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Tolerance of faba bean plants to drought stress and plant density via yield components and pathogenicity tests

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ABSTRACT

This study examined the effects of water stress and plant density on faba bean plants. It was carried out in the Research and Experimental Centre, Faculty of Agriculture, Moshtohor, Benha University, Qaluibia Governorate, Egypt, over the course of two growing winter seasons (2022–2023, 2022–2023).Therefore, two field studies were conducted to investigate the effect of four different water regimes one, two, and three irrigations as well as conventional irrigations four regular, consecutive irrigations as a control applied at all vegetative and reproductive stages and at three plant densities of faba bean (Cv. Marriott 2) 20, 30 and 40 kg/fed. As compared to the growth metrics of the unstressed plants, the results demonstrated that an increase in the duration of water stress caused a drop in all growth parameters. Plant density also significantly affected a number of aspects throughout the two growing winter seasons (2022–2022, 2022–2023).The majority of the features were considerably impacted at the interaction level. While there were differences in the values of vegetative growth parameters, yield, and yield components, as well as in microbiological analysis with different water regimes and plant densities, the overall presentation of the faba bean was generally well-intentioned. The crop composition may be slightly delayed by a water deficit (three irrigation treatments) up to (3/4) of the water holding capacity, but this does not limit the crop's ability to adapt to anomalies in its growth composition. Additionally, in every attribute evaluated, faba beans performed well at the most advantageous plant density of 30 kg/fed.

Keywords: water stress, plant density and faba bean.

INTRODUCTION

The most important legume crop in Egypt is the faba bean (*vicia faba L.*), which is prized for both its high nutritional value for human consumption and its use as a break crop in the cereal rotation cycle. A total of 216,000 feddans were grown over the course of the preceding five seasons, yielding an average seed yield of 1.4 kg/fed as stated by **[1].**

A restricted water supply has a significant impact on plant species' development and metabolic processes. In general, it hinders the growth and development of plants. Nonetheless, studies have shown that restricted water availability has a favourable impact on solute buildup, enzyme activity, and the production of secondary metabolites **[2].**

A portion of these reactions might be connected to the plant's capacity to endure in restrictive environments. Even while research on the metabolic reactions of food crops to dry conditions has been done, there aren't many studies on medicinal and aromatic plants.

In the field, the faba bean frequently modifies its structure and plant distribution based on the pattern of environmental conditions **[3].** Regarding agronomic procedures, it's critical to modify the proper plant density and row spacing in addition to controlling weeds, pests, and diseases. These factors are crucial in restricting the quantity and quality of legume output [4].

In particular, the best row spacing for faba bean yields, when considering the plantation site, is found to be between 20 and 25 cm [5] in Egypt and between 30 and 40 cm [6 -7]in Ethiopia. In the Mediterranean region, **[8]** discovered that faba beans cultivated with a wider row spacing (50–70 cm) produced more seeds. In Australia, a row spacing of 25–50 cm allows for a larger yield of faba beans than 75 cm, and it has a bigger impact on yielding than plant density, according to **[9].**

The principal aims of this inquiry stood to:

- Decide the ideal irrigation period for faba bean irrigation in the research location,

-Survey the impact of trickle irrigation intervals and plant densities on the chemical makeup of one faba bean variety (c.v.Marriott 2).

MATERIAL AND METHOD

During two growing winter seasons (2021–2022 and 2022–2023), this autopsy was conducted at the Agricultural Research and Experimental Centre, Faculty of Agriculture, Moshtohor, Benha University, Qaluibia Governorate, Egypt, to investigate the effects of water stress and plant density at different growth stages on the values of vegetative growth characteristics, yield, and yield components of faba bean plants.

The current study's treatments are as follows:

-Irrigation regimes:

1. Severe stress at 60 days after planting (one irrigation) (DAP).
2. Two irrigations at 40, 80, and 120 days following planting (DAP) to mitigate mild stress.
3. Three irrigations at 50 and 100 days after planting (DAP) under moderate stress.
4. Once every 30 days, do regular follow-up irrigations (four conventional irrigations as a control).

Triangular weirs (V-notch) were used to modify the irrigation outflow. The water's flow height was set at

30 centimetres. Water discharge was measured using the [10] equation, which is as follows:
Q is the water discharge, measured in m^3 per hour, and $Q = 0.0138 \times h^{2.5} \times 3.6$.
Realising that: h = Water height or pressure head (cm); 0.0138 and 3.6 =constant values, where 3.6 was used to achieve Q in m3 hr^{-1}. Efficiency of water usage (WUE)

- Faba bean densities: there are three plant populations with densities of 20, 30, and 40 kg/fed.

