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Estimation of some genetic parameters in potatoes by the effect of biological and organic fertilization

jassim jawad jader alnuaimi[1], Marwa Hasan Jaralla [2, *]
1,2 Department of Plant Production Techniques / Al-Musayyib Technical College / Al-Furat Al-Awsat Technical University

Abstract
The research was carried out in Babil Governorate / the project area, which is 42 km from the center of Babil Governorate. The cultivation was carried out in 4/2/2020 and the harvest was done on 9/5/2020. For the purpose of studying the performance evaluation of three potato genotypes (HERMOSA, SIFRA and ALVERSTONE) under the influence of bio-fertilizers (Mycorrhizal fungi (MY) and Azotobacter (AZ)) and organic (ITALPOLLINA chickens) at eight levels (0, I, MY, AZ, MY* I, AZ*I, MY+AZ and (MY+AZ)*I) using a randomized complete block design (RCBD) with three replications, and a total of (72) experimental units divided into eight environments to perform genetic calculations. The results are as follows:
1- High values of genetic variance compared to environmental variance for all traits. The characteristic of the leaf area of the plant (cm^2. $Plant^{-1}$) gave the highest genetic, environmental and phenotypic variance for the two seasons and for all eight environments.
2- The values of the genetic variation coefficients (G.C.V.) and phenotypic (P.C.V.) range from medium to high for most traits for all eight environments, due to the higher values of genetic and phenotypic deviation for these traits than the average trait, except for some traits where they were low. This is because the variance is small for these characteristics, which led to the lack of deviation, and therefore the coefficient of variation was of a low value.
3- High percentage of heritability in the broad sense (H^2BS%) for all traits and all environments. The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance, and this indicates that genetic structures transfer their good traits from one generation to another at very high rates with little impact on the environment.

Keywords: Mycorrhizae, Azotobacter , fertilization, Organic, yield .

INTRODUCTION

The potato (Solanum tuberosum L.) is one of the most important and most widely used crops rich in nutrients and energy. It is one of the crops of the Solanaceae family, which includes more than 2000 species and 90 genera. It is of great importance in various countries of the world and ranks fourth as a basic and economic crop after all. Of wheat, rice, and corn (Bowen, 2003). Potatoes contain a percentage of vitamins, proteins, energy, carbohydrates, salts and some nutrients (FAO, 2010). The area allocated for the cultivation of this crop in Iraq in 2019 amounted to about (74) thousand dunums, and its total production amounted to (426) thousand tons (Annual Statistical Collection, 2019). The composting process is one of the important means to increase the yield of fruits and improve their physical properties. Its purpose is to reduce the use of chemical fertilizers and move towards clean (sustainable) agriculture. Those concerned are now turning to the use of bio-fertilizers for their role in increasing the growth and development of plants and inhibiting the growth of pathogenic microorganisms, and at the same time contribute to resisting various stress conditions (Mahanty et al. , 2016) and (Tomer et al. , 2018). The organic fertilizer had a significant effect on the growth characteristics and yield of potatoes in comparison with the use of the same nitrogen level of chemical fertilizers (Merghany, 1998). The use of natural materials such as organic fertilizers and bio fertilizers is a suitable alternative to chemical fertilizers (El-Akabawy , 2000). The random use of chemical fertilizers results in several problems, but the use of organic and biological fertilizers reduces these problems (Zaghloul, 2002). There are many ways that lead to increasing production and improving its quality, including the selection of varieties with good specifications and high production, which is one of the most important determinants of productivity (Taha, 2007). and affects the varieties in general, environmental and genetic overlap, as the genetic nature of the cultivated variety effectively affects the Yield quantity and quality (Kumar et al, 2000). The use of natural materials such as organic fertilizers and bio fertilizers is a suitable alternative to chemical fertilizers (El-Akabawy, 2000).

MATERIALS AND METHODS:

Three newly introduced potato cultivars were used in this study (HERMOSA, SIFRA and ALVERSTONE) and eight levels of fertilization (0,MY,AZ,I,(MY+AZ),MY*I,AZ*I,(MY+AZ)*I). The varieties were planted in one of the agricultural fields in the Al-Musayyab project area, which is 42 km north from the center of Babylon Governorate, where they were obtained from Al-Saad stores in Yusufiyah / Baghdad. Tuber planting began on 4/2/2020 and harvested on 9/5/2020 .

