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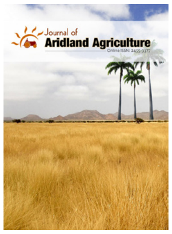

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Breeding of some cucumber hybrids according to some water stress criteria under plastic houses conditions

Maath M. M. Alabdaly[1], Laith Farhan Gar[2]*

[1]College of Agriculture – University of Anbar, Anbar governorate, Ramadi, Iraq, [2]Biotechnology and Environmental Center, University of Fallujah, Baghdad, Iraq

ABSTRACT

The study was conducted at the College of Agriculture - University of Anbar during three agricultural seasons, the autumn of 2021 and the spring and autumn of 2022, with the aim of producing F1 hybrids of cucumbers for greenhouses that are resistant to drought stress. Four Gynoecious lines were used, which were planted in the autumn season 2021, and 12 reciprocal and reverse hybrids were produced by full Diallel-crosses, and then planted in the spring season 2022 for the purpose of performance evaluation. Three hybrids were selected that were superior in characteristics of growth and yield with the best parents and a certified hybrid for comparison (Kanz) planted in the autumn season 2022 in an experiment carried out within the design of split plots with two factors according to the randomized complete block design (RCBD) and with three replications. The first factor included 6 genotypes and the second factor included two levels of moisture depletion at 25% and 50% of the available water calculated on the weight method, and the results were as follows. The results of evaluating the performance of the produced combinations showed the superiority of three hybrids, 4×1, 4×3, and 1×4, as they recorded distinct yields of 4.97, 4.38, and 4.20 kg plant^{-1} respectively. The same hybrids recorded a significant positive hybrid vigor of 34.84%, 18.91% and 14.03%, respectively. The same hybrids were introduced into the third season experiment with the two best parents, 4 and 1, and it appeared that the 4×1 hybrid excelled in plant yield, amounting to 4.06 kg plant^{-1}, and recorded the best values in all studied stress tolerance criteria, as it reached 4.06 and 4.05 in MP and GMP criteria respectively, and in SSI, YR and TOL criteria, it recorded values of 0.70, 0.10 and 0.42, respectively, and in STI, HM, YI, and DI criteria, values of 1.22, 4.05, 1.22, and 0.94, respectively while the parent P1 recorded the lowest values in stress tolerance criteria. From study concluded that the differences in the chemical responses and the amount of production of cucumber, due to the genetic variation of the genotypes under study. Three locally produced hybrids achieved superiority in yield during high moisture depletion. We recommend preserving parents 1 and 4 due to their distinctiveness and using them to produce distinctive hybrids.

Keywords: Cucumber, Genotypes, Drought tolerance criteria, Drought stress

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***Corresponding author:**
Laith Farhan Gar
E-mail: laithfr@uofallujah.edu.iq

INTRODUCTION

Cucumber (*Cucumis sativus* L., 2n = 2x = 14), is a widely cultivated herbaceous plant that belongs to the Cucurbitaceae consisting of 117 genera and 825 species and has an important place in the human diet (Wang *et al.*, 2016). There is a big gap between the demand for the crop and its supply locally, so production must be increased to meet the growing demand for the crop now and in the future (Mohammed *et al.*, 2020). Knowledge of the breeding program provides the best opportunity to produce highly productive, high-quality hybrids that are resistant to various stress conditions, including lack of water. However, the most important stress that seed producers commercially distribute is the virus-resistant varieties. This is because viruses cause great damage to cucumber plants in nature and decrease the yield (Adhab *et al.*, 2021; Nasir & Adhab, 2021). This knowledge leads plant breeders to develop new commercial varieties of cucumber (Begna, 2021). Drought is one of the most adverse environmental factors that poses severe threats to future economic agricultural crop production (Ali *et al.*, 2016; Calvo-Polanco *et al.*, 2016). Water stress impedes the absorption of water by the roots, and thus causes an imbalance in the osmotic balance, and this imbalance occurs both in the cells and at the level of the whole plant and that severe changes in it lead to the destruction of cells and stop growth until death (Zhu, 2001). It is estimated that 60 to 80% of the seasonal variation in crop yield is due to weather variability, which includes growing conditions that depend on extreme temperatures and water availability. Selection of different genotypes under conditions of environmental stress is one of the major tasks of plant breeders to exploit genetic differences to improve stress-tolerant cultivars (Baker & Eldessouky, 2019). Drought affects the different stages of plant growth, as it affects the various physiological processes such as the drying and shrinkage of plant cells, which in turn affects the process of division and expansion of cells and then leads to a small size of the plant, a lack of leaves space, the spread of roots, and the absorption of water and nutrients by the plant, then less flowering and yield (Khalil *et al.*, 2018; Tayyab *et al.*, 2018). Moreover, it also reduces photosynthesis (Khan *et al.*, 2017). Drought tolerance is defined as the ratio between the yield of certain genotypes compared to other genotypes exposed to the same stress condition (Endres *et al.*, 2018). Tolerance criteria were used as a tool or a measure of drought based on what the crop loses in drought conditions compared to natural conditions to diagnose drought-tolerant genotypes, and several methods were used to diagnose genotypes that have better productivity under conditions of stress (Reynolds *et al.*, 2007). The exploitation of natural genetic diversity is an important strategy in improving the productivity of agricultural crops. Therefore, it has become necessary to produce Gynoecious hybrids that are resistant to environmental stresses, in particular water stress, in order to contribute to the integrated management of water resources and simulate the desert environment with its appropriate genotype (Parry *et al.*, 2009). From the aforementioned, this study aims to produce and identify the best (locally produced) Gynoecious cucumber hybrids tolerant to water stress in the environmental conditions of Anbar Governorate.

