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Study of the Performance of Some Selected Genotypes F_4 in Two Peas (*Pisum Sativum* L.) Populations under Two Irrigation Levels

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Abstract

This experiment was conducted at Shandaweel Agricultural Research Station - Agricultural Research Center during the winter season of 2021/2022, to study the performance of thirteen selected genotypes (families) in the F_4 generation of two peas populations under two levels of irrigation water (100% normal irrigation recommended and 50% from irrigation water quantity recommended). The design used in the experiment was a split-plot design with three replicates, where irrigation levels (100% of the recommended irrigation water quantity and 50% of the recommended water quantity for pea irrigation) were on the main plots, while the thirteen peas genotypes (families) from each population were randomly distributed on the split plots. The results of the statistical analysis of the data showed that irrigation levels had a significant effect on most of the studied traits in the two populations, except for the No. of days to 50% flowering and the No. of branches per plant in population II, the shellout% in population I, and the pod filling% in both populations. The highest mean values of fresh pod weight per plant (114.98 and 108.22 g) were obtained at 100% of the normal irrigation level in populations I and II, respectively. The lowest mean values (102.37 and 95.69 g) for this trait were obtained at 50% of the irrigation level (water stress) in populations I and II, respectively. The genotypes (families) in peas had a significant effect on all the studied traits. Genotype (family) # 1 recorded the highest mean values of fresh pod weight per plant (175.44 and 162.93 g) in populations I and II, respectively. The genotype (family) # 13 gave the lowest mean values (66.04 and 65.87 g) for this trait in populations I and II, respectively. The interaction between irrigation levels and genotypes (families) had a significant effect on all the studied traits. Where the interaction between 100% normal irrigation level and genotype (family) #1 gave the highest mean values of fresh pod weight per plant (182.15 and 180.98 g), while the interaction between 50% recommended irrigation level and genotype (family) #13 recorded the lowest mean values (60.54 and 62.57 g) for this trait in populations I and II, respectively.

Keywords: Genotypes, Families, Irrigation levels, *Pisum sativum* L., Populations and Yield components.

INTRODUCTION

Peas (*Pisum sativum* L.) is one of the most important favorable legume crops grown in Egypt during the winter. Fresh pods and dry seeds are considered essential sources of protein and vitamins (Urbano *et al*., 2003). The total cultivated area of this crop in Egypt was estimated at 41841 feddan for fresh peas production in the year 2022/2023, with a mean of 4252 kg per feddan. The estimated area for dry seeds was 1233 feddan with a mean production of 965 kg per feddan (MALR, 2022/2023). In this research, we wanted to study the performance of thirteen selected genotypes (families) resulting from pedigree selection in F_4 generation in two different populations under two irrigation levels, a normal irrigation level (i.e. 100% of the recommended irrigation dose) and irrigation level under stress (i.e. 50% of the recommended irrigation dose) under the conditions of the Shandaweel experimental farm in Sohag Governorate. Irrigation water is important and could be a limiting factor for vegetable production in general (Ramírez *et al*., 2015) and peas in particular (Jacques *et al*., 2023). Water deficit has a large impact on the yield of peas crop. Even mild and brief periods of drought stress affect important aspects such as growth and internal trophic relations (Jacques *et al*., 2023). Drought stress affects the productivity and quality of crops, including peas. Nowadays, water will be the most critical resource in the Middle East, including Egypt and the water deficit will be a very complicated problem. Water saving became a decisive factor for agricultural production. Therefore, properly understanding the optimal water requirements of various crops is very important for the judicious use of scarce water resources. Drought is one of the most influential environmental factors that hinders plant growth, development, and, ultimately. productivity (Conforti *et al*., 2018). Under climate change conditions, crops face frequent and severe stressful conditions during their growth cycle; among these conditions is the frequency of drought. Drought reduces photosynthetic activity (Zhou *et al*., 2007) either by closing stomata (Flexas *et al*., 2004) or directly, negatively affecting metabolic activities (Bota *et al*., 2004). Drought also induces morphological changes; these include reduced leaf expansion and size (Alves and Setter, 2004), which results from both a lower number of cells and smaller cells, which in turn generate less transpiration area (Basu *et al*., 2016). Drought-induced stomatal closure also reduces plant transpiration and water loss through leaves (Chai *et al*., 2016). These responses depend on the extent of the drought. In mild drought, both leaf number and leaf expansion rate decrease; in severe drought, leaf growth may be stunted (Prasad *et al*., 2008), and prolonged drought may accelerate leaf senescence (Jagadish *et al*., 2015). Moreover, roots, as the first organs to sense water stress in the soil (Weemstra *et al*., 2016), are also significantly affected by water availability (Chapman *et al*., 2012); under moderate water stress, the distribution of carbohydrates to the roots is maintained or increased, promoting their growth, but this, in contrast, is reduced by severe drought (Prudent *et al*., 2016). In this context, Mohamed and Abd El-Hady (2009) found that increasing both irrigation intervals decreased the time till the first picking, especially for the Master-B cultivar, which was picked earlier than the Progress cultivar. Irrigating pea plants every 30 days increased No. of branches per plant, plant height (cm), pod length (cm), pod diameter (cm), No. of pods per plant, No. of seeds per pod, and fresh pod yield (ton per fed). Irrigating pea plants every 20 days interval led to more water consumption. The irrigation Progress pea cultivar at 30-day intervals achieved the highest values for vegetative growth and fresh pod yield i.e., 5.76 and 5.75 tons per fed. of the 2006/2007 and 2007/2008 seasons, respectively. Also, El-Noemani *et al*., (2010), studied the effect of different irrigation systems (surface drip, subsurface drip, gated pipes, and furrow irrigation) and water regimes (100 %, 80%, and 60 % Eto) on vegetative growth, productivity, and WUE of snap bean (*Phaseolus vulgaris* L.). They showed that surface drip and/or subsurface drip systems exhibited the highest values of plant height, No. of branches per plant, No. of pods per plant and pods yield per fed. (Kg). Increasing irrigation treatment up to 100 % Eto exhibited the highest values of vegetative growth. However, the highest values of pods yield per fed, WUE were achieved by 80

