Response of Different Cultivars of Common Bean (Phaseolus vulgaris L.) to Different Plant Distances and Planting Dates

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Abstract

A field experiment was conducted in two seasons the first season was on September 15th 2023 to January 20th 2024 and the second season on March 10th 2024 to June 25th 2024 at Grdarasha Research Field, Collage of Agricultural Engineering Sciences, Salahaddin University – Erbil to examine the response of different varieties of common bean to different plant distances and planting dates. A factorial experiment based on randomized complete block design (RCBD), with three replicates was used. Three varieties of common bean (Mitofarm, Kucuk Ciftlik and Biotek) and two distances between plants were implemented. Results show the highest rates of plant height and leaf area for Biotek and Mitofarm varieties, however these parameters significantly increased to (39.480cm and 69.827cm2) respectively with the distance with the distance 40cm between plants in the first season of plant growing. Pods weight plant-1 and no. of pods plant-1 achieved the highest rates (164.677g and 9.066) respectively with the distance 40cm between plants for both seasons. While, the maximum rates (14.795mm, 5.361 and 49.610g) respectively of pod length, no. of seeds pod-1 and pods weight were produced by Kucuk Ciftlik and no. of pods plant-1 (11.700) by Biotek in the second season. Findings of interaction between the varieties and distances significantly affected pod diameter and pods plant-1 and recorded maximum values by the Mitofarm variety and 50cm distance, and for pods weight plant-1 was obtained by Kucuk Ciftlik variety and 40cm on the first season. Seed characteristics significantly affected by varieties and distances in both seasons and maximum rates recorded by Kucuk Ciftlik, form interaction between factors Mitofarm and Kucuk Ciftlik with 40cm achieved the highest rates of seed parameters. Biotek and 50cm occupy the first position in seed chemical content for both seasons. Comparison between two seasons, vegetative parameters, pods and seed characteristics significantly progressed in the first season but, for chemical content in the seed at second season .

Keywords: Legumes, Yield components, Agronomic techniques, growing seasons.

Introduction

The common bean (Phaseolus vulgaris L.) is one of the most important legume crops grown worldwide because, of its high protein, fiber, carbohydrate content and other essential minerals for humans [13]. Common bean is the most commonly consumed legume worldwide, and it is the most important legume produced for direct human consumption, with a commercial value exceeding that of all other legume crops combined [17.[

A crop's growth, development, and yield can be accelerated by choosing the best sowing time and highly productive types. This

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is because sowing time affects a variety of climatic elements, including temperature, moisture content, and sunlight. Also, Higher yields are produced by using suitable varieties and sowing at the right time.

Mashiqa et al. [15] in their study about five sowing dates (October 10th, November 10th, December 10th, February 10th and March 10th), and two cultivars of common bean (DAB 564 and DAB 520) resulted that, the number of pods plant-1, pod length, and seed output were all considerably boosted by cultivar DAB564 during the planting period of March, yielding 2424 kg ha-1. Al-huseein Jasim and Esho [3] conducted that in their study about 12 different common bean varieties, there was a highly significant differences in all traits between the 12 varieties. Woldesenbet [21] showed that common bean planting in 30cm X 5 cm distance significantly increased plant height (105.83cm) as compared to the others, also planted in 50 cm X 15 cm distance increased the number of leaves (76.17) and the maximum yield produced in planted at distance of 40 cm X 15 cm .

This study aims to evaluate the appropriate planting date and select a better variety and plant distance for growth, development and yield performance under the existing environmental conditions.

Materials and Methods

This experiment was conducted in two seasons the first season was on September 15th 2023 to January 20th 2024 and the second season on March 10th 2024 to June 25th 2024 at Grdarasha Research Field, Collage of Agricultural Engineering Sciences, Salahaddin University – Erbil to study the effect of different varieties of common bean to different plant distances and planting dates, Grdarasha Research Field is locating at 36. 40^{o} N, 44.10^{o} E and at an elevation 470m above sea level. An air – dried soil sample was taken from field at the depth (0-30cm), then sieved with 2mm mesh and analyzed for some physical and chemical properties as shown in Table (1). Minimum and maximum temperature, relative moisture and the amount of rain fall of field in planting season are shown in Table (2.(

The land was ploughed with two perpendicular lines, and the soil was well softened with Rotavator plow to erosion control and conserve of soil moisture. The land was divided in to plots with dimensions (1.60cm × 1.60cm) area and 40cm distance between rows with three replications resulting, 18 plots for each season.