- Source of plant seeds: Faba bean (Vicia faba L.), seeds of plants(Cv. Marriott 2) were provided from legumes department,ARC, Egypt.

Design of an experiment:

There were three replications of the split plot design. The main plots were assigned to the four irrigation treatments, whereas the sub plots were randomly assigned to three faba bean denisties. The subplot's dimensions were 3 x 3.5 m, or 10.5 m^2.

Cultural practices:

Before seeding, the proper soil preparation was carried out, and 150 kg/feddan of phosphorus fertilizer calcium super phosphate (15.5%) was used. 5 ridges measuring 3.5 metres long and 60 centimetres wide make up the experimental unit. Faba bean seeds were hand-drilled into the ridges. In the 2022–2023 season, planting took place on November 17 and in the 2022–2023 season on November 19. A 25 kg N/fed nitrogen fertiliser was divided into two equal dosages and applied both before the first irrigation of the two seasons and during planting. Urea (46.5%N) was employed as the N_2 carrier.

Climate data for both of the experiment's growing seasons (Table 1) came from the Agriculture Research Center's Climates Research Station.

Vegetative growth characteristics:

During the two growth seasons, ten plants were chosen at random from each experimental unit to examine the following limitations:

- Plant height (Cm).
- No. of shoots $plant^{-1}$.

Yield and yield components:

Ten guarded faba bean plants were randomly selected at harvest from each experimental plot's middle ridge in order to estimate the following parameters:

- Weight of pods(kg) $plant^{-1}$.
- Weight of 100 seeds (g).
- No. of pods $plant^{-1}$.
- Biological yield (kg $plot^{-1}$), estimated on the whole sub-plot basis.

Microbiological analysis(Pathogenicity tests) of faba bean seeds:

Procedure

At a product to medium ratio of 1:9, dried faba bean seeds were combined and stomached separately with buffered peptone water (BPW) (Oxoid, Unipath, Ltd., Basingstoke, UK). Next, three separate mediums were used to pour-plate 1 mL of the solution in order to count the following microorganisms:

- Total aerobic bacteria(log cfu/g) was measured using amethod reported by **[11].**

-Total Moulds(log cfu/g) were counted according to **[11].**

-**Enterobacteracae(log cfu/g)** was counted according to **[12].**

-Staphylococcus aureus (log cfu/g) activity was confirmed according to method **[13].**

-Salmonella sp./25g was done according to method **[13].**

Statistical analysis: In accordance with **[14],** the analysis of variance was performed for the data from each of the two growth seasons. For the means comparison, the 5% threshold of the L.S.D. test was employed.

Table (1) Qaluibia Governorate's predominant ambient climate parameters for each of the two growth seasons.

Climatic factors and weather average during two growing winter seasons (2021-2022 and 2022-2023)		growing winter seasons (2021-2022)							growing winter seasons (2022-2023)						
Factors per Months		NOV. 2021	DEC. 2021	JAN. 2022	FEB. 2022	MAR. 2022	APR. 2022	May 2022	NOV. 2022	DEC. 2022	JAN. 2023	FEB. 2023	MAR. 2023	APR. 2023	May 2023
Temp. (°C)	Max.	25	20	19	20	23	28	32	24	19	19	20	23	28	32
	Min.	15	11	10	11	13	15	19	14	10	10	11	13	15	19
Humidity (%)		63	63	63	58	56	50	49	64	63	63	58	56	50	49
Pressure(mbar)		1017	1019	1019	1018	1016	1014	1013	1016	1018	1019	1018	1016	1014	1013
Precipitation(mm)		0.0	0.2	0.5	0.3	0.1	0.0	0.0	0.1	0.1	0.5	0.3	0.1	0.0	0.0

*The Ministry of Agriculture and Land Reclamation's Central Laboratory for Agricultural Climate (CLAC) at the Agricultural Research Centre (ARC) is the source of this data.