% Eto treatment. The Paulista variety exhibited its superiority in growth parameters. However, the Bronco variety surpassed the Paulista in pods yield per fed. and WUE. Therefore, the Bronco bean variety was recommended in cultivation (for export or local marketing) with irrigation at 80 % Eto, corresponding to 1556 m^3 per feddan per season, using surface or subsurface drip irrigation systems due to its superiority in green pods yield per feddan with higher efficiency in using water (WUE) and finally higher net profits per feddan. Al-Mansor *et al*. (2015) evaluated the effect of surface and subsurface drip irrigation on the yield and water use efficiency of the tomato crop under deficit irrigation conditions. They reported that the use of subsurface drip irrigation techniques with deficit irrigation strategies improved irrigation water use efficiency and tomato productivity. Sahin *et al*., (2015) studied the effects of different irrigation quantities on fruit yield and its components, irrigation water use efficiency (IWUE), and fruit quality of drip-irrigated cucumber. Three different treatments (T1: 1.0, T2: 0.85, and T3: 0.70) of cumulative evaporation from a Class A pan were tested. The maximum fruit yield parameters were detected with T1 irrigation level. The highest IWUE was recorded with a T2 irrigation level. Finally, the study recommended using treatment T1 to obtain higher fruit yield in semi-arid areas with a cool climate, and treatment T2 to obtain higher IWUE and fruit quality if water is scarce. Durigon *et al.,* (2016), studied the effect of water stress on the transpiration of common bean plants. They stated that daily, afternoon depression and long-term components for the fully irrigated treatment were more related to atmospheric forcing variables (specific humidity deficit between stomata and air, relative air humidity, and canopy temperature). Daily and afternoon depression components for the deficit-irrigated treatment were related to both atmospheric and soil dryness, and the long-term component was related to soil dryness. Jacques *et al*., (2023) identified the strategies underlying plant responses to water stress. They revealed that the type of stress can be characterized in leaves or roots by the economic imprint of each stress. The increased concentration of Mn in leaves seems to be a common response of pea plants to water stress, whatever the stage of the plant growth cycle or type of stress encountered. During acclimation to long-term water stress, soil prospection was promoted via a higher lateral root number that could also be related to high levels of B in this organ. Finally, under recurrent stress, the recovery period between the two stress periods was beneficial for N_2 fixation through the increase of initiation, which could thus be thus considered as an ecophysiological imprint of a first stress period. So, the main objective of this investigation was to study the performance of thirteen selected genotypes (families)in the F_4 in two peas populations under two irrigation levels, normal irrigation level (100 %) and water stress irrigation level (50 % of the recommended irrigation levels) under Sohag Governorate conditions.

MATERIALS AND METHODS

The present study was conducted during the winter season of 2021/2022 at Shandaweel Agriculture Research Station, Sohag Governorate, Egypt. Thirteen genotypes (families) from the two F_2 populations in the F_4 generation through the pedigree selection program were selected by Fatma Mohamed (2025) during her PhD studies from two F_2 populations derived from (Master-Hindy x Super-2) and (Progress x Sweet-2). In this investigation, the performance of thirteen selected genotypes (families) in the F4 generation of two peas populations under two levels of irrigation water i.e. 100% normal irrigation recommended and 50% of the irrigation water quantity recommended (water stress) was studied. The experimental soil was clay loam. Ten random samples from the soil at a depth of 45 cm were taken. Physical and chemical characteristics of the soil were determined before sowing (Table 1)

Table (1): Physical and chemical soil properties of the experimental site.

Season	Texture	$CaCO_3$%	Soil pH	Organic matter (O.M %)	Available nutrients in soil (ppm)		
					N	P	K
2021/2022	Clay loom	7.70	7.80	1.05	20	22	40

A split-plot design with three replications was used. The two irrigation levels water i.e., 100% normal irrigation recommended and 50% from irrigation water quantity recommended (water stress), were assigned in the main plots. The thirteen genotypes (families) were randomly distributed in sub-plots. The plot area was 3.5 m long and 3 m wide (10.5 m^2) with 6 ridges. Seed genotypes (families) were sown on the 15th of October, in hills 15 cm apart on one side of ridges and two seeds per hill. The normal culture procedures for peas production over the applied treatments were followed.

The studied traits measurement:

1) No. of days to 50 % flowering: It was measured as the No. of days from the date of sowing until the date of the flower opening of 50 % of the plants.
2) Plant height (cm): It was measured as the mean of five plants from the cotyledonary to the terminal bud with the last harvest of fresh pods at the end of the season
3) No. of branches per plant: It was measured as the mean of No. of branches of five plants, with the last harvest of fresh pods at the end of the season.
4) No. of nodes to flowering: It was measured as a mean of the nodes of five plants at the time of flowering
5) Pod length (cm): It was measured as the mean of ten pods at the time of fresh pod harvest.
6) Pod diameter (cm): It was measured as the mean of ten pods at the time of fresh pod harvest.
7) No. of pods per plant: It was measured as the mean of No. of pods of five plants randomly taken after each harvest from each experimental plot, immediately after harvesting their fresh pods.
8) No. of seeds per pod: It was measured as the mean of fresh seeds of ten fresh pods immediately after harvesting and peeling them at the time of fresh pod harvest.
9) Fresh pods weight per plant (g): It was measured as the mean of the weight of pods of five plants randomly taken after each harvest from each experimental plot immediately after harvesting their fresh pods.
10) Fresh seeds weight per plant (g): It was measured as the mean of the weight of seeds of pods of five plants randomly taken after each harvest from each experimental plot immediately after harvesting and peeling them.
11) Pod filling (%): It was measured as the mean of ten pods at the time of fresh pod harvest and determined according to Remison (1978) according to the following formula:

$$\textbf{Pod filling (\%)} = \frac{\textbf{No. seeds per pod}}{\textbf{Pod length (cm)}} \textbf{ X 100}$$

12) Shellout (%): It was measured as the mean of ten random pods at the time of fresh pod harvest and was obtained by dividing the seeds weight per pod by the entire weight of pods multiplied by 100 according to the following formula:

$$\textbf{Shellout (\%)} = \frac{\textbf{Seeds weight per pod (g)}}{\textbf{Entire weight of pod (g)}} \textbf{ X 100}$$

Statistical analysis:

The data for each experiment were then analyzed using the computer MSTAT-C statistical analysis package (Freed *et al.,* 1989). Mean values were compared by the LSD test at the 5% level. Response equations were calculated according to Snedecor and Cochran (1988).

RESULTS

No. of days to 50 % flowering:

Data in Table (2) clearly showed that irrigation levels significantly affected No. of days to 50% flowering only in population I. The irrigation level under stress i.e. 50% of the recommended irrigation level was earlier in flowering (42.54 days) than the normal level i.e.100% of the normal irrigation level (45.82 days) by about three days. Peas genotype (family) significantly affected No. of days to 50 % flowering in both populations (Table 2). Genotype (Family) # 13 was the earliest (31.17 and 29.67 days) in populations I and II, respectively. Meanwhile, genotype (family) # 4 was the latest (50.17 days) in population I, and # 6 was the latest (50.00 days) in population II. The interaction between irrigation levels and genotype (family) showed a significant effect No. of days to 50 % flowering (Table 2) in both populations. The interaction between 50 % of the recommended irrigation level and genotype (family) # 13 was the earliest (30.33 and 29.33 days) in populations I and II, respectively. The interaction between 100 % normal irrigation level and genotypes (families) # 2 and 3 was the latest (52.00 days) of this trait in population I. Meanwhile, in population II, the interaction between 100 % normal irrigation level and genotype (family) # 6 was the latest (50.00 days).

Table (2): Effect of Irrigation levels on peas genotypes (families) for No. of days to 50 % flowering and plant height (cm) at populations I and II during the 2021/2022 season.