MATERIALS AND METHODS

The study was carried out in the fields of the College of Agriculture - University of Anbar in one of the unheated greenhouses of the Department of Horticulture and Landscape Engineering during three agricultural seasons, the autumn season of 2021 and the spring and autumn of 2022 for the purpose of producing F1 hybrids of cucumbers for protected cultivation, evaluating their field performance, and then introducing the superior ones. Among them in an experiment evaluating the response of superior genotypes to different levels of water stress, and the research was conducted according to the following order:

The Autumn Season of 2021

Four genetically pure strains were used, whose specifications are shown in Table 1. They were planted on 9/12/2021 in cork dishes, then transferred to the plastic house after 12 days of cultivation and entered into a full diallel crosses with all possible compatibility according to the first method according to the first model Griffing (1956), Then all service operations were carried out until the fruits were ripe and harvested, and the seeds were extracted, dried and stored.

The Spring Season of 2022

The seeds resulting from the previous season were sown in a field performance evaluation experiment within a randomized complete block design and with three replications in sandy loam soil as explained in Table 2. Each replication included 17 experimental units consisting of 6 reciprocal hybrids and 6 reverse hybrids with the four parents and a hybrid certified

Table 1: Some specifications of the pure lines included in cross-crossing

Line number	Line symbol	Some characteristics of the line
P1	C-p-1008	100% female line with good vegetative growth and containing a high number of flower clusters and elongated fruits
P2	C-L-1016	100% female line with medium vegetative growth, medium yield and tubular fruits
P3	C-K-1030	100% female line with good vegetative growth and gives a good number of fruits with an elongated shape.
P4	C-S-1029	100% female line with good vegetative growth, good yield and tubular fruits

by the Iraqi Ministry of Agriculture (Kanz) for the purpose of comparison. The results were analyzed statistically by GenStat software, then the averages were compared according to the least significant difference test at the 5% probability level. They were planted with cork plates on 1/15/2022 and transferred to the experimental site on 2/2/2022. All necessary service operations were performed on them as recommended, and drip irrigation was used to irrigate the experiment.

Autumn Season 2022

After calculating the vegetative growth, yield, and hybrid vigor in the spring season 2022, the reciprocal hybrid 1x4 and the two reverse hybrids 4 x 1 and 4 x 3 were selected with parents P1 and P4 and the certified hybrid (Kanz). The six genotypes were entered into a factorial experiment of two factors within the split plots with according to the randomized complete block design (RCBD) and with three replications, the first factor included two levels of moisture depletion (at depletion of 25% and 50% of the available water for the plant, (calculated on the weight method). Depletion levels were placed in the main plots, and the genotypes were placed in the secondary plots. The seeds were sown on 9/13/2022 in cork dishes in a medium consisting of peat moss, then seedlings were planted in the greenhouse after two true leaves appeared on 9/25/2022.

