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Response of Three Faba Bean (Vicia faba L.) Varieties to Different levels of Irrigation Water salinity

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Faba bean, Varieties, Irrigation water salinity, Growth traits, yield component

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ABSTRACT

A field experiment was conducted during the 2022–2023 growing season at Al-Faris Agricultural Research Station, located in Al-Zubair district, southwestern Basrah, Iraq. This study aimed to investigate the effects of varying irrigation water salinity levels on the growth and yield of different faba bean (Vicia faba L.) Varieties. Two factors were examined: three faba bean Varieties Spanish (Lozde otono), Dutch (Histal), and a local Variety and three levels of irrigation water salinity: 1.5, 3.5, and 5.5 dS m^{-1}. The experiment followed a factorial experiment within a Randomized Complete Block Design (RCBD) with three replications. The results showed that both the Varieties (Lozde otono and Histal) and water salinity, as well as their interaction, had a significant impact on the studied traits. The Spanish Variety (Lozde otono) showed the highest values for plant height (67.76 cm), number of branches per plant (6.34 branch $plant^{-1}$), pods per plant (6.67 pod $plant^{-1}$), seeds per pod (5.30 seed), 100 seed weight (157.05 g), and seed yield per plant (475.60 g). the salinity levels, 3.5 dS m^{-1} records highest plant height, number of branches, pod length, and yield per plant (69.28 cm, 5.92 branches $plant^{-1}$, 8.29 cm). On the other hand, the lowest salinity level (1.5 dS m^{-1}) resulted in higher pod number, seeds per pod, and 100-seed weight (6.48 pods, 5.00 seeds, 152.44 g). Moreover, the interaction between the Spanish Variety and the two salinity levels (1.5 and 3.5 dS m^{-1}) significantly improved all measured traits, including plant height, number of branches, pods per plant, 100-seed weight, and seed yield per plant (74.59 cm, 6.68 branches $plan^{-1}$, 7.80 pods, 164.28 g, and 510.10 g, respectively). Based on these results, Lozde otono can be considered a promising variety for cultivation in saline-prone areas of southern Iraq, offering both adaptability and productivity under moderately saline irrigation condition.

استجابة ثلاثة أصناف من محصول الباقلاء (*Vicia faba* L) لمستويات مختلفة من ملوحة مياه الري

روافد هادي العبيدي وخولة داود

قسم المحاصيل الحقلية – كلية الزراعة – جامعة البصرة

الخلاصة : أُجريت التجربة الحقلية خلال الموسم الزراعي 2022-2023 في محطة أبحاث الفارس الزراعية، الواقعة في قضاء الزبير، جنوب غرب البصرة- العراق. هدفت هذه الدراسة إلى معرفة تأثير مستويات مختلفة من ملوحة مياه الري في نمو وحاصل عدة أصناف من محصول الباقلاء (*Vicia faba* L). شملت الدراسة على عاملين – الأول: ثلاثة أصناف من الباقلاء - الإسباني (Lozde otono)، والهولندي (Histal)، والصنف المحلي , والعامل الثاني ثلاثة مستويات من ملوحة مياه الري: 1.5 ,3.5 و5.5 ديسي سيمنزمتر$^{-1}$. طبقت التجربة بأسلوب التجارب العاملية وفق تصميم القطاعات الكاملة العشوائية (RCBD) بثلاثة مكررات. أظهرت نتائج الدراسة أن الأصناف ومستويات ملوحة مياه الري والتداخل بينهما اثرت معنوياً في الصفات المدروسة , تفوق الصنف الإسباني مسجلاً أعلى المتوسطات في ارتفاع النبات (67.76 سم)، عدد الفروع لكل نبات (6.34 فرع نبات$^{-1}$)، عدد القرون لكل نبات (6.67 قرن نبات$^{-1}$) ، عدد البذور في القرن (5.30 بذرة)، , وزن 100 بذرة (157.05 غم)، وحاصل البذور الفردي (475.60 غم). بالنسبة لمستويات الملوحة، سجل المستوى 3.5 ديسي سيمنز م$^{-1}$ إعلى ارتفاع نبات، عدد الفروع، وطول القرون، وحاصل النبات الفردي (69.28 سم، 5.92 فرع، 8.29 سم) على التتابع. من ناحية أخرى، أدت المعاملة بمستوى ملوحة (1.5 ديسي سيمنز م$^{-1}$) إلى تسجيل اعلى متوسط في عدد القرون، عدد البذور لكل قرن، ووزن 100 بذرة (6.48 قرن، 5.00 بذرة، 152.44 غم على التتابع). كما أدى التداخل بين الصنف الإسباني ومستويي الملوحة (1.5 و3.5 ديسي سيمنز$^{-1}$ إلى التأثير المعنوي في صفات ارتفاع النبات، عدد الفروع، عدد القرون لكل نبات، وزن 100 بذرة، وحاصل النبات الفردي (74.59 سم، و6.68 فرع، و7.80 قرون، و164.28 جم، و510.10 غم، على التوالي).من النتائج نلاحظ انه يمكن زراعة الصنف Lozde otono صنفاً ملائماً للزراعة في المناطق المعرضة للملوحة في جنوب العراق تحت ظروف الري بالمياه متوسطة الملوحة