Traits	No. of days to 50 % flowering						Plant height (cm)					
Genotypes	Population I			Population II			Population I			Population II		
	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean
	100%	50%		100%	50%		100%	50%		100%	50%	
Family 1	48.00	44.33	**46.17**	46.67	46.67	**46.67**	72.53	69.00	**70.77**	75.00	72.40	**73.70**
Family 2	52.00	42.00	**47.00**	47.67	47.67	**47.67**	84.00	79.00	**81.50**	72.80	72.47	**72.63**
Family 3	52.00	46.67	**49.33**	45.00	45.00	**45.00**	83.33	81.00	**82.17**	79.77	76.33	**78.05**
Family 4	51.67	48.67	**50.17**	45.67	45.67	**45.67**	82.50	82.33	**82.42**	74.87	68.60	**71.73**
Family 5	49.00	47.00	**48.00**	45.67	45.67	**45.67**	72.20	71.00	**71.60**	77.93	74.93	**76.43**
Family 6	50.67	46.33	**48.50**	50.00	50.00	**50.00**	75.02	70.33	**72.68**	74.68	69.33	**72.01**
Family 7	50.33	48.67	**49.50**	45.00	45.00	**45.00**	62.67	60.53	**61.60**	73.78	69.33	**71.56**
Family 8	48.00	46.33	**47.17**	48.33	47.67	**48.00**	62.13	59.40	**60.77**	57.60	54.33	**55.97**
Family 9	49.00	46.00	**47.50**	46.67	46.67	**46.67**	71.47	60.67	**66.07**	72.63	68.22	**70.43**
Family 10	45.00	43.00	**44.00**	30.00	30.00	**30.00**	57.13	54.00	**55.57**	55.27	52.44	**53.85**
Family 11	35.00	31.67	**33.33**	33.00	32.33	**32.67**	52.33	49.00	**50.67**	67.13	63.67	**65.40**
Family 12	33.00	32.00	**32.50**	33.33	32.33	**32.83**	57.40	54.67	**56.03**	34.67	32.00	**33.33**
Family 13	32.00	30.33	**31.17**	30.00	29.33	**29.67**	55.50	52.73	**54.12**	30.33	29.33	**29.83**
Means	**45.82**	**42.54**		**42.08**	**41.85**		**68.33**	**64.90**		**65.11**	**61.80**	
$LSD_{0.05}$ A			**1.27**		**NS**				**1.04**		**1.27**	
B			**1.39**		**1.02**				**1.97**		**2.37**	
AB			**1.96**		**1.02**				**2.78**		**3.18**	

Plant height (cm):

Data presented in Table (2) showed that irrigation levels significantly affected plant height in populations I and II. The 100% normal irrigation level was taller (68.33 and 65.11 cm) than the under stress, i.e., 50% from the recommended irrigation level (64.90 and 61.80 cm) in populations I and II, respectively.

Peas genotype (family) significantly affected plant height in both populations (Table 2). Genotype (family) # 11 was the shortest (50.67 cm), while genotype (family) # 4 was the tallest (82.42 cm) in population I. Genotype (family) # 13 was the shortest (29.83 cm), meanwhile, genotype (family) # 3 was the tallest (78.05 cm) in population II. The interaction between irrigation levels and genotype (family) showed a significant effect on plant height in both populations (Table 2). In population I, the interaction between 100% of normal irrigation level and genotype (family) # 2 recorded the highest value (84.00 cm), meanwhile, the lowest value of this trait was the interaction between 50 % of recommended irrigation level and genotype (family) # 11 (49.00 cm). In population II, the highest value of this trait was the interaction between 100 % of normal irrigation level and genotype (family) # 3 (79.77 cm). The lowest value of this trait was the interaction between 50 % of the recommended irrigation level and genotype (family) # 13 (29.33 cm).

No. of branches per plant:

Data illustrated in Table (3) showed that irrigation levels significantly affected No. of branches per plant only in population I. The highest mean value (2.59 branches) was obtained by 100 % of the normal irrigation level, while the lowest mean value (2.38 branches) was obtained by 50 % of the recommended irrigation level.

Table (3): Effect of Irrigation levels on peas genotypes (families) for No. of branches per plant and No. of nodes to flowering at populations I and II during the 2021/2022 season.

Traits	No. of branches per plant						No. of nodes to flowering					
Genotypes	Population I			Population II			Population I			Population II		
	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean
	100%	50%		100%	50%		100%	50%		100%	50%	
Family 1	3.27	3.17	**3.22**	3.53	3.33	**3.43**	9.13	9.20	**9.17**	7.33	7.20	**7.27**
Family 2	2.87	2.66	**2.77**	2.77	3.07	**2.92**	8.90	8.80	**8.85**	8.90	8.00	**8.45**
Family 3	3.03	2.93	**2.98**	3.70	3.73	**3.72**	8.33	8.13	**8.23**	9.50	9.30	**9.40**
Family 4	3.33	3.13	**3.23**	4.03	3.29	**3.66**	8.60	8.23	**8.42**	9.37	8.30	**8.83**
Family 5	3.00	2.87	**2.93**	4.07	3.87	**3.97**	9.30	8.87	**9.08**	10.27	8.63	**9.45**
Family 6	2.70	2.43	**2.57**	1.43	1.33	**1.38**	8.97	8.70	**8.83**	8.80	8.37	**8.58**
Family 7	2.47	2.07	**2.27**	3.60	3.17	**3.38**	8.47	8.33	**8.40**	8.70	8.70	**8.70**
Family 8	3.07	2.70	**2.88**	2.60	2.17	**2.38**	8.10	7.83	**7.97**	9.57	9.20	**9.38**
Family 9	3.63	3.17	**3.40**	2.17	2.10	**2.13**	9.17	8.77	**8.97**	11.63	9.73	**10.68**
Family 10	2.63	2.23	**2.43**	1.03	0.97	**1.00**	9.00	8.47	**8.73**	9.73	7.23	**8.48**
Family 11	1.20	1.13	**1.17**	1.17	1.10	**1.13**	8.60	8.40	**8.50**	10.67	8.53	**9.60**
Family 12	1.13	1.00	**1.07**	1.03	0.97	**1.00**	8.00	7.70	**7.85**	11.63	8.55	**10.09**
Family 13	1.30	1.23	**1.27**	1.17	1.10	**1.13**	7.47	7.20	**7.33**	8.13	8.10	**8.12**
Means	**2.59**	**2.38**		**2.48**	**2.32**		**8.62**	**8.36**		**9.56**	**8.45**	
$LSD_{0.05}$ A	**0.09**			**NS**			**0.11**			**0.14**		
B	**0.20**			**0.24**			**0.31**			**0.20**		
AB	**0.29**			**0.34**			**0.44**			**0.28**		

Peas genotype (family) significantly affected No. of branches per plant in both populations (Table 3). Genotype (family) # 9 had the highest value (3.40 branches) while genotype (family) # 12 had the lowest value (1.07 branches) in population I. On the other hand, in population II, the highest value (3.97 branches) was obtained by genotype (family) # 5, while the

lowest value (1.00 branches) was obtained by genotypes (families) # 10 and 12. The interaction between irrigation levels and genotypes (families) showed a significant effect in No. of branches per plant (Table 3). The highest mean value (3.63 branches) of this trait was the interaction between 100 % of normal irrigation level and genotype (family) # 9, while the lowest value (1.00 branch) was the interaction between 50 % of recommended irrigation level and genotype (family) # 12 in population I. On the other hand, in population II, the highest mean value (4.07 branches) of this trait was the interaction between 100 % normal irrigation level and genotype (family) # 5, while the lowest value (0.97 branches) was the interaction between 50 % recommended irrigation level and genotypes (families) # 10 and 12.