Irrigation is scheduled and levels determined based on soil moisture depletion. And to follow up the moisture changes in the soil, determine the irrigation time, and determine the depth of the added water. Soil samples were taken from the active root zone, and the moisture content in the soil samples was estimated by drying the samples in a microwave oven for a period of twelve minutes after the drying time was standardized for the microwave oven with the electric oven according to the method proposed by Zein (2002). Irrigation was done by adding the depth of water needed to reach the moisture content at the field capacity, and the moisture content was estimated according to the Formula mentioned Hillel (1980).

$\theta w = \left(\frac{Msw - Ms}{Ms}\right) \times 100$ Where: θw = moisture content based on mass (g gm^{-1}), Msw = mass of wet soil (g), Ms = dry soil mass (g).

Weighty humidity was adjusted to volumetric humidity according to the equation reported by Al-Taif and Al-Hadithi (2004) as follows $\theta v = \theta w \times \rho b$ Where: θv = moisture content based on volume, θw = moisture content based on weight (gm^{-1}), ρb = bulk density of soil (mega gm m^{-3}).

The depth of water to be added to compensate for moisture depletion was calculated using the equation of Kovda *et al.* (1973).

$$d = (\theta f.c - \theta bi) \times D$$

Where: d = depth of added water (cm), $\theta f.c$ = moisture content by volume at field capacity, θbi = moisture content based on the volume before irrigation and according to the moisture depletion ratio of 25 and 50% of the available water, D = soil depth (cm).

The time required to operate the drip irrigation system was calculated according to the equation provided by Al-Taif and Al-Hadithi (2004).

$a \times d = q \times t$ Where: a = area of the wetted area (m^2), d = depth of added water (m), q = dripper discharge (m^3 hr^{-1}), t = the time required for irrigation (hours).

In the irrigation of the experiment, drippers of the type Gr with a discharge of 3.2 liters per hour were used. The area of the wetted area was calculated on the basis of a circle with a dotted center and a diameter equal to the distance between two drippers (40 cm).

Studied Traits

1. Spring season 2022:
    - Plant Yield ($plant^{-1}$ kg): Cumulatively calculated for along the growing season.
    - Hybrid vigor (%) of plant yield calculated on the basis of the highest parentage as reported by Laosuwan and Atkins (1977). Hybrid vigor (H%)=((F1-Hp))/Hp*100.
2. The autumn season 2022:
    - Determination of hydrogen peroxide H_2O_2 (µg m^{-1}) content of leaves by AOAC method (AOAC, 1980).
    - Determination of leaf proline content (µg m^{-1}) according to the method of Bates *et al.* (1973).
    - Estimation of catalase enzyme activity in leaves (mmol min^{-1} mg^{-1}) according to the method Luhová *et al.* (2003).
    - * Determination of the activity of the enzyme Super Oxide Dismutase (SOD) in leaves (unit $minute^{-1}$ mg^{-1}) according to the method of Marklund and Marklund (1974).
    - Characteristics of leaf content of proline, H_2O_2, CAT and SOD were taken in mature leaves from the center of the plant after the seventh harvest at the end of November.
    - Early yield (kg $plant^{-1}$): This trait was measured for the first five harvests of the season.
    - Plant yield ($plant^{-1}$ kg): cumulatively for all fairies.
    - Criteria for tolerance based on the rate of plant yield under stress conditions or not, and included:

Criteria	Symbol	Measurement method	Notes
Mean productivity	MP	MP = (Ys+Yp)/2 (Rosielle & Hambling, 1981)	High value genotypes are more desirable
Geometric mean	GMP	GMP= $(Yp*Ys)^{0.5}$ (Schneider *et al.,* 1997)	High value genotypes are more desirable
Stress susceptibility index	SSI	SSI = (1- (Ys/Yp))/1- (Ŷs/Ŷp) (Fischer & Maurer, 1978)	Genotypes with an SSI>1 are more resistant to drought stress conditions
Yield reduction ratio	YR	YR=1- (YS/YP) (Araghi & Assad, 1998)	Low value genotypes are suitable for drought stress condition
Tolerance	TOL	TOL = (Yp – Ys) (Rosielle & Hambling, 1981)	Genotypes with lower values are more stable
Stress Tolerance Index	STI	$STI=(YP\times YS)/(\hat{Y}P)^2$ (Fernandez, 1992)	Genotypes with high drought stress tolerance values
Harmonic Mean	HM	HM=2(YP×YS)/ YP+YS (Jafari *et al.,* 2009)	Genotypes with a high value for this indicator are more desirable
Yield index	YI	YI=Ys/Ŷs (Lin *et al.,* 1986)	Genotypes with a high value for this indicator would be suitable for a drought stress condition
Drought Resistance Index	DI	DI=Ys (Ys/Yp)/ŶP (Lan, 1998)	Genotypes with a high value for this indicator are suitable for a drought stress condition
Yield Stability index	YSI	YSI=Ys/Yp (Bouslama & Schapaugh, 1984)	Genotypes with high YSI values can be considered as stable genotypes

