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Effect Of Soil Mulching On Genetic Performance In Potatoes (*Solanum Tuberosum* L.)

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Abstract
The study was conducted under the conditions of Nineveh Governorate - Iraq on the nature of inheritance of some growth and yield traits of two imported potato varieties of the E rank (Bada and Sefra) under the influence of three types of covering treatments (exposed (without covering), green plastic covering and transparent plastic covering), during the spring growing season of 2024/2025 at the College of Agriculture and Forestry / University of Mosul as a factorial experiment with six treatments according to the complete randomized block design and three replicates.The results of the analysis of variance indicate that there were significant differences between the two cultivars for all studied traits except the number of aerial stems. The Bada cultivar had a significant superiority over the Sefra cultivar, as well as the treatments of green and transparent plastic covering over the open for the yield traits represented by the total plant yield, total tuber yield, marketable plant yield, and marketable tuber yield. The Bada cultivar plants covered with green plastic gave the best values for the total plant yield and total tuber yield, while the Sefra cultivar plants covered with transparent plastic gave the best values for the marketable plant yield and marketable tuber yield.Genetic and environmental variances were significant for all traits. Broad-sense heritability was high for plant height, total number of tubers per plant, number of marketable tubers per plant and total tuber weight. The high heritability indicates that the appearance of the individual is closely related to its genetic makeup, which suggests the possibility of introducing direct improvements to these traits in the following seasons. The expected genetic improvement values as a percentage of mean were moderate for most of the studied traits.
Keywords: *soil cover, inheritance and genetic improvement, potato.*

INTRODUCTION

Potato *Solanum tuberosum* L. is one of the most important vegetable crops of the Solanaceae family, as it tops the list of tuber crops in terms of nutritional value because it contains a high percentage of carbohydrates and is a balanced food in its protein to calorie content, providing the body with sufficient calorie content and outperforming other tuber crops (Hassan 1999). The percentage of dry matter is 15-29%, the percentage of starch ranges from 10-24%, proteins 1-2%, carbohydrates 17.5%, and salts 1%, including magnesium, potassium, phosphorus, calcium, sodium, iron, as well as vitamins A, B, and C (Boras et al. 2011).High crop yields require knowledge of the nature and amount of variation in genetic stocks because genetic variations are desirable for plant breeders, and the success of any breeding program must depend on the desirable genetic variants present in the plant community. Without the occurrence of these variants, plant species that surpass their parents in productive and qualitative traits would not exist. Researchers have divided phenotypic variation into environmental variation, which is the difference between plants with identical genetic compositions and grown in different environmental conditions. The appearance of the trait is the final result of the interaction of genetic composition and environment. Phenotypic variation occurs as a result of genetic and environmental influences, and genetic variation, which is the difference between plants with dissimilar genetic compositions and grown in the same or controlled environmental conditions (Al-Sahouki, 1990). Environmental differences may mask genetic differences, so the more phenotypic differences there are between individuals within a single genetic makeup and the reasons for them are due to environmental variation, the more difficult it becomes to select for genetic differences. On the other hand, the less the effect of the environment on changing the trait compared to genetic differences, the more effective selection will be because most of the traits of the selected plants will be inherited by the offspring (Al-Mufarji, 2006). Hence the need to find a quantitative measure to describe the extent of the environment's influence on traits. This measure is known as the degree of heritability. The heritability ratio represents the ratio between the components of the genetic variance of the trait to the phenotypic variance. This is what is expressed as heritability in the broad sense. Heritability plays an important role in choosing the appropriate method for breeding and improving desired traits. Selection is based on it, especially if its value is high. Selection is affected by the variations in the community in which selection is required, the intensity of selection and heritability, and these factors enter together into the equation for estimating the expected genetic improvement of the quantitative trait. Estimating genetic improvement (Genetic Advance) is the largest application of the quantitative genetics theory in plant breeding and improvement programs (Al-Kamer, 1999). Accordingly, the current study aims to estimate the heritability rate, genetic and phenotypic variations, their coefficients, and the expected genetic improvement of the yield traits and their components for two potato varieties under study, under the effect of soil cover under the conditions of Nineveh Governorate, for the purpose of selecting the best of these traits in subsequent early generations, and more effectively, to continue the good ones in future breeding programs for this crop.