No. of nodes to flowering:

Data illustrated in Table (3) showed that irrigation levels significantly affected populations I and II on the No. of nodes to flowering. The highest mean values (8.62 and 9.56 nodes) were obtained by 100 % of the normal irrigation level in populations I and II, respectively. while the lowest mean values (8.36 and 8.45 nodes) were obtained by 50 % of the recommended irrigation level in populations I and II, respectively. Peas genotype (family) showed a significant effect on No. of nodes to flowering in populations I and II (Table 3). Genotype (family) # 13 had the lowest mean value (7.33 nodes), while genotype (family) # 1 had the highest mean value (9.17 nodes) in population I. On the other hand, in population II, the lowest mean value (7.27 nodes) was obtained by genotype (family) # 1, while the highest mean value (10.68 nodes) was obtained by genotype (family) # 9. The interaction between irrigation levels and genotypes (families) showed a significant effect in No. of nodes to flowering (Table 3). The highest mean value (9.30 nodes) of this trait was the interaction between 100 % of normal irrigation level and genotype (family) # 5, while the lowest mean value (7.20 nodes) was the interaction between 50 % of recommended irrigation level and genotype (family) # 13 in population I. On the other hand, in population II, the highest mean value (11.63 nodes) of this trait was the interaction between 100 % of normal irrigation level and genotypes (families) # 9 and 12, while the lowest mean value (7.20 nodes) was the interaction between 50 % of recommended irrigation level and genotype (family) # 1.

Pod length (cm):

Data presented in Table (4) showed that irrigation levels significantly affected pod length in both populations. Whereas the highest mean values of pod length (10.91 and 11.99 cm) were found in 100 % of normal irrigation levels in populations I and II, respectively. The lowest mean values of pod length (10.46 and 11.52 cm) were obtained by 50 % of the recommended irrigation levels in populations I and II, respectively. Peas genotypes (families) showed a significant effect on pod length in populations I and II (Table 4). Genotype (family) # 13 was the shortest in a pod (9.29 and 11.15 cm) in populations I and II, respectively. Meanwhile, genotype (family) # 6 was the tallest in a pod (11.85 cm) in population I, but in population II, genotype (family) # 5 was the tallest in a pod (12.36 cm).

Table (4): Effect of Irrigation levels on peas genotypes (families) for pod length (cm) and pod diameter (cm) at populations I and II during the 2021/2022 season.

Traits	Pod length (cm)						Pod diameter (cm)					
Genotypes	Population I			Population II			Population I			Population II		
	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean
	100%	50%		100%	50%		100%	50%		100%	50%	
Family 1	11.76	11.33	**11.55**	12.24	11.95	**12.09**	1.32	1.01	**1.17**	1.38	1.36	**1.37**
Family 2	11.99	10.96	**11.47**	12.29	11.75	**12.02**	1.28	1.02	**1.15**	1.40	1.32	**1.36**
Family 3	12.03	11.61	**11.82**	11.73	11.67	**11.70**	1.27	0.99	**1.13**	1.43	1.07	**1.25**
Family 4	11.98	11.00	**11.49**	12.19	11.72	**11.96**	1.26	0.98	**1.12**	1.44	1.35	**1.40**
Family 5	11.75	11.29	**11.52**	12.48	12.24	**12.36**	1.24	1.02	**1.13**	1.48	1.40	**1.44**
Family 6	12.05	11.64	**11.85**	11.36	11.51	**11.43**	1.18	1.00	**1.09**	1.39	1.40	**1.40**
Family 7	10.47	10.17	**10.32**	11.53	11.03	**11.28**	1.19	1.06	**1.13**	1.22	1.01	**1.12**
Family 8	9.96	9.74	**9.85**	11.74	11.78	**11.76**	1.21	1.04	**1.13**	1.34	1.41	**1.38**
Family 9	9.83	9.62	**9.73**	12.38	11.13	**11.76**	1.19	1.08	**1.14**	1.32	1.28	**1.30**
Family 10	9.74	9.56	**9.65**	12.00	11.08	**11.54**	1.19	1.01	**1.10**	1.24	1.33	**1.29**
Family 11	10.42	10.05	**10.24**	12.23	11.56	**11.90**	1.17	1.03	**1.10**	1.30	1.29	**1.30**
Family 12	10.32	9.95	**10.13**	12.10	11.73	**11.92**	1.16	1.01	**1.09**	1.38	1.34	**1.36**
Family 13	9.48	9.11	**9.29**	11.62	10.68	**11.15**	1.14	0.97	**1.06**	1.24	1.10	**1.17**
Means	**10.91**	**10.46**		**11.99**	**11.52**		**1.22**	**1.02**		**1.35**	**1.28**	
$LSD_{0.05}$ A	**0.03**			**0.14**			**0.05**			**0.02**		
B	**0.24**			**0.20**			**0.04**			**0.05**		
AB	**0.34**			**0.28**			**0.06**			**0.07**		

The interaction between irrigation levels and genotypes (families) (Table 4) showed a significant effect on the pod length trait. In population I, the highest mean value (12.05 cm) was recorded in the interaction between 100 % of normal irrigation level and genotype (family) # 6. The lowest value (9.11 cm) was recorded in the interaction between 50 % of the recommended irrigation level and genotype (family) # 13. In population II, the interaction between 100 % normal irrigation level and genotype (family) # 5 recorded the highest mean value (12.48 cm). The lowest mean value (10.68 cm) of this trait was the interaction between 50 % of the recommended irrigation level and genotype (family) # 13.

Pod diameter (cm)

Data illustrated in Table (4) showed that irrigation levels significantly affected pod diameter trait. Data showed that the highest mean values (1.22 and 1.35 cm) were obtained by 100 % of the normal irrigation level in populations I and II, respectively. The lowest mean values (1.02 and 1.28 cm) were obtained by 50 % of the recommended irrigation level in populations I and II, respectively. Peas genotypes (families) showed a significant effect on pod diameter in both populations (Table 4). Genotype (Family) # 13 had the lowest mean value (1.06 cm) while genotype (family) # 1 had the highest mean value (1.17 cm) in population I. On the other hand, in population II, the lowest mean value (1.12 cm) was obtained by genotype (family) # 7, while the highest mean value (1.44 cm) was obtained by genotype (family) # 5. The interaction between irrigation levels and genotypes (families) showed a significant effect in pod diameter (Table 4). The highest mean value (1.32 cm) of this trait was the interaction between 100 % of the normal irrigation level and genotype (family) # 1, while the lowest mean value (0.97 cm) was the interaction between 50 % of the recommended irrigation level and genotype (family) # 13 in population I. On the other hand, the highest mean value (1.48 cm) of this trait was the interaction between 100 % of normal irrigation level and genotype (family) # 5, while the lowest mean value (1.01 cm) was the interaction between 50 % of the recommended irrigation level and genotype (family) # 7 in population II.

No. of pods per plant:

Data presented in Table (5) showed that irrigation levels significantly affected No. of pods per plant in both populations. Data showed that the highest mean values (25.64 and 26.04 pods) were obtained by 100 % of the normal irrigation level. The lowest mean values (23.76 and 23.70 pods) were obtained by 50 % of the recommended irrigation level in populations I and II, respectively. Peas genotypes (families) showed a significant effect on No. of pods per pod in both populations (Table 5). Genotype (Family) # 1 had the highest mean values (36.63 and 46.50 pods) in populations I and II, respectively. The lowest mean values (15.31 and 15.48 pods) were recorded by genotypes (families) # 12 and 11 in populations I and II, respectively. Peas genotypes (families) showed a significant effect on No. of pods per pod in both populations (Table 5). Genotype (Family) # 1 had the highest mean values (36.63 and 46.50 pods) in populations I and II, respectively. The lowest mean values (15.31 and 15.48 pods) were recorded by genotypes (families) # 12 and 11 in populations I and II, respectively. The interaction between irrigation levels and genotypes (families) showed a significant effect in No. of pods per plant (Table 5). The highest mean values (37.87 and 48.00 pods) of this trait were the interaction between 100 % of normal irrigation level and genotype (family) # 1 in populations I and II, respectively. The lowest mean values (15.00 and 14.67 pods) of this trait were the interaction between 50 % of the recommended irrigation level and genotypes (families) # 13 and # 11 in populations I and II, respectively.