*Yp = mean yield without stress for each genotype, Ys = mean yield under stress per genotype, Ŷs, Ŷp = mean of both genotypes under stress and without stress

Statistical analysis

Statistical analysis: The data were analyzed statistically according to ANOVA analysis of variance using the Genstat program, and the arithmetic means were compared using the least significant difference test (LSD) at a significant level of 0.05 (Al-Muhammadi & Al-Mohammadi, 2012).

RESULTS AND DISCUSSION

Spring Season 2022

Plant yield and hybrid vigor of plant yield

The results of Table 3 indicated the superiority of parent 4 by giving the best plant yield of 3.68 kg $plant^{-1}$, followed by parent 1, who did not differ significantly from P4 and scored 3.44 kg $plant^{-1}$, while parent2 recorded the lowest plant yield of 2.01 kg $plant^{-1}$. The same table showed superiority The reverse hybrid 4×1 had the highest plant yield, outperforming all genotypes, including the certified hybrid, which recorded 4.97 kg $plant^{-1}$, followed by the 4×3 reverse hybrid, which did not differ significantly from it and produced a yield of 4.38 kg $plant^{-1}$. The 1 × 4 reciprocal hybrids also outperformed its parents, recording 4.20 kg $plant^{-1}$, while the rest of reciprocal and reverse hybrids were below the parental level. As for the hybrid vigor, the 4×1

Table 2: Some physical and chemical characteristics of the study soil before planting to a depth of 0-0.3 m

Characteristics		Unit	Value	Characteristics	Unit	Value
Sand		Gm kg^{-1}	249	PH	-	7.86
Silt			560	EC	Dm m^{-1}	3.4
Clay			191	OM	Gm kg^{-1}	1.64
soil texture			Silty Loam	CaSO4		56.88
bulk density		Mega gm m^{-3}	1.33	CaCO3		167.13
Volumetric soil moisture (kPa)	0	%	62.76	CEC	Cmolc kg^{-1}	11.77
	33		39.54	N	mg kg^{-1}	71.00
	100		30.82	P		42.00
	500		22.31	K		143.00
	1500		21.77			
Available Water		%	17.77			

reverse hybrid, the 1×4 reciprocal hybrid, and the 4×3 r reverse hybrid achieved significant positive hybrid vigor of 34.84%, 14.03%, and 18.91%, respectively, while the 3×4 reciprocal hybrid achieved non-significant positive hybrid vigor, and the other hybrids were recording Negative hybrid vigor.

Results for the Autumn Season 2022

The results of Table 4 showed an increase in the content of hydrogen peroxide in the leaves of the cucumber plant with an increase in the level of moisture depletion, as the level achieved 50% content of 326.83 (μg gm^{-1}), while the level of depletion achieved 25% content of 286.72 (μg gm^{-1}). The genotypes showed different contents of hydrogen peroxide, as the 4×3 hybrid recorded the highest content of 323.17 (μg gm^{-1}), This was followed by the first parent, then the fourth parent, then the certified hybrids, and they did not differ significantly from the 4×3 hybrid, and their values were 321.00, 315.33, and 307.33 (μg gm^{-1}), respectively. The results of the interaction between the two study factors showed the superiority of the 4 × 3 hybrid at 50% depletion, giving the highest value of 376.33 (μg gm^{-1}), while the same hybrid at the 25% depletion level recorded the lowest value of interaction amounting to 270.00 (μg gm^{-1}).

The results of the leaf content of proline, shown in the same table, showed that the level of depletion was 50% significantly superior in the leaf production of proline, with an average production of 2.34 (μg gm^{-1}), while it was at the low level of depletion 1.97 (μg gm^{-1}). The genotypes differed in their content of proline, as the 4 × 3 hybrid recorded the highest mean of proline, which reached 2.34 (μg gm^{-1}), and the genotypes P1 and the comparison cross did not differ significantly, reaching 2.33 and 2.32 (μg gm^{-1}), respectively. The 4×1 hybrid recorded the lowest average of reached 1.82 (μg gm^{-1}).