الكلمات المفتاحية: محصول الباقلاء، الأصناف، الري بمياه مالحة، مؤشرات النمو، مكونات الحاصل

INTRODUCTION

Broad beans (*Vicia faba* L.) are an annual legume native to western Asia and North Africa. Widely cultivated as a winter crop, they play a key role as a source of plant protein, particularly in densely populated, low-income areas. Due to their high nutritional value, they are often called "the poor man's meat.", Their seeds contain protein (25–40%) and carbohydrates (48–54%) (Karkanis *et al*., 2018). It ranks third in importance after soybean and pea, at a global scale, the average yield of faba beans reaches 9.41 tons ha^{-1} (FAO, 2024), while in Iraq, the reported production efficiency is only 5.42 tons ha^{-1} (Central Statistical Organization, 2024, Agricultural Statistics Division). Broad beans are used in crop rotations because of their importance in improving the physical and chemical properties of the soil by fixing atmospheric nitrogen through symbiotic bacteria found in root nodules.

Varieties are one of the most important factors that determine crop productivity. Varieties differ from each other in terms of production and qualitative characteristics, as well as in their growth and the length of time required to reach maturity. They differ according to their genetic ability to respond to growth and production factors, in addition to environmental factors. There is also a relationship between the phenotypic and anatomical characteristics of each Variety and its ability to absorb water and nutrients. As well as increase the process of photosynthesis and transfer of manufactured products from the leaves to the fruits to obtain the highest productivity per unit area, which is one of the most important primary goals of plant breeders (Al-Sahouki, 2006). Salinity tolerance is a complex physiological feature with several subcomponents; the traditional view holds that salinity affects plant performance through osmotic stress and specific-ion

toxicity. Salt concentration in soil severely affects faba bean yield ([Bimurzayev *et al*, 2021); however, faba bean seed germination is more sensitive to growth under salinity.

Characterizing salt tolerance, faba bean genotypes have shown enhanced productivity under salinity (Yang *et al*, 2020). Plants compensate for decreasing osmotic potential in the rhizosphere by minimizing water loss. It has been claimed that stomatal transpiration accounts for around 95% of plant water loss. Lower stomatal density is an essential physiological characteristic in salinity-tolerant quinoa, while farmed barley uses a stress-escaping strategy by lowering stomatal density to conserve water when grown in saline circumstances (Kiani-Pouya *et al*, 2020).

