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Effect of planting distances on the growth and productivity of mung bean (*Vigna radaita* L.) varieties in southern Iraq

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Abstract

A field experiment during the fall season of 2023, it was conducted at the Agricultural Research Station affiliated to the College of Agriculture / University of Basra in the Garmat Ali area, north of Basra Governorate (latitude 30.57 north and longitude 47.80 east)) with the aim of knowing the effected of three planting distances(20, 25, 30 cm in growth , yield and quality of four genotypes of mung bean crop (local, Omrani, parto, Gohar). A factorial experiment was applied according to the arrangement of split_split plots using a randomized complete block design (R.C.B.D) with three replicates where the planting distances occupied the main plots and the varieties occupied the secondary plots (sub-plot).

The results of statistical analysis of the data showed the significant effect of the varieties on the study traits, as the V4 variety outperformed in most of the traits that included plant height, number of branches, number of leaves, leaf area and leaf area index, and achieved the highest seed yield of 1.583 tons ha1 and the highest percentage of protein in the seeds of 23.392%.

The results also showed that the 20 cm planting distance was superior in plant height, leaf area, leaf area index and achieved the highest seed yield of 1.708 tons/ha. While the interaction between the V4 variety and the 20 cm planting distance achieved the highest average number of leaves and leaf area, the interaction between the V4 variety and the 25 cm planting distance achieved the highest percentage of protein in the seeds, reaching 624.30%.

Keywords, mung bean, planting distances, Varieties, growth, yield and quality A field experiment during the fall season of 2023, it was conducted at the Agricultural Research Station affiliated to the College of Agriculture / University of Basra in the Garmat Ali area, north of Basra Governorate (latitude 30.57 north and longitude 47.80 east)) with the aim of knowing the effected of three planting distances(20, 25, 30 cm in growth , yield and quality of four genotypes of mung bean crop (local, Omrani, parto, Gohar). A factorial experiment was applied according to the arrangement of split_split plots using a randomized complete block design (R.C.B.D) with three replicates where the planting distances occupied the main plots and the varieties occupied the secondary plots (sub-plot).

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The results also showed that the 20 cm planting distance was superior in plant height, leaf area, leaf area index and achieved the highest seed yield of 1.708 tons/ha. While the interaction between the V4 variety and the 20 cm planting distance achieved the highest average number of leaves and leaf area, the interaction between the V4 variety and the 25 cm planting distance achieved the highest percentage of protein in the seeds, reaching 624.30%.