The land was prepared for cultivation by plowing, then smoothing it with disc harrows, leveling it and dividing it into three sectors for each experiment, where the planting was done on a meadow with a length of 2 m, a width of 1 m in the meadow, and the distance between a mead and another 1 m, with 2 meadows for each experimental unit whose area is 4 m 2 (the length of the unit is 2 m and width unit 2 m), leaving a space of 1 m between the experimental units. The tubers were planted for each plant 8 tuber on one side of the meadow with a distance of 20 cm between tuber and another where the number of tubers for one experimental unit amounted to 16 tuber.

A factorial experiment was carried out according to the RCBD (Randomized complete block design) (varieties and fertilization, which includes organic fertilization (ITALPOLLINA poultry) and biological fertilization (Mycorrhizal fungi (MY) and Azotobacter (AZ))), and with three replications, all soil and crop service operations were conducted. Fertilization according to the recommendations for the potato crop. DAP mineral fertilizer was added before planting. Also, urea fertilizer was added by 300 kg. ha-1 in two batches, the first after emergence and the second one month after the first batch (Isho et al, 2009). The transactions were randomly distributed within each replicate. The results were analyzed according to the statistical program GENSTATE 12 and using the EXCEL program, and the means were compared according to the least significant difference test (LSD) at a probability level of 5% (Al-Rawi and Khalaf Allah, 2000). The potato tubers were planted in soil of known characteristics as in Table (1).

Table (1) Some physical and chemical properties of the soil of the experiment site

Measured characteristic	Unit of measure	Value
Electrical conductivity (EC)	**$ds.m^{-1}$**	2.4
P.H	---	7.23
Ready Nitrogen (N)	mg. kg^{-1} soil	25
Ready phosphorous (P)	mg. kg^{-1} soil	4.21
Ready potassium (K)	mg. kg^{-1} soil	111.01
Organic matter (OM)	$g.kg^{-1}$	7.5
Calcium carbonate (CaCO3)	$g.kg^{-1}$	292.1
Dissolved calcium (Ca+2)	mEq. L^{-1}	14.22
Dissolved magnesium (Mg+2)	mEq. L^{-1}	6.22
Dissolved sodium (Na+)	mEq. L^{-1}	4.21
Dissolved bicarbonate (HCO3)	mEq. L^{-1}	1.01
Dissolved chlorine (Cl)	mEq. L^{-1}	21.03
Dissolved potassium (K)	mEq. L^{-1}	3.22

Volumetric moisture content at field capacity	$cm^3. cm^{-3}$	0.303
Volumetric moisture content at permanent wilting point	$cm^3. cm^{-3}$	0.140
Soil separated sand	2 g. kg^{-1} soil	464
The silt	2 g. kg^{-1} soil	336
Clay	2 g. kg^{-1} soil	200
Tissue class		loam

A factorial experiment was implemented according to a randomized complete block design (RCBD) with three replications.

studied traits

Plant height (cm):

It was measured from the area of contact of the stem with the soil to the highest peak of five plants selected from each experimental unit of the middle rice and taken the average.

The leaf area of the plant (cm^2 . $plant^{-1}$):

It was calculated by multiplying the average surface area of the leaf (cm^2) by the number of leaves per plant For five plants. Where the surface area of the leaf was measured by (PLANNIMETER) device .

The relative content of chlorophyll in leaves (SPAD):

The percentage of chlorophyll in potato leaves at the time of flowering was estimated by a Chlorophyll Content Meter type CCM - 200 plus by taking the reading for five plants from each experimental unit and then taking the average and it was measured in SPAD units (Walter,1975) and (Burton, 1952).

Number of marketable tubers per plant:

It was calculated for five plants randomly taken from each experimental unit and the average was extracted after excluding damaged and distorted tubers with a diameter of less than 2.5 cm (Falconer, 1981).

Marketable tuber weight (gm):

The weight of tubers of the previous five plants was measured and divided by the number of tubers per experimental unit.