The K^+/Na^+ ratio is thought to be the fundamental trait imparting salinity stress resistance in plants, and it is frequently used as a screening tool for plant breeders. Under salt stress, Na^+ and K^+ transporters are critical for maintaining Na^+ and K^+ homeostasis in cells and plants. An important sustainable strategy to alleviate the adverse effect of salinity on crop yield is to increase its salt-tolerance potential (Luo *et al*, 2019). Kadhim *et al.* (2024) found that varieties differed greatly for plant height, number of branches and weight of 100 seeds among other traits. Similarly, Filipović,*et al*.,(2020) found that higher salinity levels had a negative impact on plant performance, causing reductions in average plant height, branch number, and pod length. In contrast, Halil and Ali (2019) observed that the American Variety demonstrated superior growth, yield, and quality characteristics compared to other Varieties.The objective of this study is to identify the variety that demonstrates the best growth and yield performance under different levels of irrigation water salinity.

MATERIALS AND METHODS

A field experiment was conducted during 2022-2023 agricultural season in AL-Faris station for Agricultural research at AL-Zubair district, located in the southwestern side of Basrah, Southern Iraq.The experiment was conducted using a randomized complete block design (R.C.B.D.) with three replications. Each experimental unit was a 2 × 3 m² area composed of four rows spaced at 75 cm. The spacing between seeds planted in different experimental units was 25 cm , while a buffer zone of one meter was used between experimental units to minimize potential interference. The experiment was designed to evaluate two main factors. The first factor involved three faba bean varieties: the Spanish variety (Lozde otono), the Dutch variety (Histal), and a local variety. The second factor consisted of irrigating the plants with three levels of water salinity (1.5, 3.5, and 5.5 dS m^{-1} EC).The required salinity levels were obtained by diluting artesian well water from the field, which had an initial salinity of 18.11 dS m^{-1} and was used as the irrigation source throughout the growing season. Three tanks, each with a capacity of 1000 liters, were prepared, with each tank adjusted to represent one of the designated salinity levels used in the experiment. . Seeds of faba bean Varieties were soaked in water for 12 hours before sowing. We put two to three seeds in each planting hole. Thinning was done two weeks after planting, leaving a strong plant per hole (germinated Oct 10^{th} 2022)

Chemical fertilizers were applied following standard recommendations, with specific adjustments for the experimental treatments. Nitrogen (N) was supplied as urea (46% N) at a rate of 120 kg N ha^{-1}(Kamal *et al*,2021). This was split into two equal applications: the first at the time of planting and the second during the flowering stage. For

phosphorus, triple superphosphate (43% P) was applied at a rate of 80 kg ha during the planting phase, following the protocols established by Al-Abadi (2011).
Soil samples were collected from five different locations within the experimental field at a depth of 0–30 cm. The samples were combined, cleaned of debris, thoroughly mixed, and a representative subsample was taken for laboratory analysis of selected physical and chemical properties (Table 1).

Table 1. Some of the physical and chemical properties for the experimental soil

Value	Traits
805. 4	Sand (g kg^{-1})
116. 7	Silt (g kg^{-1})
77.9	Clay (g kg^{-1})
sandy loam	Soil texture
1.86	Electrical conductivity of the soil solution E.C dS m^{-1}
7.19	Soil pH
2.11	Total nitrogen (mg kg^{-1})
0.35	Phosphorus (mg kg^{-1})
12.34	Available potassium (mg kg^{-1})

Traits Studied

Studied features were calculated based on the average of 10 plants taken from the two middle harvested lines for each experimental unit.

1-Plant height (cm): was measured using a measuring tape from the ground to the top of the plant.

2-The number of branches (branch $plant^{-1}$): was determined by counting a total of ten plants and calculating their average.

3-The number of pods per plant (pod per $plant^{-1}$): was calculated manually for all experimental units.

4-Pod height (cm) was measured with a measuring tape after the pods had fully matured.

5-The number of seeds per pod (seed per pod^{-1}): was calculated for all pods and their average for each plant was recorded.

6-The weight of 100 seed (g): was measured using the sensitive scale for each experimental unit.

7-Yield per plant (g): was assessed using the sensitive scale for each experimental unit.

Statistical Analysis

Statistical analysis of the data was performed using GenStat 12.1statistical software (Table 2). Treatment means were compared using the Least Significant Difference (LSD) test at a significance level of 0.05 (Al-Sahouki and Wahib, 1990).