The results of the interaction showed the superiority of P1 at the depletion level of 50%, with the highest average proline content of 2.64 (μg gm^{-1}), and the hybrid 1×4 recorded at the depletion level of 25% the lowest content of 1.54 (μg gm^{-1}).

The results presented in Table 5 indicated that the catalase enzyme increased its average activity when the moisture depletion increased, reaching 140.83 (mmol min^{-1} mg^{-1}) at the 50% level, while it was 126.72 (mmol min^{-1} mg^{-1}) at the first depletion 25%. The results also showed that genetic variation

Table 3: Plant yield for parents, diameter values, reciprocal hybrids, over-diameter values, and reverse hybrids, under-diameter values ($plant^{-1}$ kg) for the spring planting season 2022, and hybrids vigor (%) of plant yield

Plant yield (Kg $plant^{-1}$)					Hybrid vigor			
parents	P1	P2	P3	P4	P1	P2	P3	P4
P1	3.44	3.16	3.37	4.20		-8.05	-2.04	14.03
P2	3.39	2.01	3.25	3.62	-1.26		-0.61	-1.72
P3	3.42	3.22	3.27	3.71	-0.48	-1.63		0.81
P4	4.97	3.53	4.38	3.68	34.84	-4.25	18.91	
Control	4.16	LSD 0.05		0.42	Standard error		3.55	
General Average			3.58					

Table 4: Effect of moisture depletion levels on cucumber leaves H_2O_2 content (μg gm^{-1}) and proline content (μg gm^{-1}) in the autumn season 2022

H_2O_2 (μg gm^{-1})				Proline (μg gm^{-1})		
Genotype (g)	Moisture depletion (I)		Average (G)	Moisture depletion (I)		Average (G)
	25%	50%		25%	50%	
1×4	271.33	290.00	280.67	1.54	2.34	1.94
4×1	289.00	297.33	293.17	1.62	2.03	1.82
4×3	270.00	376.33	323.17	2.30	2.39	2.34
P1	290.00	352.00	321.00	2.02	2.64	2.33
P4	308.67	322.00	315.33	2.14	2.21	2.17
Con-(Kanz)	291.33	323.33	307.33	2.20	2.43	2.32
Average (I)	286.72	326.83		1.97	2.34	
LSD	I	G	I*G	I	G	I*G
0.05	36.87	19.67	27.82	0.08	0.15	0.21

led to a difference in enzyme activity, as the comparison hybrid achieved the highest value of 141.50 (mmol min^{-1} mg^{-1}). The hybrid 4×3 and P4 did not differ significantly from it, as they reached 141.17 and 139.67 (mmol min^{-1} mg^{-1}), respectively. The results of the interaction between genotypes and levels of depletion showed that P4 at a depletion level of 50% achieved the highest activity level of 148.67 (mmol min^{-1} mg^{-1}), while genotype 1×4 recorded at a depletion level of 25% the lowest activity level for catalase amounted to 114.00 (mmol min^{-1} mg^{-1}).

The results of the same table showed that the level of SOD enzyme activity increased significantly between the two levels of moisture depletion, as the depletion recorded 50% 128.67 (U min^{-1} mg^{-1}), while it was at the level of 25% 110.06 (U min^{-1} mg^{-1}).

The results of the genotypes showed significant differences in increasing the activity of the SOD enzyme in the leaves of the cucumber plant, as P1 achieved the highest activity of the enzyme reaching 132.83 (U min^{-1} mg^{-1}), P4 and comparison compositions did not differ significantly from it.

The results of the interaction showed the superiority of P1 at 50% depletion and reached 137.33 (U min^{-1} mg^{-1}), while the genotype 4 × 1 recorded at a depletion level of 25% the lowest activity of the enzyme amounted to 88.33 (U min^{-1} mg^{-1}).