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I. Introduction

Mung beans (*Vigna radiata* L.) are an annual plant belonging to the legume family Fabaceae and are a staple crop in most countries that produce them, especially in developing countries. Mung beans are characterized by their short growing season and their tolerance to drought and temperature conditions. Mung beans are grown for many purposes, including the production of seeds used in human nutrition because they contain a high percentage of protein, reaching 29%, rich in essential amino acids, including lysine, which is low in grains and non-essential amino acids such as proline. They also contain riboflavin and minerals (Sidar et al., 2023). Mung beans seeds contain starch, sugar, oil, vitamins and carbohydrates. Mung beans are used in animal feed and as green manure to improve the natural properties of soil and in agricultural cycles in succession with grain crops because of their importance in fixing atmospheric nitrogen, increasing soil fertility and improving some of its physical properties by supplying it with nitrogen. Despite the importance of the crop, its productivity in Iraq is still low when compared to global production. Therefore, This crop must be given attention and its productivity increased by following all modern means and techniques, including introducing high-yielding varieties or genetic compositions, as one of the most important factors that restrict the productivity of the mung bean crop is the lack of improved varieties and the insufficiency of skills related to good agricultural practices that suit mung bean production (Binagwa et al., 2023), especially since the Iraqi farmer relies on the poorly productive local variety, which is characterized by its impurity, disease, and lack of resistance to lodging (Al-Sulagh, 2007). The planting distances have a clear effect on the number of plants and their distribution in the unit area, which affects the nature of competition between plants for various growth elements such as moisture, nutrients and sunlight, and the resulting effect on the physiological processes in the plant, which is reflected in the growth, productivity and quality of the crop. Establishing an ideal number of plants in the unit area is necessary to obtain maximum crop productivity, and high density seems necessary to benefit from other growth factors with high efficiency, as the size of the plant spread or the area occupied by the plant at the time of flowering affects the distances in which the crop plants should be placed. Many studies have indicated that varieties have a significant and significant effect on the growth characteristics and yield of the mung crop. In a study conducted on four varieties of mung crop BARI Mung-6, Binamoog-4, Binamoog-6 and Binamoog-8, it was found that there were significant differences between the varieties in the growth characteristics of the plant height, the number of branches in the plant, and the yield characteristics of the pod length, the number of pods in the plant, the seed yield and the harvest index. (Parvez et al., 2013), and Tanya et al. (2015) showed the significant effect of cultivars (PUSA 1- SHEKHAR 2- T9) on plant height, number of branches per plant, number of leaves and dry weight of plant, pod length, number of pods and seed yield. A study using two genetic combinations of mung bean crop (local-Indian VC6089A10) for the seasons 2012-2013 showed significant differences in growth traits of mung bean crop, number of leaves, leaf area and number of days from planting until full maturity of pods (Abdalgafor and Al-Jumaily, 2016). Patel et al. (2020) found significant differences between three varieties of mung bean (Meha, GM 4, GAM 5) in the traits of plant height, number of branches, number of days to physiological maturity, and number of days to 50% flowering. Mota et al. (2021) in their study on two varieties of mung bean (Shewa Robit - N-26) indicated significant differences in the studied growth and yield traits, number of days from planting to 50% flowering, number of days to physiological maturity, plant height, number of branches per plant, leaf area per plant and area index, seed yield and harvest index. Growth and yield traits of mung bean crop were also affected by planting distances between plants and gave different rates for each distance. Pulok et al. (2015) reported that there was a significant effect of planting distances of 15, 20, 25, 30 cm between holes in the traits. The studied traits, which included plant height, number of leaves, and dry matter weight, gave different averages for each trait, with the effect of the distance at which the plant was planted. Wubetu and Markos (2018) indicated in their study on mung bean crop planted with three distances between holes 5, 10, and 15 cm, that there was a significant effect on the traits he studied, the number of days from planting to physiological maturity, plant height, seed yield, and harvest index. Muchira et al., (2018) in their study on mung bean crop using three planting distances (40×15, 45×15, 50×15) cm found that it had a significant effect on growth and yield traits, which included plant height, number of leaves and dry weight in the plant, number of pods in the plant, total seed yield and harvest

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index. Siraje et al., (2020) found when studying three planting distances between holes for mung bean crop 5, 10, 15 cm a significant effect on the studied growth and yield traits, number of days from planting to 50% flowering and number of days until physiological maturity and plant height, biological yield, seed yield and harvest index. Tehulie and Fikadu, (2021) in an experiment conducted to determine the effect of planting at different distances between holes (5, 10, 15) cm on growth and yield traits of mung bean crop found that it had a significant effect on height traits Plant and number of secondary branches While there was no significant effect of planting distances on the characteristics of number of days from planting to 50% flowering and number of days from planting to 90% physiological maturity, while the dry biomass of the plant, seed yield and harvest index were affected and gave different values for each planting distance, a study conducted by Solanki et al. (2023) on the effect of planting distances on the growth characteristics and yield of the cowpea crop by planting it at three planting distances of 30 cm × 30 cm, 45 cm × 30 cm, 60 cm × 30 cm showed a significant effect on plant height, number of days to maturity, number of branches per plant, number of days from planting to the beginning of flowering and total seed yield. Due to the lack of studies related to the varieties and genetic compositions introduced in the southern region or the lack of research related to different distances, this study came with the aim of determining the best variety that gives high production and good quality at the planting distance that gives optimal growth and regular distribution in the field and thus adopting it in the food system and cropping system in the region.