Table 2. Analysis of variance representing the mean square of the studied characteristics in faba bean

Source of variation	D.F.	P.H.	N.B	P.L	N.P.	N.S	W.S.	Y.
Replication	2	75.56	1.5447	0.4090	0.2298	0.4385	3.13	920
Varieties	2	479.00	35.1592**	296.29**	30.4289	21.6121**	3368.13**	554030
salinity	2	840.03	4.2692	1.5808	6.6222	7.0434**	543.41**	3902n.s
varieties ×salinity	4	185.88	2.7174	7.3055	5.7229	2.8260**	540.21	40051
Error	16	1501.52	18.6950	37.66	26.1925	4.2631	1051.16	155382

RESULT AND DISCUSSION

The results in Table 3 indicate that Variety Lozde otono achieved the highest average for plant height at 67.76 cm with no significant difference from Variety Histal, In contrast, Local Variety had the lowest average at 60.52cm, The variation in plant height among the studied cultivars can be attributed to genetic differences, which play a key role in determining growth performance. The superior performance of the cultivar Lozde otono, with no significant difference compared to Histal, suggests that these improved cultivars possess higher efficiency in utilizing available resources under the given environmental conditions. This result is consistent with what Al-Fahdawi (2014) and Hantoush, (2021). This advantage may be associated with enhanced nutrient and water uptake, greater photosynthetic capacity, and more effective regulation of growth-related hormones such as auxins and gibberellins, which promote stem elongation. In contrast, the local cultivar exhibited lower plant height, possibly due to its comparatively limited physiological efficiency and higher sensitivity to environmental stresses, particularly salinity.

Table 3 also indicates that the second level of irrigation water salinity (3.5 dS $m^{-1)}$ gave the highest plant height. (69.28 cm), while the third level (5.5 dS m^{-1}) gave the lowest average at 59.62cm,With a decrease of 13.94% , The reason for the decrease in plant height due to the increase in salinity levels in irrigation water may be attributed to either the increase in the osmotic potential of the soil solution, thus hindering the ability of the roots to absorb water and nutrients, or the toxic effect, which hinders many vital processes within the plant tissues, including the process of photosynthesis, thus reducing the production of nutrients, which leads to a decrease in cell elongation (Tuteja, 2005 and Ahmed, 2022). The interaction (figure 1) between Variety Lozde otono treatment with the second level (3.5 dS.m^{-1}) from irrigation water has resulted in the highest average plant height at (74.59 cm), with no significant difference from the combination 3.5 x Histal. Conversely, the combination Histal x 1.5 recorded the lowest average (58.77cm).

The results presented in Table 3 show that the variety Lozde otono exhibited superior performance in terms of the number of branches per plant, recording the highest average (6.34 branches $plant^{-1}$), whereas the local cultivar produced the lowest average (4.43 branches $plant^{-1}$). This superiority may be attributed to the cultivar's better adaptation to the prevailing environmental conditions of the region, as well as to its genetic characteristics that influence branching capacity. These findings are in agreement with those reported by Zidane (2018). Furthermore, the results indicate no significant differences between the first and second salinity levels (1.5, 3.5 ds m^{-1}), which recorded averages of 5.83 and 5.92 branches $plant^{-1}$, respectively. However, increasing the salinity of irrigation water to the third level resulted in a reduction in the number of branches, with the lowest average recorded at 5.29 branches $plant^{-1}$.This decline in branching under

higher salinity levels may be attributed to the negative effects of salt stress on photosynthetic activity, leading to a reduction in the production of assimilates. Consequently, the availability of nutrients required for the formation and development of branches is limited, which ultimately reduces branching in the plant Notably the interaction Lozde otono x 3.5 dS m^{-1} combination (figure 2) recorded the highest average this feature at 6.68 branch $plant^{-1}$ with no significant difference from the Lozde otono x 5.5dS m^{-1} treatment, while the Local Variety x 5.5 dS m^{-1} combination had the lowest average (3.80 branch $plant^{-1}$).