RESULTS AND DISCUSSION

-Actions of water regimes, faba bean at varying densities, and their combinations on:

1.Vegetative growth characteristics:

1.1. Plant height (cm):

Results in table (2) exposed that the effects of water regime, faba bean densities and their interactions on plant height performance of faba bean plants during the two growing winter seasons (2021/2022 and 2022/2023).

table (2) presents the major changes in plant height (measured in centimetres) that resulted from different water regime treatments during the two growing winter seasons (2022/2022 and 2022/2023).In both seasons, one irrigation treatment considerably reduced plant height when compared to other irrigation treatments. The tallest plants (83.55 and 80.11 cm) were generated in the first and second seasons by the normal irrigation treatment; these were followed by three irrigations (79.66 and 75.78 cm) and two irrigation treatments (74.77 and 75.00 cm). In order for the water regimes to be ordered as follows in descending order based on plant height (in centimetres) during the first season: There are notable variations in the following order: control (83.55) > three irrigations (79.66) > two irrigations (74.77) > one irrigation (72.22). Similar trend was observed during 2^{nd} growing winter season with different magnitudes with significant differences. This result muscularly supports the findings of **[15-22]**

The data presented in table (2) make it abundantly evident that, in terms of plant height (cm), there were considerable variations in the examined faba bean densities during the first season and minimal variances during the second. The tallest plants were recorded at plant density 40 kg/fed in the first and second seasons, measuring 79.16 and 76.25 cm, respectively. The shortest plants were measured at plant density 20 kg/fed in the first season, measuring 76.08 cm, and at plant density 30 kg/fed in the second season, measuring 75.08 cm, respectively. These data show that throughout the two winter seasons, plant densities of 40 kg/fed are more stimulated than other densities. For faba bean plant heights in the first and second seasons, table (2) shows that the interaction between faba bean densities and water regime had no discernible influence. The tallest faba bean plants, measuring 85.67 cm, were grown using standard irrigation in the first season, with a plant density of 40 kg/fed, and 81.00 cm in the second, with a plant density of 20 kg/fed, using the same water regime. In the meantime, one irrigation with a plant density of 20 kg/fed in the first season and 70.33 cm with the same density and water regime in the second season produced the shortest faba bean plants (71.00 cm). The obtained results were in agreement with those obtained by **[23 & 24].**

Table (2) Effect of water regimes and plant density on plant height of faba bean plants during each of two growing winter seasons (2021/2022 and 2022/2023).

Water regimes (W)	2021/2022 Season Faba bean densities kg/fed			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	71.00	72.00	73.67	**72.22**
Two	73.33	74.66	76.33	**74.77**
Three	78.33	79.67	81.00	**79.66**
Control	81.67	83.33	85.67	**83.55**
Means	**76.08**	**77.42**	**79.16**	
L.S.D. at 5% for water = 0.94 ,for Densities = 0.31 and for interaction = N.S				

Water regimes (W)	2022/2023 Season Faba bean densities kg/fed			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	70.33	71.67	73.00	**71.67**
Two	75.33	73.67	76.00	**75.00**
Three	75.67	75.33	76.33	**75.78**
Control	81.00	79.67	79.67	**80.11**
Means	**75.58**	**75.08**	**76.25**	
L.S.D. at 5% for water = 0.94 ,for Densities = N.S and for interaction = N.S				

One =One irrigation at beginning of flowering (B.F.).
Two =Two irrigations at vegetative growth (V.G) and beginning of flowering (B.F.).
Three =Three irrigations at (V.G.), beginning of flowering (B.F.) and full seed formation.
Control =Normal irrigation (Four irrigations as a control).at all vegetative and reproductive stages.

2.1.Number of shoots plant^{-1}:

Data illustrated in table (3) clarify the effects of water regimes, faba bean densities and their interactions on the no. of shoots plant^{-1} for the faba bean plants in the the two growing winter seasons (2021/2022 and 2022/2023).

table(3) displays the average number of shoots per plant^{-1} as a function of water regime. Regarding the number of shoots plant^{-1}, there were notable variations in the irrigation regimes during the first season and negligible variations during the second. Additionally, the number of shoots plant^{-1} in the first and second seasons showed a negative connection. Normal irrigation treatment produced the highest value of the studied trait (4.2 and 4.0 shoots plant^{-1}), which was followed by three irrigation treatments in the first season (3.7 shoots plant^{-1}), and three and two irrigation treatments in the second season (3.4 shoots plant^{-1}). As a result, the stress of waterlogging greatly reduced the number of shoots per plant. As a result, they also displayed various drought avoidance strategies. It appears to be generally true that there are no appreciable variations between three irrigations of slightly different magnitudes that are applied and regular irrigation (control). Similar results were also obtained by **[17-22].**