II. Materials and methods

A field experiment was conducted in the fall season of 2023 at the Agricultural Research Station of the College of Agriculture / University of Basra in Garmat Ali (latitude 30.57 north and longitude 47.80 east), to know the effect of planting distances on the growth and productivity of four varieties of mung bean crop, three of which were introduced to Iraq and compare them with the local variety. A factorial experiment was applied using the split plot method with three replicates and using the Randomized Complete Block Design (R.C.B.D). The experiment included two factors, the first factor is the planting distances (20, 25, 30) cm between holes and is symbolized by the symbol (D1, D2, D3) respectively, and the second factor is four varieties of mung bean (local, Omrani, Parto, Gohar) and is symbolized by the symbol (V1, V2, V3, V4). The planting distances occupy the main plots and the varieties the sub-plots, so the number of experimental units is (3*4*3) = 36 experimental units. The experimental land was plowed, leveled and spread, then divided into three equal sectors according to the design used, and the area of the experimental unit was 3×3 = 9 m2. Each experimental unit contains 5 lines of 3 m length and a distance between the lines (60) cm, leaving a distance of 50 cm between each experimental unit. Mung beans seeds were planted in the soil on 8/8/2023 AD by placing three seeds in each hole, then thinned to one plant with patching the failed holes. Phosphate fertilizer was added in an amount of 100 kg Ph-1 45% P2O5 in the form of triple superphosphate (Al-Juheishy, 2019) in one batch when preparing the land for cultivation and equally for all experimental units. Nitrogen fertilizer was added in an amount of 120 kg N h-1 (5) in the form of urea 46% nitrogen (Al-Juheishy and Al-Layla, 2019) in two batches, the first batch after germination and the second batch 30 days after the first batch. Weeds were controlled manually whenever weeds appeared in the experimental field. The harvesting process is carried out after the appearance of signs of crop maturity, such as yellowing and drying of plants and pods, at different times depending on the nature of the variety and its reaching the stage of full maturity.

Table (1) Some physical and chemical properties of field soil before planting

properties	Value	Unit
PH	8.50	-
E.C.e	7.32	ds m^{-1}
Organic matter	1.81	g kg $soil^{-1}$

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Available elements	N	53.3	mg kg soil^{-1}
	P	5.2	
	K	122.3	
Dissolved positive ions	Ca++	6.93	m mol^{-1}
	Mg++	9.08	
	Na+	49.81	
Dissolved negative ions	Cl-	41.77	m mol^{-1}
	So4=	8.33	
	HCO3-	8.19	
Soil texture	clay	100	g kg^{-1}
	silt	515	
	sand	385	

Studied characteristics:

Number of days from planting to 50% flowering

Plant height (cm)

Number of branches per plant (plant branch^{-1})

Number of leaves per plant (plant leaf^{-1})

Leaf area per plant (cm^2)

Leaf area index

Dry weight per plant (g plant^{-1})

Seed yield (ton ha^{-1})

Biological yield (ton ha^{-1})

Protein content in seeds (%)

III. Results and discussion

Number of days from planting to 50% flowering

The results of Tables (2) indicate a significant effect of the varieties on the number of days from planting to 50% flowering, as the variety V3 achieved the lowest average number of days, reaching 38.44 days, and did not differ significantly with the variety V1, which gave an average of 38.61 days, while the variety V2 achieved the highest average number of days, reaching 43.67 and 42.50 days, which did not differ significantly with the variety V4, which achieved 41.67 days. The reason for the difference in the number of days from planting to 50% flowering between the varieties may be due to the fact that the trait of early and late flowering are genetically determined traits and the extent of adaptation or tolerance of the varieties to the conditions of the region. These results agree with what Shiferaw and Abewoy, (2023), Rehman et al. (2009), and Pamei et al. (2020), who indicated a difference Varieties that are close to 50% flowering in number of days are due to their genetic makeup.

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The results of the same table show that there is no significant effect of distances and interaction between varieties and planting distances on the trait of number of days from planting until 50% flowering.