The reason for the increase in proline may be attributed to the fact that proline is an amino acid that accumulates in large quantities under the influence of environmental stresses (Kishor *et al.*, 2005). Among these tensions is the water tension. Proline is a rich source of carbon and nitrogen and neutralizes free radicals. Thus, it acts as a protector for cell membrane and protein synthesis (Yasir *et al.*, 2022). It is also noted from the results of the study that there are significant differences in the activity levels of CAT enzyme and SOD enzyme, as increasing levels of moisture depletion led to an increase in the activity of antioxidant enzymes CAT and SOD. This increase in the activity of enzymes may be a reflection of the defensive response to cellular damage resulting from increased stress (Zhang *et al.*, 2021). It was hypothesized that an increase in stress levels may increase the activity of these enzymes, which determine cellular damage, and increase the antioxidant capacity of plants to resist stress, and this increase may be attributed to overcoming metabolic damage by reducing the level of toxicity resulting from H2O2 during cellular metabolism, the results of which showed an increase in the samples studied through the analysis of the plant part and for protection from harmful oxidative stress (Coşkun, 2023).

Early yield and plant yield (kg plant^{-1})

The results of Table 6 showed that with regard to the early yield of the plant by increasing moisture depletion in this trait, the early yield increased significantly in moisture depletion by 50%, recording 1.313 kg plant^{-1} while depletion reached 25%, 1.280 kg plant^{-1}. As for the genotypes, the table showed significant differences, as the 4×1 hybrid outperformed by giving it the highest early plant yield of 1.414 kg plant^{-1}, It did not differ significantly from him the certified hybrid and the 4×3 and 1×4 hybrids, as their values were 1.398, 1.398 and 1.336 kg plant^{-1}, respectively.

The results of the statistical analysis did not show significant differences for interaction between the moisture depletion factors and the genotypes.

The results of plant yield shown in Table 6. Moisture depletion had a significant effect on the aforementioned trait, as the yield decreased with increasing moisture stress. Depletion recorded 50% 3.15 kg plant^{-1}, while it was at a level of depletion of 25% 3.68 kg plant^{-1}. The results of the genotypes indicated differences in the amount of yield due to the genetic difference, as the 4×1 genotype achieved a significant superiority over all the genotypes in plant yield amounting to 4.06 kg plant^{-1}, while the P1 genotype had the lowest yield of 2.33 kg plant^{-1}. The results of the interaction between the two factors of the study showed the superiority of the 4×1 hybrid at the level of depletion of 25% by giving the highest yield of 4.27 kg plant^{-1}, while P1 recorded at the level of depletion of 50% the lowest yield of 1.95 kg plant^{-1}.

The genotypes that are resistant to water stress flowered early and set their fruits faster than others. This is a reaction to preserve the species. The plant flowered and forms seeds when exposed to different stresses.

Stress Tolerance Criteria

The results presented in Table 7 related to the results of the stress tolerance criteria and based on the MP (Mean productivity) criterion between the stress and non-stress conditions, the table shows that the genotype 4×1 was classified as drought tolerant, as it gave the highest value of 4.06 kg plant^{-1} Compared to the lowest value was in genotype P1, which was classified as sensitive to stress, which amounted to 2.33 kg plant^{-1}, And since this evidence is based on the arithmetic mean, and this criterion may have a bias as a result of the relative difference between the result in the non-stress condition and the stress condition, it may be

Table 5: The effect of moisture depletion levels on the activity of the Catalase enzyme (mmol min^{-1} mg^{-1}) and Superoxide dismutase enzyme (U min^{-1} mg^{-1}) in leaves in the autumn season 2022

Catalase (mmol min^{-1} mg^{-1})				Superoxide dismutase (U min^{-1} mg^{-1})		
Genotype (g)	Moisture depletion (I)		Average (G)	Moisture depletion (I)		Average (G)
	25%	50%		25%	50%	
1×4	114.00	137.33	125.67	91.33	119.33	105.33
4×1	114.67	134.67	124.67	88.33	122.00	105.17
4×3	137.67	144.67	141.17	102.00	131.33	116.67
P1	128.00	132.00	130.00	128.33	137.33	132.83
P4	130.67	148.67	139.67	127.00	130.00	128.50
Con-(Kanz)	135.33	147.67	141.50	123.33	132.00	127.67
Average (I)	126.72	140.83		110.06	128.67	
LSD	I	G	I*G	I	G	I*G
0.05	6.03	5.71	8.08	1.87	7.45	10.53

Table 6: Effect of moisture depletion levels on early yield (kg plant^{-1}) and plant yield (kg plant^{-1}) in the autumn season 2022