The information shown in table (3) makes it abundantly evident that, in terms of the number of shoots per plant, there were considerable variations in the examined faba bean densities during the first season and minimal variances during the second. In comparison to the other two faba bean populations, the plant density of 20 kg/fed resulted in significantly higher numbers of shoots per plant^{-1}, with 3.9 and 3.6 shoots per plant^{-1}, respectively. Though there were notable variations in the densities of faba beans among accessions in both seasons, the plant denisty 40 kg/fed in the first season and denisty 30 kg/fed in the second season yielded the lowest value of no. of shoots plant^{-1} by (3.4 shoots plant^{-1}). Stated differently, the optimal plant density in terms of the number of shoots per plant in both seasons was found to be 20 kg/fed. The present results is confirmed with those obtained by **[28-34].**

In the first season, the interaction between the water regime and plant population did not significantly affect the number of shoots per plant; however, in the second season, there was a significant difference table (3). The highest number of branches plant^{-1} (4.6 shoots plant^{-1}) was produced by one irrigation treatment under all of the studied densities in the first and was recorded under normal irrigation treatment by plant density 30 kg/fed in the second season, respectively. The lowest number of shoots plant^{-1} (3.0 shoots plant^{-1}) was produced by one irrigation treatment under all of the studied densities in the first and was recorded under normal irrigation treatment by plant density 30 kg/fed in the second season, respectively. Similar results were also obtained by **[35&36].**

Table (3) Effect of water regimes and plant density on number of branches of faba bean plants during each of two growing winter seasons (2021/2022 and 2022/2023).

Water regimes (W)	2021/2022 Season Faba bean densities kg/fed			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	3.0	3.0	3.0	**3.0**
Two	4.0	3.3	3.0	**3.4**
Three	4.0	3.6	3.6	**3.7**
Control	4.6	4.0	4.0	**4.2**
Means	**3.9**	**3.5**	**3.4**	
L.S.D. at 5% for water = 0.26 , for Densities = 0.22 and for interaction = N.S				
Water regimes (W)	**2022/2023 Season Faba bean densities kg/fed**			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	3.3	3.0	3.3	**3.2**
Two	3.6	3.3	3.3	**3.4**
Three	3.6	3.3	3.3	**3.4**
Control	4.0	4.0	4.0	**4.0**
Means	**3.6**	**3.4**	**3.5**	
L.S.D. at 5% for water = N.S ,for Densities = N.S and for interaction = 0.49				

2.Yield and yield components:

1.2.Weight of pods(kg plot^{-1}):

The effects of drought tolerance, faba bean densities and their interactions on weight of pods(kg) plot^{-1}in the two growing winter seasons (2021/2022 and 2022/2023),are presented in table (4).

As demonstrated in Table (4), it was evident that fewer irrigations led to a significant drop in pod weight (kg) plot^{-1} in both seasons. In the first and second seasons, the control treatment yielded pods with maximum weights of 0.830 and 0.726 kg plot^{-1}, respectively. On the other hand, the lowest ones, which were obtained from a single irrigation administered at vegetative Growth stage 35 D.A.P. (day after planting) in the first and second seasons, were (0.438 and 0.472 kg plot^{-1}).

Overall, it appears to be true that there are no appreciable variations between two irrigations of slightly different magnitudes that are applied and regular irrigation (control). These results are in harmony with those reported by **[37-40].**

In the first season, plant density 40 kg/fed significantly outperformed the other two densities in this character, followed by plant density 30 kg/fed in the second rank with no significant difference between them; however, in the second season, plant density 30 kg/fed gave the maximum weight of pods (kg) plant^{-1}, followed by plant density 20 kg/fed in the second rank, then plant density 40 kg/fed with a significant difference between them. The results in table (4) showed slight variations in weight of pods (kg. plot^{-1}) in both seasons among the three densities of faba bean under study.

It is abundantly evident that the observed variations in pod weight (kg) for each of the faba bean densities may result from each plant's unique genetic makeup interacting in different ways with the specific ecological conditions under investigation. The same trend was obtained by **[6,24,31,41-43]**

table (4) shows that in the first and second seasons, respectively, the weight of pods (kg. plot^{-1}) was not significantly affected by the interaction between water regimes and faba bean plant densities. The findings show that, when watered with standard irrigation (control) treatment, the maximum weight of pods (kg) plot^{-1}was (0.910 and 0.760 kg plot^{-1}), produced from plant density 40 kg/fed in the first season and that plant density 30 kg/fed in the second season, respectively. In the meantime, the minimum one was **(0.380** and **0.427** kg plot^{-1}**)**, obtained from plant density 20 kg/fed with irrigation at the lowest irrigation number (one irrigation). It could be concluded that plant density 30 kg/fed were the best selected density in weight of pods (kg. plot^{-1}) and gave very good results when irrigated by three irrigations. Such results agree with those reported by **[24&44].**

2.2.Weight of 100 seeds (g):

table (5) records the impact of water-limited conditions and the interactions between faba bean densities and weight of 100 seeds (g) over the two growing winter seasons (2022/2022 and 2022/2023).