Table 2: Effect of planting distances, varieties and their interaction on the number of days from planting to 50% flowering of mung bean crop.

Distances (cm)	Varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	39.17	43.00	36.67	40.67	39.88
25 (D_2)	38.83	43.33	40.33	41.83	41.08
30 (D_3)	37.83	44.67	38.33	42.50	40.83
Varieties means	38.61	43.67	38.44	41.67	
L.S.D. $_{P<(0.05)}$	Varieties= 1.615		Interaction=N.S		Distances= N.S

Plant height (cm)

The results of Tables (3) indicated that the V4 variety achieved the highest average height of 54 cm, with an increase of 38.46% over the V3 variety, which achieved the lowest average height of 39.00. The reason for this difference between the varieties may be attributed to the difference in their genetic nature and the difference in the number of days from planting until 50% flowering, Table (2), in which the V4 variety excelled, which allowed sufficient time for the development of the root system as well as the development of the vegetative system, and hence the height of the plant. These results agree with the results of Singh et al. (2022), Kabir and Sarkar (2008), and Cortez (2017).

The results of Table (3) indicated that distance D1 achieved the highest average plant height of 50.83 cm, outperforming other distances and by an increase of 25.38% over distance D3, which recorded the lowest average of 40.54 cm. The reason for this difference may be that plants planted at narrow distances and high plant density per unit area increased competition for light to meet the requirements of photosynthesis, which led to an increase in plant height. This is consistent with what Bohara et al. (2022), Kumari et al. (2020), and Chandubhai (2015) reached, who indicated that the smallest distance between plants achieves the highest height of the mung bean plant.

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As for the effect of the binary interaction between varieties and planting distances, the interaction treatment (D1*V2) was superior and recorded the highest average plant height of 59.83 and did not differ significantly from the interaction treatment (D1*V4) which gave an average height of 59.00 cm, while the interaction treatments (D2*V3) gave the lowest average height of 36.17 cm. The reason for the difference in the characteristics of plant height for different planting distances may be due to their difference in the extent of their response to different plant densities. This is consistent with what Singh et al. (2022) and Thavaprakash (2017) reached, who indicated that varieties differ in plant height at different plant densities.

Table 3: Effect of planting distances, varieties and their interaction on the height characteristic of mung bean crop.(cm).

Distances (cm)	varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	43.33	59.83	41.17	59.00	50.83
25 (D_2)	43.67	51.17	36.17	54.83	46.46
30 (D_3)	36.50	36.33	39.67	49.67	40.54
Varieties means	41.17	49.11	39.00	54.50	
L.S.D. $_{P<(0.05)}$	Varieties= 1.855		Interaction= 3.438		Distances= 2.303

Number of branches per plant (plant branch^{-1})

The results of Table (4) indicate that the V4 variety achieved the highest average number of branches per plant with an average of 5.61 branches per plant^{-1}, an increase of 46.48% compared to the V1 variety, which gave the lowest average of 3.83 branches per plant^{-1}. The reason for this superiority may be due to the difference in the genetic composition of the varieties and the increase in plant height Table (3) is consistent with what Singh et al. (2006) and (Cortez, 2017) reached, who indicated that the different varieties have distinct agricultural characteristics related to the number of branches per plant.

The results of Table (4) showed the superiority of the interaction treatment (D3*V4) and recorded the highest average number of branches per plant, amounting to 6.17 branches plant^{-1}, which did not differ significantly from the interaction treatments (D2*V4) and (D1*V4), which recorded an average of 5.00 and 5.67 branches/plant^{-1}, while the interaction treatment (D2*V1) recorded the lowest average number of branches, amounting to 3.33 branches/plant^{-1}.

The results of Table (4) showed that there was no significant effect of planting distances on the number of branches of the mung bean crop.