Three common bean varieties (Mitofarm, Kucuk Ciftlik and Biotek) called (V1, V2 and V3) were chosen for this study, these are Turkish origin varieties processed and packed in 2021-2022. Different distances between plant (40cm and 50cm) called (D1 and D2) were used. Seeds were sown in two seasons; the first season was on September 15th 2023, and the second season on March 10th 2024, at depth of 3cm. Through the experimental period, plants were watered depending on the dropping system, and manual weed control was repeated more than once .

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Table 1. Some chemical and physical properties of the field soil of Grdarasha

Soil properties	Soil component
Sand (g kg^{-1})	384.75
Slit (g kg^{-1})	515.00
Clay (g kg^{-1})	100.25
Texture Class	Silty clay loam
pH	7.53
Electrical Conductivity (EC) ds m^{-1}	0.38
Organic Matter (%)	0.91
Bulk density (Mg m^{-3})	1.45
Total Nitrogen (N) ppm	89.17
Total Phosphor (P) ppm	5.36
Total Potassium (K) ppm	64.10

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Table 2. Maximum and Minimum temperature, relative moisture and the amount of rain fall during the growing season

Months (2023-2024)	Air Temp. C°		Relative moisture %	Rainfall (mm)
	Minimum	Maximum		
September	26.1	38.4	16.0	
October	20.0	30.0	30.7	0.7
November	13.4	21.5	60.5	10.1
December	9.5	18	67.0	46.5
January	7.9	14.8	72.1	66
February	7.8	15.9	62.5	142
March	11	19.5	52.5	71
April	18.3	29.2	34.3	67
May	20.6	30.7	32.7	46
June	29.8	41	12.9	

*Data source: Meteorological Directory- Erbil province

Five plants were selected randomly from each experimental unit to study the plant height (cm), no. of branches plant-1, leaf area (cm2), no. of pod plant-1, pod length (cm), pod diameter (mm), pod weight (g plant-1), no. of seed pod-1, yield (kg ha-1), seed length (mm),weight of 100 seeds (g), seed yield (g plant-1), seed yield (g plot-1), seed yield (kg ha-1). Seeds ground by electrical grinder for each experimental unit. A 0.3g of ground samples were digested by adding 10ml of concentrated $H_2 SO_4$ and 10ml of $H_2 O_2$ with heating for digestion as described by (18). Chemical content in seeds were estimated from digested samples for the percentage of nitrogen and protein by kjeldahl method [14 and 6] and carbohydrate by Titration method [9.[

The experiment was designed according to factorial randomized complete block design (RCBD) with three replicates, comparisons between means were made using Duncan's

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Multiple Range Test at 5% level. The statistical analysis was carried out by using SPSS (Statistical Package for Social Sciences) Program, version (22.0) in 2019 [21 .[

Results and Dissuasion

Vegetative parameters

According to the results presented in Table (3), the third variety recorded the highest value (41.053cm) of plant height and the first variety (75.103cm2) of leaf area in the first season. With decreasing the distances between plants, plant height and leaf area significantly increased in the first season. No significant differences between no. of branches plant-1 in the first season and for all vegetative parameters between all varieties and between the distances in the second season were found. The interaction effect between varieties and distances is also shown in the same table for both seasons. The results observed that the distances between plants significantly affected plant height and leaf area in all varieties. The greater rates (44.333cm and 79.333 cm2) were recorded for first and third varieties with the first distances in the first season. In contrast, no significant differences of interaction between the treatments were obtained of no. of branches plant-1 in the first season and for all vegetative parameters in the second season; the findings of comparison between seasons revealed that significant differences between plant growing in both seasons of vegetative parameters and with the highest data of these parameters were recorded in the first season of plant growing.

These differences in genotypes of varieties are due to their toleration behaviour at both low and high temperature condition [12 and 1]. The differences of the periods between sowing dates and that periods are located in different season effect on growth and development of the plants and measurements parameters are extremely sensitive to environmental factors such as, light intensity, growing season, day length, rainfall and temperature (Table 2) and soil properties (Table 1). Additionally, agronomic factor like plant density, fertility and weeds also play a role [4.[