Statistics in table (5) demonstrated that increasing the number of irrigations from one to the typical irrigation (control) in each growing season greatly increased the weight of 100 seeds (g). In both seasons, a single watering greatly reduced the weight of 100 seeds (g).

It is also evident that, in the first and second seasons, a single irrigation treatment reduced the weight of 100 seeds (g) by 69.00 and 59.44 g, respectively, in comparison to two irrigations (73.22 and 63.78 g), three irrigations (83.55 and 65.67 g), and a standard irrigation treatment (94.33 and 74.56 g).The application of two irrigations of slightly different magnitudes and regular irrigation (control) appear to be similar in general, with no discernible changes.Similar results were also reported by **[20,22,37,38,40,45&46].**

Table (4) Effect of water regimes and plant density on weight of pods(kg) plot-1 of faba bean plants during each of two growing winter seasons (2021/2022 and 2022/2023).

Water regimes (W)	2021/2022 Season Faba bean densities kg/fed			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	0.380	0.447	0.487	**0.438**
Two	0.537	0.610	0.633	**0.593**
Three	0.640	0.717	0.793	**0.717**
Control	0.757	0.823	0.910	**0.830**
Means	**0.578**	**0.649**	**0.706**	
L.S.D. at 5% for water = 0.02 ,for Densities = 0.01 and for interaction = N.S				
Water regimes (W)	**2022/2023 Season Faba bean densities kg/fed**			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	0.427	0.477	0.513	**0.472**
Two	0.633	0.620	0.623	**0.626**
Three	0.697	0.720	0.687	**0.701**
Control	0.757	0.760	0.660	**0.726**
Means	**0.628**	**0.644**	**0.621**	
L.S.D. at 5% for water = 0.05 ,for Densities = 0.02 and for interaction = N.S				

Table (5) Effect of water regimes and plant density on weight of 100 seeds (g) of faba bean plants during each of two growing winter seasons (2021/2022 and 2022/2023).

Water regimes (W)	2021/2022 Season Faba bean densities kg/fed			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	72.00	68.00	67.00	**69.00**
Two	76.66	72.33	70.66	**73.22**
Three	88.33	82.00	80.33	**83.55**
Control	98.00	94.00	91.00	**94.33**
Means	**83.75**	**79.08**	**77.25**	
L.S.D. at 5% for water = 1.27,for Densities = 0.67 and for interaction = N.S				
Water regimes (W)	**2022/2023 Season Faba bean densities kg/fed**			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	64.67	59.67	54.00	**59.44**
Two	68.67	64.00	58.67	**63.78**
Three	73.33	68.67	55.00	**65.67**
Control	78.33	71.33	74.00	**74.56**
Means	**71.25**	**65.92**	**60.42**	
L.S.D. at 5% for water = 5.00 ,for Densities = 3.04 and for interaction = N.S				

The weight of 100 seeds (g) for each evaluated density of faba bean differed significantly in both seasons, as indicated by the amounts in table (5).With notable variations between them in the first and second seasons, respectively, the plant density of 20 kg/fed recorded the highest weight of 100 seeds (g) by (83.75 and 71.25g), followed by plant density of 30 kg/fed of (79.08 and 65.92g) and plant density of 40 kg/fed of (77.25 and 60.42g).These results are in agreement with those obtained by **[24,29,30,34,41,47,48,49&50].**

However, for the weight of 100 seeds (g) in the first and second seasons, the interaction effect between water regimes and faba bean plant densities was negligible. table (5).When compared to other densities in the first and second seasons, (plant density 40 kg/fed + one irrigation treatment) had the lowest value (67.00 and 54.00 g).When compared to other plant densities in both seasons, the current data provide a convincing case for the advantages of plant density 20 kg/fed.In contrast, the maximum weights of 100 seeds (g) were achieved in the first and second seasons, respectively, by (plant density 20 kg/fed + usual watering treatment). These weights were 98.00 and 78.33 g. Such results are in harmony with those reported by **[24,44&51]**

3.2.Number of pods plant^{-1}:

The effects of two growing winter seasons (2021/2022 and 2022/2023) on the number of pods plant^{-1}, as well as the relationships between water shortage and faba bean density.have been included in table (6).