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Table 4: Effect of planting distances, varieties and their interaction on the number of branches of mung bean crop.(branch plant^{-1})

Distances (cm)	Varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	4.33	4.33	3.50	5.67	4.46
25 (D_2)	3.33	4.83	4.17	5.00	4.33
30 (D_3)	3.83	4.33	4.17	6.17	4.62
Varieties means	3.83	4.50	3.94	5.61	
L.S.D. $_{P<(0.05)}$	Varieties= 0.5364		Interaction= 1.2252		Distances=N.S

Number of leaves per plant (leaf per plant^{-1})

The results of Tables (5) indicate that the V4 variety achieved the highest average number of leaves per plant of 44.33 leaves per plant-1, while the V1 variety gave the lowest average of 28.17 leaves per plant^{-1}, which did not differ significantly from the V3 variety, which gave 28.72 leaves per plant^{-1}. The superiority of the V4 variety in the number of leaves per plant may be due to the significant superiority of the variety in plant height Table (3) and number of branches Table (4) in addition to the genetic differences between the varieties despite their growth under the same environmental conditions Gavali et al. (2023) These results agree with the results of Verma et al. (2011).

The results of Tables (5) showed the significant effect of the two-way interaction between the experimental factors on the number of leaves per plant. The interaction between the varieties and planting distances in the combination (D1*V4) achieved the highest average number of leaves per plant, amounting to 53.33 leaves per plant^{-1}, while the combination (D3*V1) achieved the lowest average, amounting to 26.67 leaves per plant^{-1}. The reason for this superiority may be due to the superiority of the two factors individually, which was positively reflected in their superiority in the interaction.

The results of the same table showed that there was no significant effect of planting distances on the number of leaves per plant for the mung bean crop.

Table 5: Effect of planting distances, varieties and their interaction on the number of leaves in mung bean crop.(leaf plant^{-1})

Distances (cm)	varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	29.67	38.33	25.50	53.33	36.71

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25 (D_2)	28.17	33.83	32.00	38.00	33.00
30 (D_3)	26.67	30.17	28.67	41.67	31.79
Varieties means	28.17	34.11	28.72	44.33	
L.S.D. $_{P<(0.05)}$	Varieties= 5.117		Interaction= 9.119		Distances=N.S

Leaf area (cm^2)

The results shown in Tables (6) showed that the V4 variety was significantly superior to the other varieties, achieving the highest average leaf area of 2043 cm^2, while the V1 variety recorded the lowest average of 856 cm2 and did not differ significantly from the V3 variety, which recorded an average of 974 cm^2. The reason for the superiority of the V4 variety may be due to its superiority in the number of branches per plant, Table (4), and the number of leaves, Table (5), and extending the period from planting to flowering, Table (2), which provided sufficient opportunity for leaf growth and thus increased leaf area. This is consistent with the results of Mondal et al. (2013).

The planting distance D1 achieved the highest average leaf area per plant, amounting to 1585 cm2, while the distance D3 recorded the lowest average leaf area, amounting to 1102 leaves per plant^{-1}. This may be due to the superiority of these two distances in the number of leaves, Table (5).

The results of Table (6) indicate that there is no significant effect of the interaction between the two study factors on the leaf area trait of the mung bean crop.

Table 6 Effect of planting distances, varieties and their interaction on the leaf area of mung bean crop.(cm).

Distances (cm)	varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	1090	1544	1092	2616	1585
25 (D_2)	849	1252	961	1693	1189
30 (D_3)	629	1092	868	1820	1102
Varieties means	856	1296	974	2043	
L.S.D. $_{P<(0.05)}$	Varieties= 241.7		Interaction= N.S		Distances=233.2

Leaf area index (%)

University of Thi-Qar Journal of agricultural research
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The results of Table (7) showed that the V4 variety was significantly superior to the other varieties in the leaf area index, achieving the highest average of 1.440, while the V1 variety recorded the lowest average leaf area index of 0.608. The reason for the superiority of the V4 variety may be due to its superiority in the leaf area of the plant, Table (6), which came from the increase in the average number of leaves, Table (5), and the number of branches, Table (4), consistent with the results of Ali et al. (2021).