Table (5): Effect of Irrigation levels on peas genotypes (families) for No. of pods per plant and No. of seeds per pod at populations I and II during the 2021/2022 season.

Traits	No. of pods per plant						No. of seeds per pod					
Genotypes	Population I			Population II			Population I			Population II		
	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean
	100%	50%		100%	50%		100%	50%		100%	50%	
Family 1	37.87	35.40	**36.63**	48.00	45.00	**46.50**	10.10	9.87	**9.98**	8.90	8.53	**8.72**
Family 2	35.37	32.93	**34.15**	46.33	42.73	**44.53**	9.77	9.33	**9.55**	8.50	8.67	**8.58**
Family 3	33.17	30.40	**31.78**	24.47	23.20	**23.83**	9.00	8.90	**8.95**	9.73	9.30	**9.52**
Family 4	29.80	27.23	**28.52**	29.38	26.58	**27.98**	10.33	9.53	**9.93**	8.77	8.60	**8.68**
Family 5	27.27	25.33	**26.30**	29.10	25.93	**27.52**	9.50	9.20	**9.35**	9.47	9.13	**9.30**
Family 6	24.40	23.00	**23.70**	18.27	16.33	**17.30**	10.03	9.37	**9.70**	8.07	7.77	**7.92**
Family 7	22.50	22.53	**22.52**	23.85	21.20	**22.52**	6.83	7.03	**6.93**	9.40	9.27	**9.33**
Family 8	23.57	20.83	**22.20**	23.83	22.22	**23.03**	7.83	7.37	**7.60**	8.63	7.40	**8.02**
Family 9	26.33	24.30	**25.32**	25.40	23.64	**24.52**	7.33	7.30	**7.32**	9.30	7.83	**8.57**
Family 10	22.63	20.53	**21.58**	17.07	15.27	**16.17**	7.73	7.10	**7.42**	8.60	7.56	**8.08**
Family 11	17.47	16.30	**16.88**	16.30	14.67	**15.48**	8.50	7.77	**8.13**	8.67	7.10	**7.88**
Family 12	15.59	15.03	**15.31**	18.20	16.33	**17.27**	7.93	7.53	**7.73**	8.43	7.40	**7.92**
Family 13	17.33	15.00	**16.17**	18.27	15.00	**16.63**	6.80	6.50	**6.65**	10.10	9.73	**9.92**
Means	**25.64**	**23.76**		**26.04**	**23.70**		**8.59**	**8.22**		**8.97**	**8.33**	
$LSD_{0.05}$ A		**0.35**			**0.60**			**0.15**			**0.28**	
B		**1.32**			**1.74**			**0.33**			**0.34**	
AB		**1.86**			**2.46**			**0.47**			**0.49**	

No. of seeds per pod:

Data presented in Table (5) showed that the irrigation levels significantly affected No. of seeds per plant in both populations. Data showed that the highest mean values (8.59 and 8.97 seeds) were obtained by 100 % of the normal irrigation level. In comparison, the lowest mean values (8.22 and 8.33 seeds) were obtained by 50 % of the recommended irrigation level in populations I and II, respectively. Peas genotypes (families) showed a significant effect on No. of seeds per pod in populations I and II (Table 5). Genotype

(Family) # 1 had the highest value (9.98 seeds), while genotype (family) # 13 had the lowest value (6.65 seeds), in population I. Genotype (family) # 13 had the highest value (9.92 seeds). Genotype (family) # 11 had the lowest value (7.88 seeds) in population II. The interaction between irrigation levels and genotypes (families) showed a significant effect in No. of seeds per pod (Table 5). The highest mean value (10.33 seeds) of this trait was the interaction between 100 % of the normal irrigation level and genotype (family) # 4. The lowest mean value (6.50 seeds) of this trait was the interaction between 50 % of the recommended irrigation level and genotype (family) # 13 in population I. In population II, the highest value (10.10 seeds) was obtained by the interaction between 100 % of the normal irrigation level with genotype (family) # 13. The interaction between 50 % of the recommended irrigation level and genotype (family) # 11 recorded the lowest mean value (7.10 seeds).

Fresh pods weight per plant (g):

Data illustrated in Table (6) showed that irrigation levels significantly affected fresh pods weight per plant (g) in both populations. Data showed that the highest mean values (114.98 and 108.22 g) were obtained by 100 % of the normal irrigation level in populations I and II, respectively. The lowest mean values (102.37 and 95.69 g) were obtained by 50 % of the recommended irrigation level in populations I and II, respectively. Peas genotypes (families) showed a significant effect on fresh pods weight per plant (g) in populations I and II (Table 6). Genotype (Family) # 1 had the highest values (175.44 and 162.93 g) in populations I and II, respectively. Genotype (family) # 13 had the lowest values (66.04 and 65.87 g) in populations I and II, respectively. The interaction between irrigation levels and genotypes (families) showed a significant effect in fresh pods weight per plant (g) (Table 6). The highest values (182.15 and 180.98 g) of this trait were the interaction between 100 % of the normal irrigation level and genotype (family) # 1, in populations I and II, respectively. The lowest values (60.54 and 62.57 g) of this trait were the interaction between 50 % of the recommended irrigation level and genotype (family) # 13 in populations I and II, respectively.

Table (6): Effect of Irrigation levels on peas genotypes (families) for fresh pods weight per plant (g) and fresh seeds weight per plant (g) at populations I and II during the 2021/2022 season.