The results in Table 3 indicate that Variety Lozde otono recorded the highest average for pod length at 10.30 cm, while Local Variety gave the lowest average for the trait, with an average length of 4.86 cm. The differences among Varieties can be attributed to genetic factors and their response to environmental conditions (Altaweel and Al-Shakarchy, 2021). Regarding the irrigation water treatments, the second level (3.5 dS m^{-1}) recorded the highest average pod length, which was not significantly different from the first level (1.5 dS m^{-1}) at 8.29 and 8.15 cm for both treatments respectively, Increasing the salinity concentration in irrigation water to the third level (5.5dS m^{-1}) led to a decrease in the average pod length to 7.87 cm. The decrease in the pod length observed in the third level may be linked to increased salinity levels in irrigation water which can elevate respiration rates and subsequently reduce net photosynthesis negatively, impacting vegetative biomass growth (Passara and Albuzio ,1978). Additionally, the interaction between the study factors in figure 3, shows that the combinations Lozde otono x 3.5 dS m^{-1} and Histal x 1.5 dS m^{-1} achieved averages of pod length 10.54 and 10.58 cm, respectively, while the Local Variety treatment in 3.5 and 5.5 dS m^{-1} recorded the lowest average of 4.70 and 4.92 cm.

Table 3. Effect of varieties and salinity levels on vegetative growth characteristics of faba bean

Varieties	Plant height (cm)	No. of branches (branch $plant^{-1}$)	Length of pod (cm)
Lozde otono	67.76	6.34	10.30
Histal	64.96	5.82	9.15
Local Variety	60.52	4.43	4.86
LSD. ($p \leq 0.05$)	3.97	0.44	0.63
Water con. dS m^{-1}.			
1.5	64.33	5.83	8.15
3.5	69.28	5.92	8.29
5.5	59.62	5.29	7.87
LSD ($p \leq 0.05$)	3.97	0.44	0.63

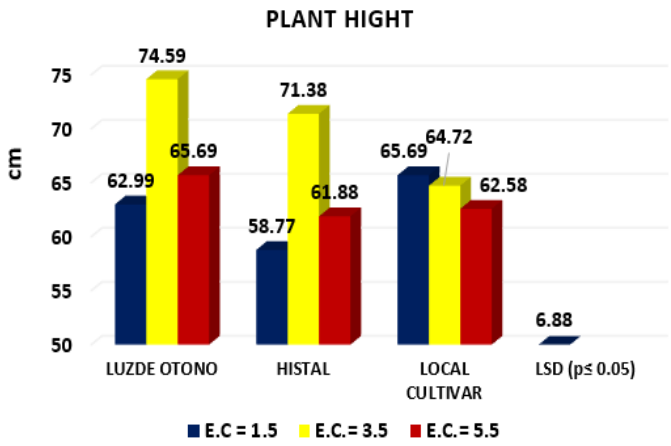

Figure (1) Effect of Varieties and salinity levels on plant height (cm)

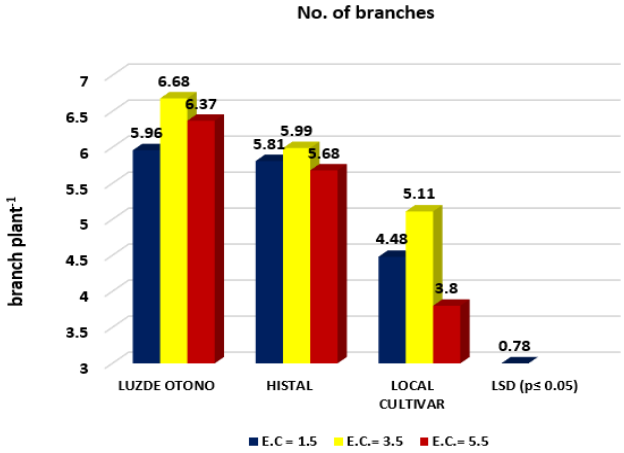

Figure (2) Effect of Varieties and salinity levels on - branches per plant (branch plant^{-1})