From Table (7), it is clear that the planting distance D1 is superior and recorded the highest average leaf area index of 1.321, while the distance D3 recorded the lowest average of 0.612. The reason may be due to the superiority of the two distances in the number of leaves Table (5) and leaf area Table (6), which was reflected in the increase in the leaf area index. This is consistent with what Hangsing (2019) and Sathyamoorthi et al. (2008) reached.

The results of Tables (7) show the significant effect of the bilateral interaction between the study factors on the leaf area index of mung bean crop. The interaction between the varieties and planting distances recorded the highest average leaf area index of 2.180 in the interaction treatment D1*V4 compared to the interaction treatment D3*V1, which gave the lowest average leaf area index of 0.350. The reason may be due to the superiority of the variety V4 and the distance D1 in the number of leaves and leaf area individually, which was reflected in their index.

Table 7 Effect of planting distances, varieties and their interaction on the leaf area index of mung bean crop.

Distances (cm)	Varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	0.908	1.287	0.910	2.180	1.321
25 (D_2)	0.566	0.835	0.641	1.128	0.792
30 (D_3)	0.350	0.607	0.482	1.011	0.612
Varieties means	0.608	0.909	0.678	1.440	
L.S.D. $_{P<(0.05)}$	Varieties= 0.1947		Interaction= 0.3307		Distances=0.1811

Dry weight of the plant (g plant^{-1})

The results of Tables (8) indicate that the V2 variety achieved the highest average dry weight of the plant at 18.72 g plant^{-1} and did not differ significantly from the V4 variety, which recorded an average of 16.61 g plant^{-1}, while the V3 variety achieved the lowest average dry weight of the plant at 10.17 g plant^{-1}. The reason for the difference in dry weight between the varieties may be due to

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https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

the difference in their genetic composition. This result is consistent with the results of Al-Fahdawi and Al-Dulaimi (2020).

The results of the table indicate that there is no significant effect of planting distances and the interaction between varieties and planting distances on the dry weight of the plant.

Table 8: Effect of planting distances, varieties and their interaction on the dry weight of mung bean crop(g plant^{-1}).

Distances (cm)	Varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	13.50	18.17	10.17	16.50	14.58
25 (D_2)	10.00	19.50	8.83	15.17	13.37
30 (D_3)	11.50	18.50	11.50	18.17	14.92
Varieties means	11.67	18.72	10.17	16.61	
L.S.D. $_{P<(0.05)}$	Varieties= 2.150		Interaction= N.S		Distances=N.S

Seed yield (t ha^{-1})

The results of Table (9) indicate the significant effect of varieties and planting distances on the total seed yield of mung bean crop. Variety V4 significantly outperformed other varieties and achieved the highest average total seed yield of 1.583 tons ha^{-1}, with an increase of 120.78% over variety V1, which recorded the lowest average of 0.717 tons ha^{-1}. The reason may be due to the superiority of variety V4 in the number of leaves Table (5) and leaf area Table (6) and leaf area index Table (7) which may be reflected in the components of the yield and thus increase the yield, consistent with Shiferaw and Abewoy, (2023) and Hasan et al. (2018) and Ajio et al. (2016) and TON (2024) who reported an increase in the mung bean seed yield resulting from an increase in its components.

The planting distance D1 achieved the highest average seed yield of 1.708 tons ha^{-1}, with an increase of 104.31% over the distance D3, which gave the lowest average seed yield of 0.836 tons ha^{-1}. The reason may be due to the superiority of this distance in the number of leaves and leaf area and its index, which caused the increase in the yield. This result is consistent with the results of Dikr and Garkebo (2022), Kanoosh and Mohammed (2024), and Tahir et al. (2024), who indicated that seed yield differs according to planting distances.

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The results of the table indicate that there is no significant effect of the interaction between varieties and planting distances on the seed yield trait of mung bean crop.