Traits	Fresh pods weight per plant						Fresh seeds weight per plant					
Genotypes	Population I			Population II			Population I			Population II		
	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean
	100%	50%		100%	50%		100%	50%		100%	50%	
Family 1	182.15	168.73	**175.44**	180.98	144.88	**162.93**	137,00	130.33	**130.33**	135.31	97.46	**116.39**
Family 2	164.69	141.00	**152.85**	170.97	137.25	**154.11**	132.00	112.67	**122.34**	128.64	92.93	**110.79**
Family 3	146.67	133.00	**139.84**	111.18	91.10	**101.14**	108.33	97.33	**102.83**	82.5	58.86	**70.68**
Family 4	128.24	104.41	**116.33**	109.44	96.85	**103.15**	82.26	66.00	**74.13**	75.79	72.41	**74.10**
Family 5	120.94	102.61	**111.78**	92.32	90.44	**91.38**	79.33	72.33	**75.83**	76.91	73.23	**75.07**
Family 6	110.32	104.65	**107.49**	95.91	88.99	**92.45**	75.61	69.00	**72.31**	72.01	56.46	**64.24**
Family 7	108.41	98.41	**103.41**	98.38	85.16	**91.77**	78.41	67.74	**73.08**	73.94	66.86	**70.40**
Family 8	105.95	100.95	**103.45**	100.07	98.38	**99.23**	79.24	69.62	**74.43**	72.12	74.40	**73.26**
Family 9	105.5	99.17	**102.34**	98.17	95.77	**96.97**	82.08	68.84	**75.46**	71.11	80.58	**75.85**
Family 10	98.38	89.38	**93.88**	96.19	88.37	**92.28**	72.22	66.25	**69.24**	71.52	68.85	**70.19**
Family 11	77.52	64.85	**71.19**	84.07	80.19	**82.13**	51.12	46.73	**48.93**	61.09	53.37	**57.23**
Family 12	74.43	63.10	**68.77**	99.95	84.07	**92.01**	49.77	46.47	**48.12**	69.65	52.16	**60.91**
Family 13	71.54	60.54	**66.04**	69.17	62.57	**65.87**	45.54	42.10	**43.82**	50.39	44.46	**47.43**
Means	**114.98**	**102.37**		**108.22**	**95.69**		**82.53**	**73.49**		**80.08**	**68.62**	
$LSD_{0.05}$ A		**1.67**			**1.47**			**5.04**			**2.94**	
B		**5.85**			**4.99**			**5.25**			**3.10**	
AB		**8.27**			**7.05**			**7.43**			**4.38**	

Fresh seeds weight per plant (g):

Data presented in Table (6) showed that irrigation levels significantly affected fresh seeds

weight per plant (g) in populations I and II. Data showed that the highest mean values (82.53 and 80.08 g) were obtained by 100 % of the normal irrigation level in populations I and II, respectively. The lowest mean values (73.49 and 68.62 g) were obtained by 50 % of the recommended irrigation level in populations I and II, respectively. Peas genotypes (families) showed a significant effect on fresh seeds weight per plant (g) in populations I and II (Table 6). Genotype (Family) # 1 had the highest values (130.33 and 116.39 g) in populations I and II, respectively. Genotype (Family) # 13 had the lowest value (43.82 and 47.43 g) in populations I and II, respectively. The interaction between irrigation levels and genotypes (families) showed a significant effect on fresh seeds weight per plant (g) (Table 6). The highest mean values (137.00 and 135.31 g) of this trait were the interaction between 100 % of the normal irrigation level and genotype (family) # 1 in populations I and II, respectively. The lowest mean values (42.10 and 44.46 g) were the interaction between 50 % of the recommended irrigation level and genotype (family) # 13 in populations I and II, respectively.

Pod filling (%):

Data presented in Table (7) showed that irrigation levels did not significantly affect pod filling % in populations I and II. Peas genotypes (families) significantly affected Pod Filling % in populations I and II (Table 7). Genotypes (Families) # 1 and 13 had the highest mean values (86.48 and 89.07%) in populations I and II, respectively. The lowest mean values (67.19 and 66.14%) were obtained from genotypes (families) # 7 and 11 in populations I and II, respectively.

Table (7): Effect of Irrigation levels on peas genotypes (families) for pod filling (%) and shellout (%) at populations I and II during the 2021/2022 season.

Traits	Pod filling (%)						Shellout (%)					
Genotypes	Population I			Population II			Population I			Population II		
	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean	Irrigation levels		Mean
	100%	50%		100%	50%		100%	50%		100%	50%	
Family 1	85.88	87.08	**86.48**	72.73	71.38	**72.06**	74.29	77.23	**75.76**	74.79	67.31	**71.05**
Family 2	81.45	85.18	**83.32**	69.18	73.78	**71.48**	74.99	79.99	**77.49**	72.28	67.76	**70.02**
Family 3	74.79	76.64	**75.72**	83.02	79.66	**81.34**	75.37	73.18	**74.28**	77.10	64.74	**70.92**
Family 4	86.28	86.64	**86.46**	71.92	73.38	**72.65**	66.96	63.33	**65.15**	73.60	74.91	**74.26**
Family 5	80.86	81.51	**81.19**	75.86	74.57	**75.22**	67.01	70.52	**68.77**	79.14	81.14	**78.64**
Family 6	83.32	80.45	**81.89**	71.04	67.48	**69.26**	68.56	65.94	**67.25**	76.40	63.46	**69.93**
Family 7	65.23	69.14	**67.19**	81.53	83.98	**82.76**	72.17	68.81	**70.49**	75.26	78.52	**76.89**
Family 8	78.62	75.67	**77.15**	73.49	62.83	**68.16**	71.99	68.95	**70.47**	74.12	75.88	**75.00**
Family 9	74.56	75.91	**75.24**	75.11	70.40	**72.76**	73.22	69.41	**71.32**	72.56	84.18	**78.37**
Family 10	79.40	74.29	**76.85**	71.65	68.24	**69.95**	70.73	75.47	**73.10**	72.68	78.33	**75.51**
Family 11	81.57	77.25	**79.41**	70.84	61.44	**66.14**	71.47	72.12	**71.80**	73.68	66.55	**70.12**
Family 12	76.85	75.85	**76.35**	69.66	63.11	**66.38**	72.07	73.70	**72.89**	69.70	62.01	**65.86**
Family 13	71.75	71.53	**71.64**	86.98	91.16	**89.07**	71.00	69.52	**70.26**	70.84	71.02	**70.93**
Means	**78.51**	**78.24**		**74.85**	**72.42**		**71.53**	**71.40**		**74.01**	**71.99**	
$LSD_{0.05}$ A		**NS**			**NS**			**NS**			**3.37**	
B		**2.93**			**2.85**			**5.18**			**4.31**	
AB		**4.14**			**4.03**			**7.33**			**6.09**	

The interaction between irrigation levels and genotypes (families) showed a significant effect in pod filling % (Table 7) in populations I and II. The highest mean values (87.08 and 91.16%) of this trait were the interaction between 50 % of the normal irrigation level and genotypes (families) # 1 and 13 in populations I and II, respectively. The lowest mean value (65.23%) of this trait was the interaction between 100 % of the normal irrigation level and genotype (family) # 7

in population I. In population II, the interaction between 50 % of the recommended irrigation level and genotype (family) # 11 recorded the lowest mean value (61.44 %)

Shellout (%):

Data presented in Table (7) showed that irrigation levels significantly affected shellout % only in population II. The highest mean value (74.01%) was obtained by 100 % of the normal irrigation level. The lowest mean value (71.99 %) was recorded by 50 % of the recommended irrigation level. Peas genotypes (families) significantly affected shellout % in populations I and II (Table 7). Genotype (Family) # 2 had the highest mean value (77.49 %), while genotype (family) # 4 had the lowest mean value (65.15 %) in population I. In Population II, genotype (family) # 5 had the highest mean value (78.64 %), while genotype (family) # 12 had the lowest mean value (65.86 %). The interaction between irrigation levels and genotypes (families) significantly affected shellout % (Table 7) in populations I and II. The highest mean values (79.99 and 84.18%) of this trait were the interaction between 50 % of the recommended irrigation level and genotypes (families) # 2 and 9 in populations I and II respectively. The lowest mean values (63.33 and 62.01%) of this trait also were the interaction between 50 % of the recommended irrigation level and genotypes (families) # 4 and 12 in populations I and II, respectively.