MATERIALS AND METHODS

This study was carried out in the vegetable field of the Department of Horticulture and Landscape Engineering / College of Agriculture and Forestry / University of Mosul / Mosul city, which is located at latitude 36.35 degrees north and longitude 43.15 degrees east, and is 223 meters above sea level (Guest, 1966), with the aim of estimating some genetic parameters under the conditions of Nineveh Governorate for two imported potato varieties of the E rank, namely (Bada and Sefra (under the effect of three types of covering treatments (exposed (without covering), covering with green plastic, and covering with transparent plastic).The seeds of the two varieties were planted on 15/2/2024 on 3 m long rows with a distance of 25 cm between one tuber and another and 75 cm between one row and another. It was implemented as a factorial experiment with three replicates within a Randomized Complete Block Design, so that the number of treatments became eight (2×3=6). Each treatment was represented by two rows, so that the number of experimental units became (2×3×3×2=36) experimental units. Agricultural service operations were carried out equally for all treatments (Matloub et al., 1989). Data were recorded for ten randomly selected plants for each experimental unit. Data were statistically analyzed using SAS (2010) program, and Duncan's multiple range test was used to compare mean values at 0.05 probability level. Phenotypic, genetic and environmental variance and coefficient of phenotypic and genetic variation were estimated according to (Steel and Torrie, 1980).

$\delta^2 P = \delta^2 G + \delta^2 E$

($\delta^2 P$) Phenotypic variance

($\delta^2 G$) Genotypic variance

($\delta^2 E$) Environmental variance

$\delta^2 G = (\delta^2 \text{ Cultivars} - \delta^2 E) / RB$

$\delta^2 E = Mse$

Where:

Mean square of cultivars = δ2 Cultivars

Mean square of experimental error = δ2 E

Mse = δ2 E

Number of replicates = R

Coverage coefficients (3) = B

$PCV\ \% = (\sqrt{\delta^2 P} / \tilde{Y}) \times 100.$

$GCV\ \% = (\sqrt{\delta^2 G} / \tilde{Y}) \times 100.$

Where:

(PCV) Phenotypic Coefficients of Variation
(GCV) Genotypic Coefficients of Variation
(Ỹ) is the arithmetic mean of the trait.
Heritability broad sense H2(b.s) was estimated according to (Hanson et al., 1955) and the following equation:
$H^2(b.s) = (\delta^2 G / \delta^2 P) \times 100$.
The expected genetic improvement E.G.A. was estimated based on the equation given by Kempthorne (1969) as follows.

$E.G.A. = [(K\ H^2(b.s)\ P)].^2 \delta \sqrt{\ }$

Whereas:
E.G.A Expected Genetic Advance
K = 2.06 which is the selection intensity for 5% of the plants.
The expected genetic improvement was estimated as a percentage of the arithmetic mean (E.G.A.%) as follows:

$E.G.A. \% = [(K\ H^2(b.s) \sqrt{\ }\ \delta^2 P) / \tilde{Y}] \times 100.$

RESULTS AND DISCUSSION

Table (1) shows the results of the analysis of variance for the studied traits in potatoes, which shows that the two varieties showed significant differences among themselves for all the studied traits except for the number of aerial stems, which was significant at a probability level of 0.01 for the traits of plant height, total number of tubers per plant, number of marketable tubers per plant, average total tuber weight, marketable yield per plant, and marketable yield of tubers, and at a probability level of 0.05 for the traits of average marketable tuber weight, total yield per plant, and total yield of tubers. The existence of such significant differences between varieties is necessary to study their genetic behavior with the aim of selecting the best and improving them. The existence of these differences and variations between varieties is the basic material for plant breeders with the aim of exploiting them by deriving new hybrids that are superior in one or more traits.Soil cover showed significant differences at 0.01 probability level for all studied traits except number of aerial stems.The differences between the interaction (varieties × soil cover) reached the level of significance at the probability level of 0.05 for the traits of total plant yield, total tuber yield, marketable plant yield, and marketable tuber yield, and at the probability level of 0.01 for the rest of the other traits, except for the number of aerial stems, where the differences did not reach the level of significance. The presence of significant effects of genetic interaction (varieties × environment (soil cover)) indicates that the contribution of the interaction (varieties × environment) for these traits measured on the total variance was high, which indicates that this interaction will have a significant impact on future breeding programs. This is consistent with what was mentioned by Prajapati et al. (2020), Al-Ajili (2021), Al-Zebari et al. (2021) , Naiem et al. (2022), Seid et al. (2023) and Agha et al. (2024 a , b) about the presence of significant differences between varieties for growth and yield traits in potatoes

Table (1): Analysis of variance for the studied traits in potatoes, which represent the mean square values.