The number of pods per plant^{-1} of faba bean plants varied significantly between the four irrigation treatments in both seasons, according to the data. It is evident that when the number of irrigations rose over both seasons, the number of pods plant^{-1} grew dramatically. In both the first and second seasons, the normal irrigation treatment produced the highest number of pods plant^{-1} (45.63 and 38.22 pods, respectively). Three irrigation treatments (43.45 and 34.44 pods), two irrigation treatments (37.26 and 30.00 pods), and one irrigation treatment (35.86 and 27.22 pods) were the next highest values, as shown in table (6). It seemed sense to state that in the first and second seasons, respectively, one irrigation treatment produced the lowest numbers of pods per plant (35.86 and 27.22 pods).On the whole, it looks to be true that there is no significant differences between normal irrigation (control) and applied two irrigations with slight various magnitudes. Similar results were also reported by **[21,37,52&53].**

Table (6) Effect of water regimes and plant density on number of pods / plant of faba bean plants during each of two growing winter seasons (2021/2022 and 2022/2023).

Water regimes (W)	2021/2022 Season Faba bean densities kg/fed			
	Density=20kg	Density=30kg	Density=40kg	Means
One	36.60	36.10	34.90	**35.86**
Two	40.00	38.70	33.10	**37.26**
Three	47.70	43.33	39.33	**43.45**
Control	50.43	45.50	40.96	**45.63**
Means	**43.68**	**40.90**	**37.07**	
L.S.D. at 5% for water = 4.13 ,for Densities = 1.16 and for interaction = 2.32				
Water regimes (W)	**2022/2023 Season Faba bean densities kg/fed**			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	26.33	27.33	28.00	**27.22**
Two	27.00	31.33	31.67	**30.00**
Three	34.67	34.00	34.67	**34.44**
Control	37.67	38.00	39.00	**38.22**
Means	**31.42**	**32.67**	**33.33**	
L.S.D. at 5% for water =1.53, for Densities = 1.02 and for interaction = N.S				

The results displayed in table (6) demonstrate that there are notable variations in the number of pods plant^{-1} of faba bean densities between the first and second seasons under investigation, as well as in the mean values of the number of pods plant^{-1} between the first and second seasons. Furthermore, in comparison to the other densities, the plant density of 20 kg/fed yielded the best value (43.68 pods) in the first season, and the mean plant density of 30 kg/fed produced the highest value (32.67 pods) in the second season. Plant density 40 kg/fed gave 37.07 pods in the first season and plant density 20 kg/fed gave 31.42 pods in the second, respectively, are the lowest values of no. of pods plant^{-1}.

It is widely accepted that, in comparison to the other densities, the plant densities of 20 kg/fed and 30 kg/fed had the highest number of pods per plant during the first and second seasons, respectively. It is evident that the observed variations in the number of pods for each of the growing densities of faba beans could be attributed to their unique genetic make up, which interacts in distinct ways with the environmental variables under investigation in varied patterns.These results agree with those obtained by **[5,7,24,30,31,34,41&54].**

For the first season only, table (6) shows a substantial interaction impact between water regimes and the population of faba bean plants in terms of the number of pods plant^{-1}. In the first season, normal irrigation treatment with plant density of 20 kg/fed produced the maximum value of no. of pods plant^{-1} (50.43 pods), whereas in the second season, normal irrigation treatment with plant density of 40 kg/fed produced 39.00 pods. Conversely, the two irrigation treatments that were performed in the first season with a plant density of 40 kg/fed and the second season with a plant density of 20 kg/fed produced the lowest values (33.10 and 26.33 pods, respectively). This result might be the result of the second season's colder conditions.Such results are in agreement with those reported by **[24,44&51].**

4.2.Biological yield (kg plot^{-1}):

For the two growing winter seasons (2021/2022 and 2022/2023), the grades in table (7) show the biological yield kg fed-1 of faba bean densities as influenced by water regimes and their interactions.