DISCUSSION

Performance of thirteen genotypes (families) resulting from one cycle after the pedigree selection from two different populations was studied under normal irrigation level (100%) and water stress irrigation level (50% of the recommended irrigation level). Our data presented in Tables (2, 3, 4, 5, 6 and 7) showed that irrigation levels significantly affected all studied traits in thirteen genotypes (families) from populations I and II, except for No. of days to 50 % flowering and No. of branches per plant in population II and shellout % in population I. Meanwhile, irrigation levels had no significant effect on pod filling % in the two populations. These results were in line with those obtained by Mohamed and Abd El-Hady (2009), who found that increasing the irrigation level up to 100 % increased vegetative growth. The strong influence of increasing irrigation up to the maximum level on plant height could be explained as a result of enhancing cell division and enlargement, which require more water supplies. El-Noemani *et al.,* (2010) also found that increasing the irrigation rate may increase water availability in the root zone, resulting in improved plant water status and better stomatal conductance, which eventually reflects on photo assimilate production. On the other hand, the early flowering observed in both traits (No. of days to 50% flowering and lower No. of nodes to flowering) associated with drought is thought to be due to the fact that many plant species resort to accelerating flowering as a survival mechanism to ensure reproduction under adverse conditions. This phenomenon, known as drought-induced flowering, is caused by changes in hormonal signals, especially increased levels of abscisic acid (ABA) and modifications of gibberellin and ethylene. These hormonal shifts induce the expression of flowering-related genes, such as FLOWERING LOCUS T (FT), which promotes flowering even under limited water availability (Guo *et al*., 2020). Additionally, drought stress can induce oxidative stress, leading to the accumulation of reactive oxygen species (ROS), which act as secondary messengers to activate flowering pathways (Riboni et al., 2013). While this adaptation is beneficial for reproduction in water-scarce environments, it can negatively impact yield and quality due to shorter vegetative growth periods. The reduction in yield and yield components associated with drought is also thought to be caused by a decrease in photosynthate assimilation and poor carbohydrate partitioning to the developing grain because of drought stress. The strong association between photosynthate assimilation and better remobilization of carbohydrates by drought-tolerant genotypes permits them to maintain high fresh pods weight irrespective of the moisture content of the soil (Durigon *et al*., 2016). These results are also similar to those of (Prasad *et al*., 2008; Lipiec *et al*., 2013; and Conforti *et al*., 2018), who reported that drought is one of the most impactful environmental factors that impair plant growth, development, and, finally, plant

yields. Moreover, impacts of recurrent water stress on different physiological variables linked to overall growth and yield, on physiological processes such as photosynthetic activity, transpiration, osmotic regulation, and antioxidant system, have been studied in several crop species, including wheat (Wang *et al*., 2014; Abid *et al*., 2016; Abid *et al*., 2017; Abid *et al*., 2018), corn (Virlouvet *et al*., 2018), rice (Auler *et al*., 2017; Aihemaiti *et al*., 2019; Auler *et al*., 2021), sugarcane (Marcos *et al*., 2018), sugarbeet (Leufen *et al*., 2016), potato (Ramírez *et al*., 2015), and peas (Jacques *et al*., 2023).

CONCLUSION

The performance of thirteen selected families from each of the two peas populations was studied in the F_4 selective generation under two levels of irrigation water (100% of the normal irrigation level and water stress, i.e., 50% of the recommended irrigation level). The results showed that irrigation levels had a significant effect on all of the studied traits in the two populations, except for the No. of days to 50% flowering and the No. of branches per plant in population II, the shellout% in population I, and the pod filling% in both populations. The genotypes (families) in peas had a significant effect on all the studied traits. There were three (#11, 12, and 13) and four (#10, 11, 12, and 13) promising peas genotypes (families) among the thirteen families selected in the F_4 generation in each population, early flowering in populations I and II, respectively.. In population I, they flowered in a range from 31.17 days in family # 13 to 33.33 days in family # 11. While in population II, they flowered in a range from 29.67 days in family # 13 to 32.83 days in family # 12. There were nine (#1, 2, 3, 4, 5, 6, 7, 8 and 9) and four (#1, 2, 3 and 4) promising peas genotypes (families) among the thirteen families selected in F4 generation in each population, high in fresh green pod yield, as they have a fresh pods weight per plant greater than 100 g. There were three (# 1, 2 and 3) and two (# 1 and 2) promising peas genotypes (families) among the thirteen families selected in the F_4 generation in each population high in fresh green seed yield, as they have fresh seeds weight per plant greater than 100 g). The interaction between irrigation levels and genotypes (families) had a significant effect on all the studied traits.

REFERENCES

Abid, M., A. Hakeem, Y. Shao, Y. Liu, R. Zahoor and Y. Fan (2018). Seed osmopriming invokes stress memory against post-germinative drought stress in wheat (*Triticum aestivum* L.). *Environmental and Experimental Botany, 145, 12–20*.

Abid, M., Y. Shao, S. Liu, F. Wang, J. Gao and D. Jiang (2017). Pre-drought priming sustains grain development under post-anthesis drought stress by regulating the growth hormones in winter wheat (*Triticum aestivum* L.). *Planta, 246, 509–524*.

Abid, M., Z. Tian, S. T. Ata-Ul-Karim, Y. Liu, Y. Cui and R. Zahoor (2016). Improved tolerance to post-anthesis drought stress by pre-drought priming at vegetative stages in drought-tolerant and -sensitive wheat cultivars. *Plant Physiology and Biochemistry,106, 218–227.*

Aihemaiti, A., J. Jiang, Y. Gao, Y. Meng, Q. Zou and M. Yang (2019). The effect of vanadium on essential element uptake of setaria viridis' seedlings. *Journal of Environmental Management, 237(1):399-407.*

Al-Mansor, A. N., A. M. El-Gindy, M. M. Hegazi, K. F. El-Bagoury and S. A. Abd-El Hady (2015). Effect of surface and subsurface trickle irrigation on yield and water use efficiency of tomato crop under deficit irrigation conditions. *Misr Journal of Agricultural Engineering, 32 (3): 1021 – 1040*

Alves, A. A. C. and T. L. Setter (2004). Response of cassava leaf area expansion to water deficit: Cell proliferation, cell expansion and delayed development. *Ann. Bot. 94, 605–613.* doi: 10.1093/aob/mch179

Auler, P. A., G. M. Souza, M. R. G. da Silva Engela, M. N. do Amaral, T. Rossatto and M. G. Z. da Silva (2021). Stress memory of physiological, biochemical and metabolomic responses in two different rice genotypes under drought stress: The scale matters. *Plant Science, 311, 110994.*

Auler, P. A., M. N. do Amaral, G. Rodrigues, S. dos, L. C. Benitez and L. C. da Maia (2017).

Molecular responses to recurrent drought in two contrasting rice genotypes. *Planta, 246, 899–914.*

Basu, S., V. Ramegowda, A. Kumar and A. Pereira (2016). Plant adaptation to drought stress. *F1000Res 5, 1554*. doi: 10.12688/f1000research.7678.1.

Bota, J., H. Medrano and J. Flexas (2004). Is photosynthesis limited by decreased rubisco activity and RuBP content under progressive water stress? *New Phytologist. 162, 671–681*. doi: 10.1111/j.1469-8137.2004. 01056. x

Chai, Q., Y. Gan, C. Zhao, H.-L. Xu, R. M. Waskom, Y. Niu and K. H. M. Siddique (2016). Regulated deficit irrigation for crop production under drought stress. a review. *Agronomy for Sustainable Development 36, 1–21*. doi: 10.1007/s13593-015-0338-6.