The total yield per plant (gm. $plant^{-1}$):

It was calculated by multiplying the average number of tubers for the previous five plants * the average tuber weight for each experimental unit.

genetic analysis

Genetic, environmental and phenotypic variances (σ^2G , σ^2E , σ^2P)

The analysis of phenotypic, genetic and environmental variance was estimated according to the method explained by (Walter, 1975) , and then the following were calculated:

$$\delta_G{}^2 = \frac{Msg - Mse}{r}$$

$$\delta_E{}^2 = Mse$$

$$\delta_P{}^2 = \delta_G{}^2 + \delta_E{}^2$$

Since:
$\delta_G{}^2$: Genetic Variance
$\delta_E{}^2$: Environmental Variance
$\delta_P{}^2$: Phenotypic Variance

Coefficients of genetic and phenotypic variation (G.C.V, P.C.V)

The values of the phenotypic and genetic variation coefficients were calculated according to the method explained by Burton (1952) and Falconer (1981) as follows:

$$P.C.V\ \% = \frac{\delta_P}{\bar{X}} \times 100$$

$$G.C.V\ \% = \frac{\delta_G}{\bar{X}} \times 100$$

Since:
$P.C.V$: coefficient of phenotypic variation
$G.C.V$: genetic variation coefficient
δ_P : Standard deviation of phenotypic variance
δ_G : Standard deviation of genetic variance
$\bar{X}$: The general average of the adjective

Broad sense heritability ($H^2{}_{B.S}$)

Broad sense heritability was estimated according to the following equation: (Hanson et al., 1956).

$$H^2{}_{B.S}\ \% = \frac{\delta_G{}^2}{\delta_P{}^2} * 100$$

The ranges were adopted according to what Ali (1999) mentioned: less than (40) low, (40-60) medium, and more than (60) high.
Since:
$H^2{}_{B.S}$: Broad sense heritability
$\delta_G{}^2$: Genetic Variance
$\delta_P{}^2$: Phenotypic Variance

RESULTS AND DISCUSSION

The experimental units (72) approved in the experiment were divided into eight environments, as shown in Table (2), and genetic analysis was conducted for each environment.

Table (2) represents the division of the environments of the experimental units used in genetic analysis

replications	first environment	second environment	third environment	Fourth environment	Fifth environment	Sixth environment	Seventh Environment	Eighth environment
R1	H	H*MY	H*AZ	H*(MY+AZ)	H* I	H*MY*I	H*AZ*I	H*(MY+AZ)*I
	S	S*MY	S*AZ	S*(MY+AZ)	S* I	S*MY*I	S*AZ*I	S*(MY+AZ)*I
	A	A*MY	A*AZ	A*(MY+AZ)	A*I	A*MY*I	A*AZ*I	A*(MY+AZ)*I

R2	**H**	**H*MY**	**H*AZ**	**H*(MY+AZ)**	**H* I**	**H*MY*I**	**H*AZ*I**	**H*(MY+AZ)*I**
	S	**S*MY**	**S*AZ**	**S*(MY+AZ)**	**S* I**	**S*MY*I**	**S*AZ*I**	**S*(MY+AZ)*I**
	A	**A*MY**	**A*AZ**	**A*(MY+AZ)**	**A*I**	**A*MY*I**	**A*AZ*I**	**A*(MY+AZ)*I**
R3	**H**	**H*MY**	**H*AZ**	**H*(MY+AZ)**	**H* I**	**H*MY*I**	**H*AZ*I**	**H*(MY+AZ)*I**
	S	**S*MY**	**S*AZ**	**S*(MY+AZ)**	**S* I**	**S*MY*I**	**S*AZ*I**	**S*(MY+AZ)*I**
	A	**A*MY**	**A*AZ**	**A*(MY+AZ)**	**A*I**	**A*MY*I**	**A*AZ*I**	**A*(MY+AZ)*I**

first environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (first environment) as shown in table (3) below for the studied traits were calculated as follows:

Table (3) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (first environment)

symbol	Plant height (cm)	The leaf area of the plant ($cm^2 . plant^{-1}$)	The relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	The total yield per plant (gm. $plant^{-1}$)
σ2G	28.09	3558803.29	44.39	1.91	524.65	12838.05
σ2E	0.55	2673.57	0.72	0	2.58	51.34
σ2P	28.64	3561476.86	45.11	1.91	527.24	12889.39
P.C.V	11.5	38.23	34.36	40.05	21.83	32.18
G.C.V	11.38	38.21	34.08	40.03	21.78	32.11
H^2_{BS}	98.08	99.92	98.4	99.88	99.51	99.6