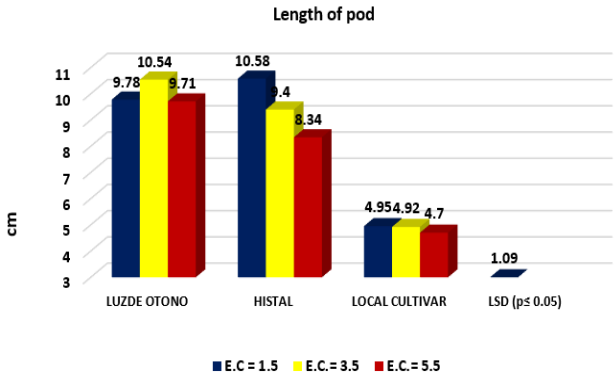

Figure (3) Effect of Varieties and salinity levels on pod length (cm)

The results of Table 4 indicate that Variety Lozde otono achieved the highest average number of pod per plant (6.67 pod plant^{-1}), without any significant difference from the second Variety (Histal), while Local Variety had the lowest average at 4.96 pod plant $^{-1}$.The superior performance of the Lozde otono in pod number per plant is linked to its strong genetic potential for vigorous vegetative growth. The increase in branch number (as shown in Table 3) provides more flowering sites, which in turn increases the

potential for pod formation. This shows a direct link between branching and pod number, as more branches can support more photosynthetic capacity, leading to more flowers being able to become pods. The result also indicates that in the first level of irrigation water treatment, significantly higher average (6.84 pod plant^{-1}) of pod per plant was obtained. The averages of 5.89 and 5.65 pod plant^{-1} for the irrigation levels that had no significant difference complement each other, but they are not statistically different. Similarly, Lozde otono Variety with the second level of irrigation water (3.5 dS m^{-1}) produced the highest number of pods per plant with an average of 7.80 while Local Variety x 3.5 dS m^{-1} and local variety x 5.5 dS m^{-1} combination resulted lowest no. of pod respectively with average value showing as 4.95 and 4.49 pod plant^{-1} (Figure 4).

The remarkable performance of Lozde otono at the second salinity level (3.5 dS m^{-1}) indicates that this variety exhibits moderate to high salt tolerance, allowing it to remain active physiologically and maintain reproductive productivity even in moderate salinity conditions Persistent deficiencies of vegetative and reproductive growth in the combinations with local variety at the second and third salinities confirm its sensitivity to salt stress, which leads to having fewer pods per plant.

The results presented in Table 4 show the highest average number of seeds per pod (5.30 seeds pod)$^{-1}$ was reached by Variety Lozde otono. On the other hand, the Local Variety gave the lowest value (3.74 seeds pod^{-1}). Lozde otono was superior based on what appears to be better vegetative traits relating directly to fertility of pods. Notably, this Variety had a considerably greater leaf area (Table 3) that served as an effective "source" available for photosynthesis. This probably allowed a more substantial flow of photo-assimilates from the leaves to its "sink" (the developing seeds). These results are consistent with those described by Alshummary *et al.* (2021), who observed that strong vegetative vigor generally results in higher reproductive performance. Besides, the data also indicated that progressively higher salinity levels in irrigation water resulted in a substantial decrease in the seed numbers. At the third salinity level, the averages obtained were lower (4.19 seeds pod^{-1}) and do not differ from those obtained in the second salinity level. In contrast, the highest average 5.00 seeds pod^{-1} for this trait was found in first level (1.5 dS m^{-1}).

Thus, the decrease in seed number observed in saline conditions is probably associated with salt-inhibitory effects on primary growth variables. Salinity had a negative effect on plant height, branch number and pod length as indicated in (Table 3). Unlike the more resilient Lozde otono, the Local Variety seemed to be more sensitive to osmotic stress, and this may have resulted in higher rates of pollen sterility or embryo abortion. This indicates that Lozde otono has a better physiological mechanism to ensure nutrient partition toward the pods under stress of high external salt concentration. This finding is in line with those of Al-Saadi *et al.* (2024), who showed that increased salinity levels have a negatively impact on all traits studied. Notably, the Lozde otono Variety when treated with the first level(1.5 dS m^{-1}) of irrigation water (Figure 5) recorded the highest average of seeds 6.14 seed pod$^{-1,}$ and the Local Variety x 3.5 dS m^{-1} and Local Variety x 5.5 dS m^{-1} combination recorded the lowest average of seed 3.50 and 3.69 seed pod$^{-1,}$ respectively.