Pods yield and pods characteristics

The data presented in Table (5) indicated that no significant effect of pods characteristics between all varieties and for effect of distances between plants in the first season excepting pods weight plant-1 recorded the maximum value (189.131g) by the second variety. Whereas, in the second season the second variety significantly improved the parameters pod length, no. of seeds pod-1 and pods weight by (14.795cm, 5.361 and 49.610g) respectively and third variety for no. of pods plant-1 by (11.700). No significant differences were recorded for effect of distances on plant growing for both seasons, excepting of the first distance recorded the highest rate (164.677g) of pods weight plant-1 in the first season and for no. of pods plant-1 by (9.066) in the second season. From the interaction between the varieties used and the different distances between plants significantly impacted the pod diameter and pods plant-1 by (8.196mm) achieved by the first variety and second distance and for pods weight plant-1 by (238.166g) obtained by second variety and first distance on the first season and no significant effect were recorded for other pods parameters in the first and second seasons. The statistical analysis of data of plant grown in two successive seasons represented also in Table (4). Pods characteristics significantly progressed in the first season compare with second season .

The variation in pods and yield characteristics of varieties could be related to the genetic differences and their response to environmental conditions [10]. For a decreasing distances between the plants competition becomes more intense, because greater number of individuals compete for the same common limiting resources [22]. Abiotic environment factor include temperature, humidity, light intensity, water supply, mineral and CO2, these parameters and recourses that determine plant growth and differ from year to year and season to season

[19]. The temperature fluctuation between seasons (shown in Table 2) affects plant growth because temperature influences all biochemical reactions of photosynthesis and membrane integrity in chloroplasts [20 and 11 .[

Seed yield and seed characteristics

Seeds play a vital role in yield and in understanding how plants behave, Seed yield has a significant variable [16]. The results display in table (5) revealed that the seed yield of all seed characteristics was affected significantly varieties and distances in both seasons and the highest rates of these parameters recorded by second variety, on the hand the first distances gave the maximum rate of most seed parameters for both seasons. In interactions of the experiment factors were significant in both seasons for seeds length which was (13.390 and 11.760 mm) recorded by the first variety and first distance, seeds yield plant-1 by (14.913 and 16.780g) achieved by second variety and first distance. While, the maximum weight of 100 seeds (24.730g) was produced by first variety and first distance in first season and (15.343g) for second variety and second distance in the second season. From the results of comparison between seasons, seed characteristics significantly increased in the first season. These results agree with those obtained by [5] that deviation in seed weight among the cultivars might be genetic makeup, nutrients uptake and utilization, and dry matter translocation efficiency. These results are compatible with those found by Gomaa et al., [8.[

Chemical content in the seed

Chemical content in the seeds was significantly affected by varieties, distances and their interaction for the two seasons (Table 6). Third variety recorded the highest ratio of seed contents for both seasons as compare with other varieties. The second distant significantly increased the seed content that first distant for both seasons. From the interaction between treatments, third variety with increasing distances between plants occupy the first position between all treatments in the first season and no significant effect were obtained in the second season. From the comparison second season surpassed first season in seed content. Nitrogen, protein and carbohydrate is a quality parameter to assess the grain quality and this trait is generally influenced by genetic makeup of varieties and application of inputs to the crop [7 and 2 .[

Table 3. Vegetative parameters affected by varieties, distances and their interaction at two growing seasons and comparison between seasons under effect the treatments

Varieties	First season			Second season		
	Plant height (cm)	**No. of branches plant^{-1}**	**Leaf Area (cm^2)**	**Plant height (cm)**	**No. of branches plant^{-1}**	**Leaf Area (cm^2)**
V1	37.832 b	17.490 a	75.103 a	31.833 a	6.596 a	58.176 a
V2	32.163 b	15.350 a	66.363 ab	32.970 a	7.521 a	48.651 a
V3	41.053 a	14.210 a	57.715 b	34.735 a	6.915 a	58.543 a
Distances	**Plant height (cm)**	**No. of branches plant^{-1}**	**Leaf Area (cm^2)**	**Plant height (cm)**	**No. of branches plant^{-1}**	**Leaf Area (cm^2)**
D1	39.480 a	16.474 a	69.827 a	34.045 a	7.248 a	52.936 a
D2	34.552 b	14.904 a	62.961 b	32.313 a	6.773 a	57.311 a
Varieties× Distances	**Plant height**	**No. of branches**	**Leaf Area**	**Plant height**	**No. of branches**	**Leaf Area (cm^2)**