Since:

σ^2G : Genotypic Variance
σ^2E : Environmental Variance
σ^2P : Phenotypic Variance
P.C.V : phenotybe coefficient of variation
G.C.V : genotybic coefficient of variation
H^2_{BS} : Heritabillity (broad sense)

Genetic, environmental and phenotypic variations (first environment) (σ^2G, σ^2E, σ^2P)

Table (3) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest genetic variance amounted to (3558803.29), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (1.91). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest environmental variance amounted to (2673.57), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.00). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest phenotypic variance amounted to (3561476.86), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (1.91). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (first environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (3) that the characteristic of the number of marketable tubers per plant gave the highest genetic variation coefficient that amounted to (40.03), while the trait of plant height (cm) gave the lowest genetic variation coefficient, which amounted to (11.38). The characteristic of the number of marketable tubers per plant gave the highest phenotypic difference coefficient of (40.05), while the characteristic of plant height (cm) gave the lowest phenotypic difference coefficient of (11.5).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (first environment) (H2BS %)

Table (3) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.972) for the characteristic of the leaf area of the plant (cm^2. Plant^{-1}). The lowest percentage of heritability in the broad sense was in the characteristic of plant height (cm) amounted to (98.08).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

second environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (second environment) as shown in table (4) below for the studied traits were calculated as follows:

Table (4) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (second environment)

symbol	Plant height (cm)	The leaf area of the plant (cm^2 . plant^{-1})	The relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	The total yield per plant (gm. plant^{-1})
σ2G	25.37	2191933.14	16.32	0.46	92.25	5408.04
σ2E	0.34	27858.33	0.22	0	0.68	43.81
σ2P	25.71	2219791.47	16.55	0.47	92.93	5451.85
P.C.V	10.5	25.04	22.43	17.72	9.81	19.5
G.C.V	10.43	24.88	22.28	17.65	9.77	19.42
H^2_{BS}	98.68	98.75	98.65	99.19	99.27	99.2

Genetic, environmental and phenotypic variations (second environment) (σ^2G, σ^2E, σ^2P)

Table (4) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest genetic variance amounted to (2191933.14), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (0.46). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest environmental variance amounted to (27858.33), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.00). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest phenotypic variance amounted to (2219791.47), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (0.47). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (second environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (4) that the characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest genetic variation coefficient that amounted to (24.88), while the trait of Marketable tuber weight (gm) gave the lowest genetic variation coefficient, which amounted to (9.77). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest phenotypic difference coefficient of (25.04), while the characteristic of Marketable tuber weight (gm) gave the lowest phenotypic difference coefficient of (9.81).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (second environment) (H^2BS %)

Table (4) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.27) for the characteristic of Marketable tuber weight (gm). The lowest percentage of heritability in the broad sense was in the characteristic of The relative content of chlorophyll in leaves amounted to (98.65).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

third environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (third environment) as shown in table (5) below for the studied traits were calculated as follows:

Table (5) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (third environment)

symbol	Plant height (cm)	The leaf area of the plant ($cm^2 . plant^{-1}$)	The relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	The total yield per plant ($gm. plant^{-1}$)
σ2G	13.49	475315.85	14.15	0.49	129.35	1970.54
σ2E	0.28	1084.65	0.03	0.01	1.59	272.68
σ2P	13.77	476400.5	14.19	0.51	130.94	2243.22
P.C.V	6.91	13.79	23.7	19.11	11.12	12.47
G.C.V	6.84	13.78	23.67	18.82	11.05	11.69
H^2_{BS}	97.96	99.77	99.77	97.05	98.79	87.84

Genetic, environmental and phenotypic variations (third environment) (σ^2G, σ^2E, σ^2P)

Table (5) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest genetic variance amounted to (475315.85), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (0.49). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest environmental variance amounted to (1084.65), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.01). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest phenotypic variance amounted to (476400.5), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (0.51). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (third environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (5) that the characteristic of The relative content of chlorophyll in leaves gave the highest genetic variation coefficient that amounted to (23.67), while the Plant height (cm) gave the lowest genetic variation coefficient, which amounted to (6.84). The characteristic of The relative content of chlorophyll in leaves gave the highest phenotypic difference coefficient of (23.7), while the characteristic Plant height (cm) gave the lowest phenotypic difference coefficient of (6.91).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (third environment) (H^2BS %)

