	2.05cd	1.78hi	3220bdc
$N_2P_2D_2$	1.91gh	1.29hi	1.89dg	2.53bc	4200a
$N_2P_2D_3$	2.03fg	1.36g	2de	2.84a	2387egf
$N_3P_1D_1$	2.28bd	1.38eg	2.28b	1.84h	2850edc
$N_3P_1D_2$	2.1ef	1.37eg	2.2bc	2.12ef	4083ba
$N_3P_1D_3$	2.04fg	1.38eg	1.87eg	1.64ij	2480egdf
$N_3P_2D_1$	2.38b	1.52c	2.29b	1.52j	2850edc
$N_3P_2D_2$	2.37b	1.67b	2.28b	1.68ij	3720ba
$N_3P_2D_3$	2.69a	1.97a	2.64a	2.4cd	1987gf
$LSD_{1\%}$	0.29	0.18	0.29	0.25	1040.93
Mean squar	0.194**	0.047**	0.229**	1.057**	2619982**
CV(%)	6.06	6.62	1.91	5.51	17.65

Mean within columns followed by different letter are significantly different (LSD test, P≤0.05).

n.s * and **:Non-significant and significant at 5 and 1% probability levels, respectively.

spacing, the highest cluster bean seed yield was obtained at a row spacing of 30 cm (Akhtar *et al*., 2012). Increasing plant density increases seed yield per unit area to optimized density, but then, under the influence of competition, seed yield remains constant and, in some cases, decreases to some extent (Siadat *et al.,* 2013).

CONCLUSION

This experiment showed that the levels of nitrogen and phosphorus fertilizers affected the seed yield, therefore, the levels of chemical fertilizers alone cannot considerably affect seed yield. This can be below expectations or its low need for nutrients and legumes that can make a high percentage to meet its nutritional needs through atmospheric nitrogen fixation. Regarding planting row spacing, it can be concluded that low row spacing (30 cm) due to increased interspecies competition and high row spacing (60 cm) due to reduced density and reduced plant number per surface unit reduces function. High levels of nitrogen, phosphorus and row spacing affected physiological properties such as chlorophyll content, carotenoids and proline. Thus, the optical density was obtained with the aim of increasing the yield from the distances between rows of 45 cm, which is recommended.

Conflict of interest: None.

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