Early yield (Kg Plant^{-1})				Plant yield (Kg Plant^{-1})		
Genotype (g)	Moisture depletion (I)		Average (G)	Moisture depletion (I)		Average (G)
	25%	50%		25%	50%	
1×4	1.306	1.366	1.336	3.92	3.40	3.66
4×1	1.420	1.407	1.414	4.27	3.85	4.06
4×3	1.381	1.415	1.398	4.06	3.62	3.84
P1	0.973	1.023	0.998	2.71	1.95	2.33
P4	1.211	1.259	1.235	3.04	2.56	2.80
Con-(Kanz)	1.389	1.406	1.398	4.05	3.54	3.79
Average (I)	1.280	1.313		3.68	3.15	
LSD	I	G	I*G	I	G	I*G
0.05	0.029	0.101	N.S	0.22	0.11	0.16

Table 7: Shows the results of the tolerance criteria based on plant yield between moisture depletion levels 25 and 50% in the autumn season of 2022

Criteria	Genotype						Mean	L.S.D 0.05
	1×4	4×1	4×3	P1	P4	Control		
YP	3.92	4.27	4.06	2.71	3.04	4.05	3.68	
YS	3.40	3.85	3.62	1.95	2.56	3.54	3.15	
MP	3.66	4.06	3.84	2.33	2.80	3.79	3.41	0.13
GMP	3.65	4.05	3.83	2.30	2.79	3.78	3.40	0.13
SSI	0.94	0.70	0.76	1.98	1.11	0.89	1.06	0.37
YR	0.13	0.10	0.11	0.28	0.16	0.13	0.15	0.05
TOL	0.52	0.42	0.44	0.77	0.48	0.51	0.52	0.21
STI	0.99	1.22	1.09	0.39	0.58	1.06	0.89	0.13
HM	3.64	4.05	3.83	2.27	2.78	3.77	3.39	0.13
YI	1.08	1.22	1.15	0.62	0.81	1.12	1.00	0.06
DI	0.80	0.94	0.88	0.38	0.59	0.84	0.74	0.08
YSI	0.87	0.90	0.89	0.72	0.84	0.87	0.85	0.05

significantly superior in the normal condition, and this causes an increase in the average, as between Ahmed and Kadhem (2017).

So, he found another guide, GMP (Geometric mean productivity), which is preferred by concerned plant breeders for its relative yield, which is less sensitive than the first criterion (MP) (Pavithradevi *et al*., 2015). Accordingly, the same table indicates the classification of the 4×1 hybrid as having the highest stress tolerance, recording 4.05 kg plant^{-1}, while the parent1 registed 2.30 kg plant^{-1}, which was classified as the least stress tolerant. From the results of the MP and GMP criteria, it is clear that they can produce high yield genotypes under normal conditions and stress conditions.

Based on the criteria of SSI (Stress Susceptibility Index), YR (Yield reduction ratio), and TOL (Tolerance), which depend on the yield in the stress condition as a function of production under natural conditions (non-stress), and that selection under these criteria will be in favor of genotypes with high production in non-stress conditions. From this trend, Table 7 indicates that the 4×1 hybrid is considered the most tolerant to stress, as it recorded values of 0.70, 0.10, and 0.42, respectively, compared to the first parent (P1), which is the most sensitive to stress, which reached 1.98, 0.28, and 0.77, respectively. The same table shows that the criteria of STI, HM, YI and DI, which consider that combinations with high values have better stability and are more suitable for drought conditions, and therefore the hybrid produced 4×1 is the best hybrid in terms of genetic stability and most suitable for drought conditions, as it recorded the highest values 1.22 and 4.05, 1.22, and 0.94 respectively. As for the YSI Yield Stability Index, which considers higher values to be more stable, therefore the 4×1 hybrid can be considered the best genotype based on this criterion, as it registers 0.90. It did not differ from him significantly the 4×3 and 1×4 and the certified hybrid, as they reached 0.89, 0.87 and 0.87 respectively, while the certified hybrid was the least tolerant under stress conditions and for all criteria.

CONCLUSION

The results of the experiment showed differences in the chemical responses and the amount of production of the cucumber crop, due to the genetic variation of the genotypes under study. Three locally produced hybrids achieved superiority in yield during high moisture depletion and were more suitable for the local environment than the certified hybrid. The results also showed the necessity of preserving and multiplying the superior parents 4 and 1, whose crossing per them led to the production of distinct hybrids. The results showed that it is possible to use the stress tolerance criteria to find out the facts of the tolerance of genotypes to different stresses and to give an image of the genotypes that produce good production at the high stress level.

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