Table (5) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.77) for the characteristic of (The leaf area of the plant (cm^2 . $plant^{-1}$) and The relative content of chlorophyll in leaves). The lowest percentage of heritability in the broad sense was in the characteristic of the total yield per plant (gm. $plant^{-1}$) amounted to (87.84).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

Fourth environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Fourth environment) as shown in table (6) below for the studied traits were calculated as follows:

Table (6) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Fourth environment)

symbol	Plant height (cm)	The leaf area of the plant (cm^2 . $plant^{-1}$)	The relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	The total yield per plant (gm. $plant^{-1}$)
σ2G	72.29	183207.67	24.71	0.69	1698.05	3796.63
σ2E	0.17	5917.14	0.04	0	0.64	6.05
σ2P	72.46	189124.81	24.75	0.69	1698.69	3802.68
P.C.V	15.07	8.54	27.77	20.01	36.09	13.67
G.C.V	15.05	8.41	27.75	20	36.08	13.66
H^2_{BS}	99.76	96.87	99.85	99.91	99.96	99.84

Genetic, environmental and phenotypic variations (Fourth environment) (σ^2G, σ^2E, σ^2P)

Table (6) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant (cm^2.$plant^{-1}$) gave the highest genetic variance amounted to (183207.67), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (0.69). The characteristic of the leaf area of the plant (cm^2.$plant^{-1}$) gave the highest environmental variance amounted to (5917.14), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.00). The characteristic of the leaf area of the plant (cm^2.$plant^{-1}$) gave the highest phenotypic variance amounted to (189124.81), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (0.69). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (Fourth environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (6) that the characteristic of Marketable tuber weight (gm) gave the highest genetic variation coefficient that amounted to (36.08), while The leaf area of the plant (cm^2 . $plant^{-1}$) gave the lowest genetic variation coefficient, which amounted to (8.41). Marketable tuber weight (gm) gave the highest phenotypic difference coefficient of (36.09), while the characteristic The leaf area of the plant (cm^2 . $plant^{-1}$) gave the lowest phenotypic difference coefficient of (8.54).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (Fourth environment) (H^2BS %)

Table (6) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.96) for the characteristic of Marketable tuber weight (gm). The lowest percentage of heritability in the broad sense was in the characteristic of the leaf area of the plant (cm^2 . $plant^{-1}$) amounted to (96.87).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

Fifth environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Fifth environment) as shown in table (7) below for the studied traits were calculated as follows:

Table (7) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Fifth environment)

symbol	Plant height (cm)	the leaf area of the plant (cm^2 . $plant^{-1}$)	the relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	the total yield per plant (gm. $plant^{-1}$)
σ2G	72.85	2367944.62	4.11	0.92	314.88	2236.84
σ2E	0.18	1087.43	0.02	0	0.33	22.31
σ2P	73.03	2369032.05	4.12	0.92	315.21	2259.15
P.C.V	14.1	22.51	13.1	22.25	16.84	10.68
G.C.V	14.08	22.51	13.08	22.19	16.83	10.63
H^2_{BS}	99.76	99.95	99.62	99.52	99.9	99.01

Genetic, environmental and phenotypic variations (Fifth environment) (σ^2G, σ^2E, σ^2P)

Table (7) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest genetic variance amounted to (2367944.62), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (0.92). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest environmental variance amounted to (1087.43), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.00). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest phenotypic variance amounted to (2369032.05), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (0.92). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (Fifth environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (7) that the characteristic of the leaf area of the plant (cm^2. $plant^{-1}$) gave the highest genetic variation coefficient that amounted to (22.51), while The total yield per plant (gm. $plant^{-1}$) gave the lowest genetic variation coefficient, which amounted to (10.63). the leaf area of the plant (cm^2. $plant^{-1}$) gave the highest phenotypic difference coefficient of (22.51), while the characteristic the total yield per plant (gm. $plant^{-1}$) gave the lowest phenotypic difference coefficient of (10.68).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (Fifth environment) (H^2BS %)