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	(cm)	plant^{-1}	(cm^2)	(cm)	plant^{-1}	
V1D1	38.110 b	16.763 a	79.333a	34.166 a	7.526 a	50.323 a
V1D2	37.553 a	18.220 a	70.873 a	29.500 a	5.666 a	66.030 a
V2D1	35.996 b	17.663 a	74.910 ab	30.803 a	7.110 a	52.206 a
V2D2	28.330 b	13.053 a	57.816 a	35.136 a	7.933 a	45.096 a
V3D1	44.333 a	14.996 a	55.236 b	37.166 a	7.110 a	56.280 a
V3D2	37.773 a	13.440 a	60.193 a	32.303 a	6.720 a	60.806 a

Comparison between seasons			
Seasons	**Plant height (cm)**	**No. of branches plant^{-1}**	**Leaf Area (cm^2)**
1st season	37.016 a	15.689 a	66.394 a
2nd season	33.179 b	7.011 b	55.124 b

*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level .

Table 4. Pods parameters affected by varieties, distances and their interaction at two growing seasons and comparison between seasons under effect the treatments

Varieties	**First season**					**Second season**				
	Pods diameter (mm)	**Pods length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pods weight g plant^{-1}**	**Pods diameter(mm)**	**Pods length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pods weight g plant^{-1}**
V1	7.073 a	13.718 a	31.501 a	5.903 a	159.581 b	12.170 a	13.573 b	5.666 b	4.423 b	30.908 b
V2	7.440 a	14.763 a	36.991 a	5.875 a	189.131 a	12.300 a	14.795 a	6.500 b	5.361 a	49.610 a
V3	6.668 a	13.736 a	30.111 a	5.586 a	103.998 c	11.400 a	11.075 c	11.700 a	4.160 b	20.580 b
Distances	**Pods diameter (mm)**	**Pods length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pods weight g plant^{-1}**	**Pods diameter(mm)**	**Pods length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pods weight g plant^{-1}**
D1	6.949 a	13.972 a	33.455 a	5.912 a	164.677 a	12.054 a	13.523 a	9.066 a	4.513 a	34.883 a
D2	7.172 a	14.173 a	32.768 a	5.664 a	137.130 b	11.858 a	12.772 a	6.844 b	4.783 a	32.515 a
Varieties× Distances	**Pods diameter (mm)**	**Pods length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pods weight g plant^{-1}**	**Pods diameter(mm)**	**Pods length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pods weight g plant^{-1}**
V1D1	5.950 b	13.163 a	28.806 a	6.186 a	183.220 b	11.720 a	14.503 a	6.700 a	4.220 a	22.650 a
V1D2	8.196 a	14.273 a	34.196 a	5.620 a	135.943 a	12.620 a	12.643 a	4.633 a	4.626 a	39.166 a
V2D1	8.020 a	14.933	43.096	5.796 a	238.166	12.383	14.356 a	6.833 a	5.273 a	57.667

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		a	a		a	a				a
V2D2	6.860 ab	14.593 a	30.886 a	5.953 a	140.096 a	12.216 a	15.233 a	6.166 a	5.450 a	41.553 a
V3D1	6.876 ab	13.820 a	28.463 a	5.753 a	72.643 c	12.060 a	11.710 a	13.666 a	4.046 a	24.333 a
V3D2	6.460 b	13.653 a	33.220 a	5.420 a	135.353 a	10.740 a	10.440 a	9.733 a	4.273 a	16.826 a

Comparison between seasons

Seasons	**Pods diameter (mm)**	**Pods length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**Pots weight g plant^{-1}**
1st season	7.061a	14.073 a	33.112 a	5.788 a	150.904 a
2nd season	11.957b	13.148 b	7.956 b	4.648 b	33.699 b

*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level .

Table 5. Seeds parameters affected by varieties, distances and their interaction at two growing seasons and comparison between seasons under effect the treatments