Table (7), presents the substantial variations in biological yield kg plot^{-1} of faba bean densities in the first and second seasons between treatments applying one, two, three, and normal (control) irrigations. In the first and second seasons, respectively, the application of normal irrigation treatments yielded the highest value of biological yield fed^{-1} (7.44 and 6.32 kg plot^{-1}), followed by the application of three irrigations (6.73 and 5.14 kg plot^{-1}) and then two irrigations (6.04 and 4.37 kg plot^{-1}) with a significant difference in both seasons. On the other hand, one irrigation treatment produced the lowest biological yield fed^{-1} values (5.40 and 3.84 kg fed^{-1}, respectively), with very significant differences in the first and second seasons.With respect to the general comparisons among all of the water regimes, application of normal irrigation treatment gave the highest value of biological yield kg plot^{-1}. In general, it aspects to be true that there is no significant differences between normal irrigation (control) and applied two irrigations with slight various magnitudes.These results were substantiated with the studies conducted by **[20,22,34,39,56&57].**

Significant variations between the three faba bean densities in biological yield kg plot^{-1} were only evident in the second season, as indicated by the results in table (7). In the first season, plant density of 40 kg/fed produced the highest biological yield kg plot^{-1} (6.85 kg plot^{-1}), followed by plant density of 30 kg/fed (6.57 kg plot^{-1}), then plant density of 50 kg/fed

(6.54 kg plot^{-1}), with significant differences; in the second season, when application of various irrigations treatments, plant density of 40 kg/fed produced the highest biological yield kg plot^{-1} (5.07 kg plot^{-1}), followed by plant density of 30 kg/fed (4.93 kg plot^{-1}), then plant density of 50 kg/fed (4.76 kg plot^{-1}).However, it may be inferred that, in the first season, plant density of 40 kg/fed and plant density of 30 kg/fed (2nd season) were superior in biological yield kg plot^{-1} compared with the other ones; this result is a clear evidence for the good performance of faba bean densities. It is commonly noticed that, plant density 40 kg/fed was the most productive density Whereas, plant density 20 kg/fed was of the lowest yield production. Many investigators are in conscident with that reported by **[24,30,31,42&43].**

Table (7), indicates that, in the second season alone, the interaction between the faba bean plant population and the water regime had a substantial impact on the biological yield kg plot^{-1} of faba beans. By applying a standard irrigation treatment with a plant density of 20 kg/fed in the first season and 40 kg/fed in the second, respectively, the highest biological production was 7.85 and 6.43 kg plot^{-1}. Conversely, the use of (one irrigation treatment + plant density 20 kg/fed) with (4.35) and (3.63) kg plot-1 in the first and second seasons, respectively, produced the lowest values of biological yield kg plot^{-1}. These results are in agreement with those obtained by **[24&51].**

3.Microbiological analysis(Pathogenicity tests) of faba bean seeds:

According to results of table (8), certain microbiological studies were conducted on faba bean seeds with the goal of enhancing the use of faba beans in novel food applications while taking into account the effects of plant densities, water regimes, and their interactions during the winter growing season (2021–2022).

I'm sure that this subject will pique people's curiosity about the microbiology of food-borne illnesses and could lead to a greater effort to comprehend the ecology and pathogenicity mechanisms of many viruses. These findings will serve as the foundation for figuring out the optimal plant density and watering schedules, which could improve food and water safety.

table (8) shows the mean value of total bacteria (log cfu/g) in faba bean seeds as influenced by faba bean densities and water regimes. Significant variations in the total bacteria present in seeds during the winter growth season were observed in the irrigation regimes (2021/2022). Plant density 40 kg/fed (5.63), which was recorded by application of one irrigation treatment, had the highest mean value of total bacteria in seeds; plant density 30 kg/fed (5.45), which was recorded by application of the same treatment during the winter growing season (2021/2022), followed. On the other hand, application of two irrigation treatments during the winter growing season (2021/2022) recorded the lowest mean value of total bacteria in seeds plant density 20 kg/fed (4.21). These findings showed that the overall amount of bacteria carried by seeds was greatly decreased by drought stress

Table (7) Effect of water regimes and plant density on biological yield (kg / plot of faba bean plants during each of two growing winter seasons (2021/2022 and 2022/2023).

Water regimes (W)	2021/2022 Season			
	Faba bean densities kg/fed			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	4.35	5.87	5.99	**5.40**
Two	7.01	7.00	7.12	**6.04**
Three	6.95	6.30	6.96	**6.73**
Control	7.85	7.11	7.36	**7.44**
Means	**6.54**	**6.57**	**6.85**	
L.S.D. at 5% for water = 0.64 ,for Densities = N.S and for interaction = N.S				
Water regimes (W)	**2022/2023 Season**			
	Faba bean densities kg/fed			
	Density=20kg	**Density=30kg**	**Density=40kg**	**Means**
One	3.63	3.87	4.03	**3.84**
Two	4.20	4.46	4.43	**4.37**
Three	4.96	5.10	5.37	**5.14**
Control	6.23	6.30	6.43	**6.32**
Means	**4.76**	**4.93**	**5.07**	
L.S.D. at 5% for water = 0.24 ,for Densities = 0.08 and for interaction = 0.16				

Table (8) Effect of water regimes, plant densities and their interactions on microbial analysis of faba bean seeds during the winter growing season (2021/2022).