		Mean Squares									
S D	D f	h p (cm)	N a s (s. p-1)	T n t(t. p-1)	N m t(t. p-1)	A t w (g. p-1)	A m w t (g. p-1	T y p (g. p-1)	T y t (t. ha-1)	M y p (g. p-1)	M y t (t. ha-1)
R	2	4.156	0.322	0.372	0.338	6.956	9.225	9026.889	25.374	9394.888	26.797

V	1	308.347 **	0.139	12.768 **	3.380 **	410.506 **	60.573 *	54010.889 *	153.130 *	41280.222 **	117.427 **
S×C	2	225.031 **	0.041	31.243 **	19.835 **	375.444 **	235.842 **	556358.722 **	1581.910 **	471753.722 **	1341.836 **
S C ×V	2	59.857 **	0.430	3.730 **	1.364 **	166.105 **	213.108 **	12853.389 *	36.484 *	7420.388 *	20.868 *
E E	10	3.418	0.013	0.306	0.155	5.303	6.257	5821.022	16.567	3541.356	10.048

* and ** are significant at the 0.05 and 0.01 probability levels, respectively.
Sources of difference / S D Replicate / R Varieties / v Soil Cover/ S C Varieties ×Soil Cover/ S C ×V Experimental Error/ E E degrees of freedom/ D f Height of the plant (cm)/ h p Number of aerial stems (stem. plant-1)/ N a s (s. p-1) Total number of tubers of the plant (tuber. plant-1) / T n t(t. p-1) Number of marketable tubers of the plant (tuber. plant-1) / N m t(t. p-1) Average total tuber weight (g. plant-1) / A t w (g. p-1) Average marketable weight of tuber (g. plant-1 / A m w t (g. p-1 Total yield of plant (g. plant-1) / T y p (g. p-1) Total yield of tubers (tons. ha-1) / T y t (t. ha-1) Marketable yield of plant (g. plant-1) / M y p (g. p-1) Marketable yield of tubers (tons. ha-1) / M y t (t. ha-1.Table (2) shows the superiority of the al Bada variety in most of the vegetative growth traits and yield traits, represented by plant height, number of aerial stems, total number of tubers per plant, number of marketable tubers per plant, total yield per plant, total yield of tubers, marketable yield per plant, and marketable yield of tubers, while the Sefra variety is superior in the trait of average total tuber weight and average marketable tuber weight. This difference between the varieties is due to the genetic difference of the varieties and their response to the environmental conditions under which these varieties are grown. This study is consistent with what was found by Zelelew et al. (2016), Qassab Bashi (2018), Merhej and Jassim (2018), Merga and Dechassa (2019), Al-Mohammadi and Al-Jumaili (2019), Al-Bayati et al. (2019), and Al-Ajili (2021) regarding the existence of significant differences between the varieties for growth and yield traits in potatoes.

Table (2): Effect of varieties on the growth and yield of potatoes.

Varieties	Studied attributes									
	h p (cm)	N a s (s. p-1)	T n t(t. p-1)	N m t(t. p-1)	A t w (g. p-1)	A m w t (g. p-1	T y p (g. p-1)	T y t (t. ha-1)	M y p (g. p-1)	M y t (t. ha-1)
Al Bada	69.055 a	2.611 a	9.432 a	7.068 a	113.653 b	144.247 b	1074.00 a	57.273 a	1018.00 a	54.297 a
Sefra	60.777 b	2.555 a	7.747 b	6.202 b	123.204 a	147.916 a	964.44 b	51.439 b	922.22 b	49.189 b

• The means that carry the same alphabetical letters do not differ significantly from each other according to Duncan's multiple range test at a probability level of 0.05.

Table (3) shows the superiority of plants grown under green plastic in most of the vegetative growth characteristics and yield characteristics, represented by plant height, total number of tubers per plant, number of tubers suitable for marketing per plant, total yield per plant (g. plant-1), total yield of tubers (ton. ha-1), marketable yield per plant (g. plant-1), and marketable yield of tubers (ton. ha-1) compared with the lowest values for these characteristics under open cultivation. There were no significant differences between plants grown under transparent plastic and plants grown under green plastic, while plants grown under transparent plastic were superior in the trait of total tuber weight (g. plant-1) and marketable tuber weight (g. plant-1) compared with those under open cultivation. All of this is due to the effective role of plastic covering and its effect on the absorption, permeability, and reflectivity of the colors of the solar spectrum, which in turn leads to raising the temperature of the soil under the plastic cover, which encourages Root growth and availability of soil moisture, which increases the absorption of nutrients and the absence of weeds that compete with the main crop for water and nutrients, which increases the results of photosynthesis, which is reflected in the increase in the number of leaves and the increase in the number of branches of the plant and the leaf area, and thus works to increase the characteristics of the plant yield and the total and marketable yield. This is consistent with Kashi et al. (2004) and Ramakrishna et al. (2006) that the characteristics of the soil, such as moisture and temperature, as well as weeds and absorption of nutrients were positive for what they found after using different types of cover. It is also consistent with Bhatta et al. (2020) and Timilsina et al. (2022) and Jhukala and Dahalb (2024) and Ghimire et al. (2024) that the characteristics of vegetative growth and characteristics of the yield were affected by plastic cover.