Table (7) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.95) for the characteristic of the leaf area of the plant (cm^2 . $plant^{-1}$). The lowest percentage of heritability in the broad sense was in the characteristic of the total yield per plant (gm. $plant^{-1}$) amounted to (99.01).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

Sixth environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Sixth environment) as shown in table (8) below for the studied traits were calculated as follows:

Table (8) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Sixth environment)

symbol	Plant height (cm)	the leaf area of the plant ($cm^2 . plant^{-1}$)	the relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	the total yield per plant ($gm. plant^{-1}$)
σ2G	51.55	1028671.41	8.44	0.31	1422.89	33336.94
σ2E	2.17	92016.05	0.03	0	2.59	45.12
σ2P	53.72	1120687.46	8.47	0.31	1425.48	33382.06
P.C.V	11.67	16.43	17.04	11.38	35.31	35.1
G.C.V	11.43	15.74	17.01	11.35	35.28	35.07
H^2_{BS}	95.95	91.79	99.63	99.47	99.82	99.86

Genetic, environmental and phenotypic variations (Sixth environment) (σ^2G, σ^2E, σ^2P)

Table (8) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest genetic variance amounted to (1028671.41), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (0.31). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest environmental variance amounted to (92016.05), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.00). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest phenotypic variance amounted to (1120687.46), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (0.31). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (Sixth environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (8) that the characteristic of the Marketable tuber weight (gm) gave the highest genetic variation coefficient that amounted to (35.28), while Number of marketable tubers per plant gave the lowest genetic variation coefficient, which amounted to (11.35). Marketable tuber weight (gm) gave the highest phenotypic difference coefficient of (35.31), while the characteristic Number of marketable tubers per plant gave the lowest phenotypic difference coefficient of (11.38).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (Sixth environment) (H^2BS %)

Table (8) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.86) for the characteristic of the total yield per plant (gm. plant^{-1}). The lowest percentage of heritability in the broad sense was in the characteristic of the leaf area of the plant (cm^2 . plant^{-1}) amounted to (91.79).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

Seventh Environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Seventh environment) as shown in table (9) below for the studied traits were calculated as follows:

Table (9) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Seventh environment)

symbol	Plant height (cm)	the leaf area of the plant (cm^2 . plant^{-1})	the relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	the total yield per plant (gm. plant^{-1})
σ2G	36.33	711555.3	4.72	0.5	1334.1	57883.69
σ2E	0.26	9442.43	0.12	0	0.76	157.87
σ2P	36.59	720997.73	4.84	0.5	1334.86	58041.56
P.C.V	9.89	12.32	11.55	15.84	31.85	45.9
G.C.V	9.86	12.24	11.4	15.77	31.84	45.84
H^2_{BS}	99.3	98.69	97.46	99.09	99.94	99.73

Genetic, environmental and phenotypic variations (Seventh environment) ($σ^2G$, $σ^2E$, $σ^2P$)

Table (9) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant (cm^2.plant^{-1}) gave the highest genetic variance amounted to (711555.3), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (0.5). The characteristic of the leaf area of the plant (cm^2.plant^{-1}) gave the highest environmental variance amounted to (9442.43), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.00). The characteristic of the leaf area of the plant (cm^2.plant^{-1}) gave the highest phenotypic variance amounted to (720997.73), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (0.5). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (Seventh environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (9) that the characteristic of the total yield per plant (gm. plant^{-1}) gave the highest genetic variation coefficient that amounted to (45.84), while Plant height (cm) gave the lowest genetic variation coefficient, which amounted to (9.86). the total yield per plant (gm. plant^{-1})gave the highest phenotypic difference coefficient of (45.9), while the characteristic Plant height (cm) gave the lowest phenotypic difference coefficient of (9.89).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (Seventh environment) (H^2BS %)

Table (9) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.94) for the characteristic of Marketable tuber weight (gm). The lowest percentage of heritability in the broad sense was in the characteristic of the relative content of chlorophyll in leaves amounted to (97.46).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

Eighth environment

The genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Eighth environment) as shown in table (10) below for the studied traits were calculated as follows:

Table (10) represents the genetic, environmental and phenotypic variances, phenotypic and genetic variation coefficients, and the percentage of heritability in the broad sense (Eighth environment)

symbol	Plant height (cm)	the leaf area of the plant (cm^2 . plant^{-1})	the relative content of chlorophyll in leaves	Number of marketable tubers per plant	Marketable tuber weight (gm)	the total yield per plant (gm. plant^{-1})
σ2G	54.7	1460941.83	7.62	1.89	1303.47	25175.36
σ2E	0.72	35390.94	0.03	0.01	3.66	306.5
σ2P	55.42	1496332.78	7.65	1.9	1307.13	25481.86
P.C.V	11.54	18.39	13.18	29.34	31.11	30.48
G.C.V	11.47	18.17	13.15	29.3	31.07	30.29
H^2_{BS}	98.71	97.63	99.6	99.71	99.72	98.8

Genetic, environmental and phenotypic variations (Eighth environment) (σ^2G, σ^2E, σ^2P)

Table (10) shows the values of genetic, environmental and phenotypic variances for the traits studied, including the difference in the value of what constitutes genetic variance from the total variance, where the higher value of genetic variance was observed compared to environmental variance and for all traits.

Where the characteristic of the leaf area of the plant (cm^2.plant^{-1}) gave the highest genetic variance amounted to (1460941.83), while the trait gave the number of marketable tubers per plant the lowest genetic variance amounted to (1.89). The characteristic of the leaf area of the plant (cm^2.plant^{-1}) gave the highest environmental variance amounted to (35390.94), while the trait gave the number of marketable tubers per plant the lowest environmental variance amounted to (0.01). The characteristic of the leaf area of the plant ($cm^2.plant^{-1}$) gave the highest phenotypic variance amounted to (1496332.78), while the trait gave the number of marketable tubers per plant, the lowest phenotypic variance amounted to (1.9). This means that the environmental influence is little in controlling these traits because of the dominant genetic action in the process of inheritance.

Genetic and phenotypic variation coefficients (Eighth environment) (G.C.V, P.C.V)

The values of genetic and phenotypic variation coefficients for the studied traits depended on the ranges used by Agarwal, Ahmed (1982) and Rashid (1989), which are less than 10% low, 10-30% medium, and more than 30% high. It is clear from Table (10) that the characteristic Marketable tuber weight (gm) gave the highest genetic variation coefficient that amounted to (31.07), while Plant height (cm) gave the lowest genetic variation coefficient, which amounted to (11.47). Marketable tuber weight (gm) gave the highest phenotypic difference coefficient of (31.11), while the characteristic Plant height (cm) gave the lowest phenotypic difference coefficient of (11.54).

We note from the results that the values of the genetic and phenotypic variation coefficients range from medium to high for all traits due to the higher values of genetic and phenotypic deviation for these traits than the trait average.

Percentage of heritability in the broad sense (Eighth environment) (H^2BS %)

Table (10) shows the percentage of heritability in the broad sense of the traits studied, depending on the ranges explained by Ali (1999) and Muhammad (2000), less than 40% are low, 40-60% are medium, and more than 60% are high. Where the results showed a high percentage of heritability in the broad sense of all traits, the maximum of which was (99.72) for the characteristic of Marketable tuber weight (gm). The lowest percentage of heritability in the broad sense was in the characteristic of the leaf area of the plant (cm^2 . $plant^{-1}$) amounted to (97.63).

The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance. This indicates that genetic structures transfer their good traits from one generation to another at very high rates that have little effect on the environment.

CONCLUSIONS

1- High values of genetic variance compared to environmental variance for all traits. The characteristic of the leaf area of the plant (cm^2 $plant^{-1}$) gave the highest genetic, environmental and phenotypic variance for all eight environments.
2- The values of the genetic variation coefficients (G.C.V.) and phenotypic (P.C.V.) range from medium to high for most traits for all eight environments, due to the higher values of genetic and phenotypic deviation for these traits than the trait average, except for some traits where they were low. This is because the variance is small for these characteristics, which led to the lack of deviation, and therefore the coefficient of variation was of a low value.
3- High percentage of heritability in the broad sense (H2BS%) for all traits and all environments. The high values of heritability in the broad sense of the above traits are attributed to the high values of genetic variance compared to environmental variance, and this indicates that genetic structures transfer their good traits from one generation to another at very high rates with little impact on the environment.

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