Varieties	**First season**				**Second season**			
	Seeds length (mm)	**Seeds yield g plant^{-1}**	**weight of 100 seeds (g)**	**Dry seeds yield ton ha^{-1}**	**Seed length (mm)**	**Seeds yield g plant^{-1}**	**weight of 100 seeds (g)**	**Dry seeds yield ton ha^{-1}**
V1	12.255 a	11.428 a	21.530 a	0.873 b	10.823 a	9.691 b	12.497 ab	0.991 a
V2	12.248 a	11.800 a	23.510 a	1.106 a	11.380 a	14.946 a	15.275 a	1.185 a
V3	11.308 a	5.505 b	16.690 b	0.470 c	9.550 b	8.373 b	11.197 b	0.908 a
Distances	**Seeds length (mm)**	**Seeds yield g plant^{-1}**	**weight of 100 seeds (g)**	**Dry seeds yield ton ha^{-1}**	**Seed length (mm)**	**Seeds yield g plant^{-1}**	**weight of 100 seeds (g)**	**Dry seeds yield ton ha^{-1}**
D1	12.321 a	10.76 a	22.765 a	0.996 a	10.861 a	13.167 a	13.977 a	1.328 a
D2	11.553 a	8.38 b	18.388 b	0.638 b	10.307 a	8.740 b	12.001 a	0.701 b
Varieties × Distances	**Seeds length (mm)**	**Seeds yield g plant^{-1}**	**weight of 100 seeds (g)**	**Dry seeds yield ton ha^{-1}**	**Seed length (mm)**	**Seeds yield g plant^{-1}**	**weight of 100 seeds (g)**	**Dry seeds yield ton ha^{-1}**
V1D1	13.390 a	12.226 b	24.730 a	0.950 b	11.760 a	14.413 a	14.906 a	1.560 a

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V1D2	11.120 ab	10.626 a	18.330 b	0.796 a	9.886 a	4.970 a	10.086 a	0.343 a
V2D1	11.843 a	14.913 a	24.620 a	1.520 a	11.280 a	16.780 a	15.206 a	1.320 a
V2D2	12.653 a	8.686 b	22.400 a	0.693 ab	11.480 a	13.113 a	15.343 a	1.050 a
V3D1	11.730 a	5.166 c	18.946 b	0.517 c	9.543 a	8.610 a	11.820 a	1.106 a
V3D2	10.886 b	5.505 c	14.433 c	0.423 b	9.556 a	8.373 a	10.573 a	0.710 a

Comparison between seasons

Seasons	**Seeds length (mm)**	**Seeds yield g plant^{-1}**	**weight of 100 seeds (g)**	**Dry seeds yield ton ha^{-1}**
1st season	11.937 a	9.577 a	20.577 a	0.817 a
2nd season	10.584 b	11.004 b	12.989 b	1.015 a

*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level .

Table 6. Chemical content in seeds affected by varieties, distances and their interaction at two growing seasons and comparison between seasons under effect the treatments

Varieties	**First season**			**Second season**		
	Nitrogen %	**Protein %**	**Carbohydrate %**	**Nitrogen %**	**Protein %**	**Carbohydrate %**
V1	3.035 c	18.965 c	61.455 b	3.665 b	23.235 b	62.190 b
V2	3.572 b	22.320 b	60.788 c	3.573 c	22.330 c	60.190 c
V3	3.673 a	22.955 a	64.533 a	3.872 a	24.193 a	63.187 a
Distances	**Nitrogen %**	**Protein %**	**Carbohydrate %**	**Nitrogen %**	**Protein %**	**Carbohydrate %**
D1	3.362 b	21.011 b	62.057 b	3.620 b	22.843 b	64.851 a
D2	3.491 a	21.816 a	62.461 a	3.787 a	23.662 a	62.860 b
Varieties× Distances	**Nitrogen %**	**Protein %**	**Carbohydrate %**	**Nitrogen %**	**Protein %**	**Carbohydrate %**
V1D1	2.940 c	18.370 c	59.900 c	3.510 a	22.600 a	64.573 a
V1D2	3.130 c	19.560 c	63.010 b	3.820 a	23.870 a	61.800 a
V2D1	3.523 b	22.020 b	61.290 b	3.430 a	21.433 a	66.390 a
V2D2	3.620 b	22.620 b	60.287 c	3.717 a	23.227 a	65.990 a
V3D1	3.623 a	22.643 a	64.980 a	3.920 a	24.497 a	63.590 a
V3D2	3.723 a	23.267 a	64.087 a	3.823 a	23.890 a	60.790 a

Comparison between seasons

Seasons	**Nitrogen %**	**Protein %**	**Carbohydrate %**
1st season	3.427 b	21.413 b	62.259 b
2nd season	3.703 a	23.253 a	63.856 a

*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level .

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Conclusions

It is concluded Mitofarm and Kucuk Ciftlik varieties with the 40cm distances between plant excelled in vegetative parameters, pods parameters, seed yield and seed characteristics, however Biotek with 50cm distance for chemical content in the seed for both seasons. Form comparison between the two seasons, vegetative growth parameters, pods characteristics and seed characteristics significantly progressed in the first season but, for chemical content in the seed at second season.

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