		Microbiological evaluation of faba bean plant seeds				
Irrig.	**Density**	**Total bacteria (log cfu/g)**	**Total mould (log cfu/g)**	**Enterobacteracae (log cfu/g)**	**S. aureus (log cfu/g)**	**Salmonella sp. /25g**
One Irrig.	**20kg**	**5.21**	**2.30**	**2.05**	**2.30**	**ND**
	30kg	**5.45**	**3.07**	**<10**	**2.00**	**ND**
	40kg	**5.63**	**2.65**	**2.85**	**2.30**	**ND**
Two Irrig.	20kg	4.21	2.98	2.32	2.00	ND
	30kg	4.30	2.12	2.30	2.03	ND
	40kg	4.91	2.51	2.04	2.45	ND
Three Irrig.	**20kg**	**4.35**	**2.45**	**2.01**	**2.30**	**ND**
	30kg	**4.85**	**3.54**	**2.31**	**1.51**	**ND**
	40kg	**4.65**	**2.45**	**<10**	**<100**	**ND**
Four Irrig.	20kg	5.11	3.85	2.30	<100	ND
	30kg	5.30	3.65	2.10	<100	ND
	40kg	5.30	3.21	<10	<100	ND

ND; Not detected in 25 g, cfu; colony forming unite

About the comparison of the mean value of total mould (log cfu/g) and total bacteria (log cfu/g) in faba bean seeds. Data in tables (8) and make it abundantly evident that there were notable variations in the total amount of mould (log cfu/g) in faba bean seeds.

It is more likely to be true that the plant density of 20 kg/fed produced the highest total mould (log cfu/g) at (3.85), which was followed by the plant density of 30 kg/fed produced by (3.65) by applying four irrigation treatments. Plant density of 30 kg/fed (2.12) with two irrigation treatments applied throughout the winter growing season (2021/2022) yielded the lowest values.During the winter growth season (2021/2022), there were nearly substantial differences among the densites.

Most often, it is observed that the best irrigation treatment configuration reduced the overall amount of mould (log cfu/g) by placing two irrigation treatments on top of other water treatments. Furthermore, it is evident that the variations in total mould (log cfu/g) observed for each of the grown faba bean densites may result from variations in their unique genetic makeup, which interacts differently with the basic environmental conditions under investigation in a variety of specific patterns.

The winter growing season (2021/2022) saw a significant impact on the levels of enterobacteracae (log cfu/g) and staphylococcus aureus (log cfu/g) in faba bean seeds due to the interaction between water regimes and densities, as table (8) indicates.In the winter growing season of 2021/2022, the highest count values of enterobacteracae (log cfu/g) (<10) were recorded by application of three irrigations treatments under plant density 40kg/fed, and in staphylococcus aureus (log cfu/g) (<100) were recorded by application of three irrigation treatments under plant density 40kg/fed. Conversely, the highest ones in staphylococcus aureus count (log cfu/g) (2.45) were obtained by application of two irrigations treatments with plant density 40kg/fed in the winter growing season (2021/2022).It is mostly noticed that the differences in the magnitudes of plant densities was insignificantly.These grades are in agreement with those obtained by **[56&57].**

The information in table (8) demonstrated that not all of the faba bean plant seed samples had salmonella sp.

In general, it can be claimed that morphological and biochemical markers were both able to distinguish between the densities of faba beans based on the background of drought tolerance. It appears, therefore, that there are no appreciable differences in the safety of faba bean seeds for human nutrition between applied (three irrigations (slight stress) + application plant density 20 kg/fed) and normal irrigation (control) + application plant density 30 kg/fed. In order to obtain appropriately adjusted disease management seeds, the data in table (8) suggest selecting a plant density of 30 kg/fed in conjunction with the application of two watering treatments. Analogous results were also obtained by**[24&58]** Finally,it could be cocluded that, in comparison to the other faba bean densities, the variety density of 20 kg/fed + application of 3 watering treatments appears to be genetically distinct and may be drought-tolerant.

And on the other hand, the commercial value for this result is to saving up to 25% from total budget water that consumed in irrigation.

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