The results in Table 4 indicate that the Lozde otono Variety achieved the highest average 100 seed weight at 157.05 g, while the Local Variety recorded the lowest average at 138.00 g. This significant difference can be attributed to inherent genotypic variations

that influence fundamental physiological processes, such as photosynthesis and respiration. These genetic factors ultimately impact both vegetative vigor and yield-related traits, including the number of seeds per pod. These findings are consistent with the studies conducted by Alwan *et al.* (2019) and Alatawi *et al*. (2024).

Regarding irrigation treatments, the first salinity level achieved the highest average 100 seed weight (152.44 g), whereas the third level recorded the lowest (144.67 g). This reduction in seed weight under high salinity is likely due to the adverse effects of salt on reproductive health, specifically affecting pollen viability and stigma receptivity. Furthermore, salt stress limits the supply of photo-assimilates during critical reproductive stages. As noted by Farooq *et al.* (2017), exposure to salinity can cause ovarian disruption and physiological injuries, leading to premature fruit drop and a subsequent decrease in total yield. The interaction effects (Figure 6) show that the Lozde otono × 3.5 dS m^{-1} combination achieved the highest 100-seed weight at 164.28 g. This result did not differ significantly from the Lozde otono × 1.5 dS m^{-1} combination, which averaged 159.32 g. Conversely, the Local Variety treated with the second and third salinity levels (3.5 and 5.5 dS m^{-1}) recorded the lowest average weights at 135.95 g and 138.70 g, respectively.

According to table 4, the Lozde otono Variety recorded the highest average yield per plant at 475.6 g, while the Local Variety had the lowest average at 229.1g. The superiority of the Lozde otono can be attributed to its yield components, specifically the number of seeds per pod and weight of 100 seed (table 4). As for the salinity levels, they had no significant effect on this trait, In terms of interaction figure 7, the Lozde otono when treated with both first and second levels of irrigation water, showed no significant differences in averages of 504.5 and 510.1 g respectively. Conversely, the lowest average for yield were observed in the Local Variety treated with the second and third levels of irrigation water, yielding averages of 221.0 and 213.8 g, respectively. reflecting the local variety's sensitivity to salt stress, which negatively affected both vegetative and reproductive growth, ultimately reducing pod production.

Table 4. Effect of varieties and salinity levels on vegetative growth characteristics of faba bean

Variety	No. of pods (Pod $plant^{-1)}$	No. of seeds in pods (seed $pods^{-1}$)	weight of 100 seed (g)	yield per plant (g)
Lozde otono	6.67	5.30	157.05	475.6
Histal	6.39	4.45	150.46	327.6
Local Variety	4.96	3.74	138.00	229.1
LSD (≤ 0.05)	0.53	0.21	3.33	40.41
Water con.ds m^{-1}				
1.5	6.48	5.00	152.44	352.5
3.5	5.89	4.29	148.40	347.4
5.5	5.65	4.19	144.67	332.5
L.S.D. (≤ 0.05)	0.53	0.21	3.33	NS

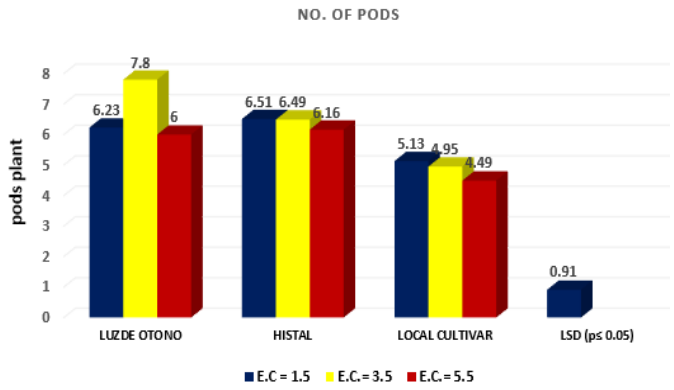

Figure (4) Effect of Varieties and salinity levels on No. of pods (pods plant^{-1})