Table 9: Effect of planting distances, varieties and their interaction on seed yield of mung bean crop(t ha^{-1})

Distances (cm)	Varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	1.056	1.950	1.624	2.203	1.708
25 (D_2)	0.573	0.973	0.884	1.349	0.945
30 (D_3)	0.524	0.864	0.758	1.197	0.836
Varieties means	0.717	1.262	1.089	1.583	
L.S.D. $_{P<(0.05)}$	Varieties= 0.1488		Interaction= N.S		Distances=0.1290

Biological yield (t ha^{-1})

The results of the statistical analysis shown in Table 10 indicate the significant effect of varieties and planting distances on the biological yield of the mung bean crop, as the variety V2 outperformed and recorded the highest average of 3.809 tons ha^{-1} and did not differ significantly from the variety V2 which gave an average of 3.764 tons ha^{-1}, while the variety V1 recorded the lowest average of the biological yield of 2.354 tons ha^{-1}, and the reason may be due to the superiority of the variety V2 in the dry weight of the plant (Table 8). This result is consistent with the results of (Abdalgafor and Al-Jumaily, 2016).

The planting distance D1 was significantly superior to the other distances by giving the highest average of 4.103 tons ha^{-1} compared to the planting distance D3, which gave the lowest average of 2.525 tons ha^{-1}. The reason may be attributed to the increase in some growth characteristics with the increase in seed yield for the distance D1 (Table)), as the biological yield increases with the increase in plant density and optimal use of resources. This result is consistent with what Siraje et al. (2020) reached, and this is consistent with Birhanu et al. (2018), who indicated that reducing planting distances between plants increases the dry biomass above the ground.

The results of the same table showed that there was no significant effect of the interaction between the two study factors on the biological yield of the mung bean crop.

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Table 10: Effect of planting distances, varieties and their interaction on the biological yield of mung bean crop.(t ha^{-1})

Distances (cm)	Varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	3.286	4.945	3.294	4.888	4.103
25 (D_2)	2.010	3.567	2.053	3.194	2.706
30 (D_3)	1.795	2.916	2.180	3.209	2.525
Varieties means	2.364	3.809	2.509	3.764	
L.S.D. $_{P<(0.05)}$	Varieties=0.3741		Interaction= N.S		Distances=0.4404

Protein content in seeds(%)

The results of Tables (11) indicate that the V4 variety achieved the highest protein content in mung bean seeds, reaching 23.392%, while the V1 variety achieved the lowest rate, reaching 22.273%. The reason for the difference in protein content between varieties may be attributed to the genetic factor (Varma et al. 2018) and its response to the environmental conditions of the agricultural area and its ability to absorb nutrients better by the V4 variety. As a result of the cumulative effect of these nutrients in the seeds, it caused an increase in their protein content. This result is consistent with the results reached by Zafar et al. (2023), Gavali et al. (2023), Sumer (2024), Patidar and Singh (2018), who noted significant differences between varieties in protein content.

Regarding the interaction between varieties and planting distances, the results of Table (11) showed that the interaction treatment D2*V4 achieved the highest average protein percentage of 24.306%, while the interaction treatment D1*V2 achieved the lowest average protein of 21.517%, respectively.

It was noted from the results of the same table that there was no significant effect of planting distances on the protein percentage in mung bean seeds.

Table 11 Effect of planting distances, varieties and their interaction on the protein content of mung bean seeds.(%).

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 253-268
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Distances (cm)	varieties				Distances means
	V1	V2	V3	V4	
20 (D_1)	22.173	21.517	22.244	23.590	22.381
25 (D_2)	22.392	23.125	23.076	24.306	23.225
30 (D_3)	22.254	22.908	22.732	22.279	22.543
Varieties means	22.273	22.517	22.684	23.392	
L.S.D. $_{P<(0.05)}$	Varieties= 0.1015		Interaction= 0.1587		Distances=N.S

Conclusions:

We conclude that the cultivar Gohar and the planting distance of 20 cm achieved the highest rates for most growth traits, achieving the highest seed yield and protein percentage of (1.583 and 1.708 t ha^{-1}) (23.392%), respectively. The interaction between the cultivars and planting distances led to differences in some of the studied traits, as the planting distances of 20 and 25 cm and the cultivar Gohar were superior, including the number of leaves, leaf area and protein percentage.

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