Chapman, N., A. J. Miller, K. Lindsey and W. R. Whalley (2012). Roots, water, and nutrient acquisition: let's get physical. *Trends Plant Sci. 17, 701–710*. doi: 10.1016/j.tplants.2012.08.001

Conforti, P., S. Ahmed and G. Markova (2018). Impact of disasters and crises on agriculture and food security. *FAO*

Durigon, A., Q. Lier, J. de van and K. Metselaar (2016). Forcing variables in simulation of transpiration of water stressed plants determined by principal component analysis. *International Agrophysics. 30 (4): 431-445.*

El-Noemani, A. A., H. A. El-Zeiny, A. M. El-Gindy, E. A. El-Sahhar and M. A. El-Shawadfy (2010). Performance of some bean (*Phaseolus Vulgaris* L.) varieties under different irrigation systems and regimes. *Australian Journal of Basic and Applied Sciences, 4(12): 6185-6196.*

Fatma A. Mohamed (2025). Genetic Studies of Yield and Its Components in Some Pea Crosses Under Sohag Conditions. Ph.D. Thesis. *Faculty of Agriculture, Sohag University* pp. 172.

Flexas, J., J. Bota, F. Loreto, G. Cornic and T. D. Sharkey (2004). Diffusive and metabolic limitations to photosynthesis under drought and salinity in c 3 plants. *Plant Biology. 6, 269–279*. doi: 10.1055/s-2004-820867

Freed, R.S.P.; S.P. Eisensmith, S. Goetez, D. Reicosky, V.W. Smail, and P. Wolberg 1989. User's Guide to MSTAT-C a software program for the design, management and analysis of agronomic research experiments. Michigan State University, U.S.A.

Guo, Y., Z. Tian, D. Yan, J. Zhang, P. Qin and L. Li (2020). The role of ABA in drought-induced flowering and its interaction with other hormones. *Plant Physiology and Biochemistry, 149, 59–66.* https://doi.org/10.1016/j.plaphy.2020.01.005

Jacques, C., S. Girodet, F. Leroy, S. Pluchon, C. Salon and M. Prudent (2023). Memory or acclimation of water stress in pea rely on root system's plasticity and plant's ionome modulation. *Frontiers in Plant Science, 13, 1089720*. https://doi.org/10.3389/fpls.2022.1089720

Jagadish, K. S. V., P. B. Kavi Kishor, R. N Bahuguna, N., von Wirén and N. Sreenivasulu (2015). Staying alive or going to die during terminal senescence– an enigma surrounding yield stability. *Front. Plant Sci. 6, 1070*. doi: 10.3389/ fpls.2015.01070

Krishna S V Jagadish 1, Polavarapu B Kavi Kishor 2, Rajeev N Bahuguna 1, Nicolaus von Wirén 3, Nese Sreenivasulu 4

Leufen, G., G. Noga and M. Hunsche (2016). Drought stress memory in sugar beet: Mismatch between biochemical and physiological parameters. *Journal of Plant Growth Regulation, 35 (3): 680–689.*

Lipiec, J., C. Doussan, A. Nosalewicz and K. Kondracka (2013). Effect of drought and heat stresses on plant growth and yield: a review. *International Agrophysics, 27, 463–477.*

MALR (2022/2023). Ministry of Agriculture and Land Reclamation, Economic Affairs Sector.

Marcos, F. C. C., N. M. Silveira, P. E. R. Marchiori, E. C. Machado, G. M. Souza and M. G. A. Landell (2018). Drought tolerance of sugarcane propagules is improved when origin material faces water deficit. *PloS One 13(12), e0206716. https://doi.org/10.1371/journal.pone.0206716*.

Mohamed, E.I. and M.A.H. Abd El-Hady (2009). Effect of irrigation intervals and potassium fertilizer levels on two pea cultivars under environmental conditions of Upper Egypt. *Annals Agric. Sci., Ain Shams Univ., Cairo, 52 (1): 197-212*.

Prasad, P. V. V., S. A. Staggenborg and Z. Ristic

(2008). "Impacts of drought and/or heat stress on physiological, developmental, growth, and yield processes of crop plants," *in Advances in agricultural systems modeling (American Society of Agronomy, Crop Science Society of America, Soil Science Society of America), 301–355.*

Prudent, M., V. Vernoud, S. Girodet and C. Salon (2016). How nitrogen fixation is modulated in response to different water availability levels and during recovery: A structural and functional study at the whole plant level. *Plant and Soil, 399, 1-12* doi: 10.1007/s11104-015-2674-3

Ramírez, D. A., J. L. Rolando, W. Yactayo, P. Monneveux, V. Mares and R. Quiroz, (2015). Improving potato drought tolerance through the induction of long-term water stress memory. *Plant Science. (Ireland). ISSN 0168-9452. 238:26-32*.

Remison, S. C (1978). The performance of cowpea (*Vigna unguiculata* (L.) Walp) as influenced by weed competition. *The Journal of Agricultural Science*, *90 (3): 523-530.*

Riboni, M., A. Robustelli Test, M. Galbiati, C. Tonelli and L. Conti (2013). ABA-induced reactive oxygen species regulate the transition to flowering in Arabidopsis. *Plant Physiology, 163(4), 1704–1712*. https://doi.org/10.1104/pp.113.229211

Sahin, U., Y. Kuslu and F. M. Kiziloglu (2015). Response of cucumbers to different irrigation regimes applied through drip-irrigation system. *The Journal of Animal and Plant Sciences, 25(1): 198-205.*

Snedecor, G.W. and W.G. Cochran (1988). Statistical Methods. 7th Ed. Iowa State Univ. Press, Ames, Iowa, USA.

Urbano, G., P. Aranda, E. Gómez-Villalva, S. Frejnagel, J. M. Porres, J. Frías, C. Vidal-Valverde and M. López-Jurado (2003). Nutrition evaluation of pea (*Pisum sativum* L.) Protein diets after mild hydrothermal treatment and with and without added phytase. *Journal of Agricultural and Food Chemistry, 51(8): 2415-2420*.

Virlouvet, L., T. J. Avenson, Q. Du, C. Zhang, N. Liu and M. Fromm (2018). Dehydration stress memory: Gene networks linked to physiological responses during repeated stresses of zea mays. *Frontiers in Plant Science, Plant Abiotic Stress, 9, 1058*.

Wang, X., M. Vignjevic, D. Jiang, S. Jacobsen and B. Wollenweber (2014). Improved tolerance to drought stress after anthesis due to priming before anthesis in wheat (*Triticum aestivum* L.) var. vinjett. *Journal of Experimental Botany*, *65, 6441–6456*.

Weemstra, M., L. Mommer, E. J. V. Visser, J. van Ruijven, T. W. Kuyper, G. M. J. Mohren and F. J. Sterck (2016). Towards a multidimensional root trait framework: a tree root review. *New Phytol., 211(4):1159-69*. doi: 10.1111/nph.14003

Zhou, Y., H. M. Lam and J. Zhang (2007). Inhibition of photosynthesis andenergy dissipation induced by water and high light stresses in rice. *Journal of Experimental Botany, 58, 5, 1207–1217.*