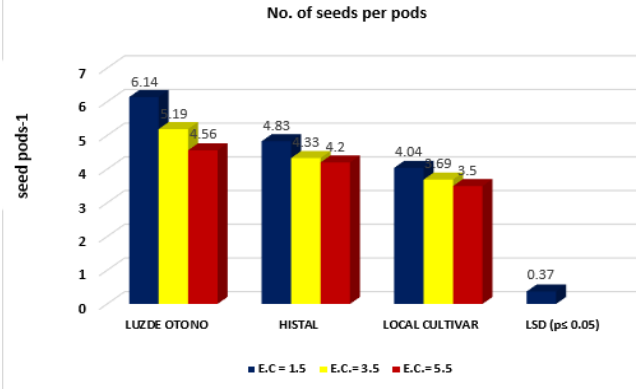

Figure (5) Effect of Varieties and salinity levels on No. of seeds per pod (seeds pod^{-1})

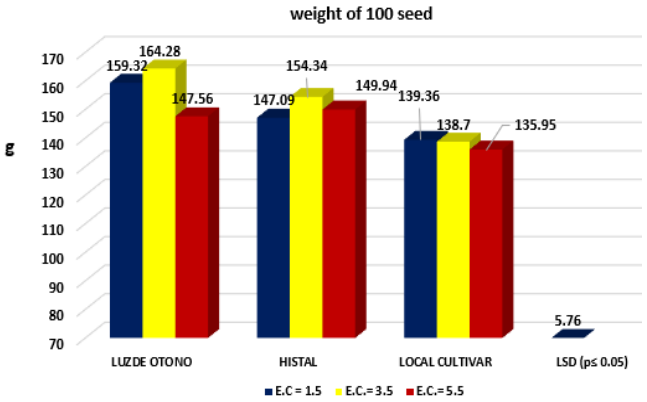

Figure (6) Effect of Varieties and salinity levels on weight of 100 seed (g)

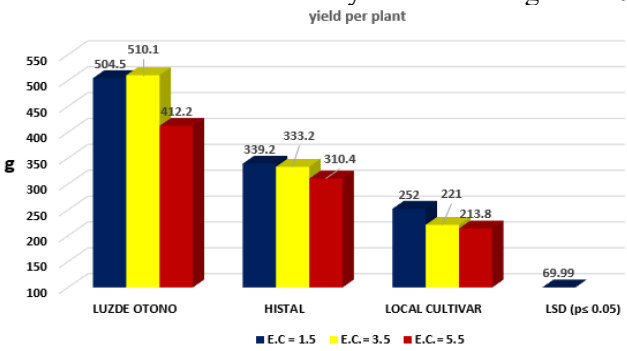

Figure (7) Effect of Varieties and salinity levels on yield per plant (g).

CONCLUSIONS

The results of this study showed that faba bean Varieties vary in response to the salinity of irrigation water under the environmental conditions of Basrah Governorate. In moderate salinity, the Spanish Variety (Lozde otono) showed relatively higher vegetative growth traits as well as yield with respect to other Varieties studied in our research. Even though the performance was significantly reduced, Lozde otono showed relatively higher tolerance than both local Variety and Dutch Variety (Histal). These results were based on a single-season experiment, and no in-depth, temporal observations of soil salinity were included. Thus, although Lozde otono appears to display promising functionality in response to saline soil relative conditions, definitive recommendations for its cultivation under saline conditions in southern Iraq require further validation through multi-season field studies and comprehensive soil salinity monitoring.

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CONFLICT OF INTEREST

The authors confirm that there are no conflicts of interest associated with this work.

Contribution of Authors

R.H.A.: Suggested the proposal of the article, collected the sample, and wrote the manuscript.

KH.D.: Suggest the proposal of the article and collect the sample.

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