Table (3): Effect of Mulching on the growth and yield of potatoes.

Mulching	h p (cm)	N a s (s. p-1)	T n t(t. p-1)	N m t(t. p-1)	A t w (g. p-1)	A m w t (g. p-1	T y p (g. p-1)	T y t (t. ha-1)	M y p (g. p-1)	M y t (t. ha-1)
NO mulch	60.833 b	2.500 a	6.083 c	4.565 c	110.417 c	141.703 b	672.00 b	35.841 b	646.50 b	34.485 b
Green mulch	71.958 a	2.666 a	10.546 a	7.971 a	118.637 b	143.277 b	1240.83 a	66.171 a	1141.00 a	60.866 a
Clear mulch	61.958 b	2.583 a	9.140 b	7.370 b	126.233 a	153.263 a	1144.83 a	61.057 a	1122.83 a	59.879 a

• The means that carry the same alphabetical letters do not differ significantly from each other according to Duncan's multiple range test at a probability level of 0.05. Table (4) shows the superiority of plants grown under green plastic of the Albada variety in the characteristics of plant height, total number of tubers per plant, number of marketable tubers per plant, total yield of tubers per plant, total yield of tubers per unit area, total yield of marketable tubers per plant, and total yield of marketable tubers per unit area compared with the same row under open cultivation, which gave the lowest values in the total number of tubers per plant and the total tuber weight rate, or with the Sefra row under open cultivation as well, which gave the lowest values in plant height, total tuber weight rate, marketable tuber weight rate, total yield of tubers per plant, total yield of tubers per plant, total yield of tubers per unit area, total yield of marketable tubers per plant, and total yield of marketable tubers per unit area, while the Sefra row was superior under transparent plastic in the characteristics of total tuber weight rate per plant and marketable tuber weight rate per plant. This shows the extent of the varieties' response to plastic coverage. Colored compared to growing varieties without soil cover

Table (4): The effect of interaction between varieties and mulching treatments on the studied traits potatoes.

Varieties	Mulch	h p (cm)	N a s (s. p-1)	T n t(t. p-1)	N m t(t. p-1)	A t w (g. p-1)	A m w t (g. p-1	T y p (g. p-1)	T y t (t. ha-1)	M y p (g. p-1)	M y t (t. ha-1)
AlBa	NO mulch	66.250 b	2.416 a	6.020 e	4.540 d	111.717 d	145.503 b	673.33 d	35.910 d	659.33 c	35.181 c

da	Green mulch	78.417 a	2.500 a	11.923 a	8.370 a	110.827 d	142.047 bc	1322.33 a	70.509 a	1188.67 a	63.405 a
	Clear mulch	62.500 cd	2.916 a	10.353 b	8.296 a	118.417 c	145.190 b	1226.33 ab	65.399 ab	1206.00 a	64.306 a
Sefra	NO mulch	55.417 e	2.583 a	6.146 e	4.590 d	109.117 d	137.903 c	670.67 d	35.771 d	633.67 c	33.788 c
	Green mulch	65.500 b c	2.833 a	9.170 c	7.573 b	126.447 b	144.507 b	1159.33 bc	61.832 bc	1093.33 ab	58.326 ab
	Clear mulch	61.417 d	2.250 a	7.926 d	6.443 c	134.050 a	161.337 a	1063.33 c	56.715 c	1039.67 b	55.453 b

• The averages that carry the same alphabetical letters for each factor and the overlap between them do not differ significantly from each other according to Duncan's multiple range test at a probability level of 0.05.

The results of Table (5) show the values of phenotypic variances and their total genetic and environmental components and genetic parameters for the traits under study in potatoes. It is clear that the genetic and environmental variance was significant above zero for all traits. These results are consistent with the findings of Mishra et al. (2017), Zeleke et al. (2021), Tessema et al. (2022), Shetty et al. (2023), and Singh et al. (2024) regarding significant values of genetic and environmental variance for some traits. The results indicate that the environmental variance values were higher than the genetic variance values for the traits of average marketable tuber weight, total plant yield, and total tuber yield, and lower than them for the other traits. The results also showed that the highest values of the coefficient of genetic and phenotypic variation were for the trait of total number of tubers per plant and the lowest for the trait of average marketable tuber weight, which is consistent with what was obtained by Asefa et al. (2016), Hu et al. (2022), Rohit et al. (2022), and Likeng-Li-Ngue et al. (2023) Saleh et al. (2025) . This can be explained by the fact that most of these traits are quantitative traits characterized by their great influence on the environmental conditions surrounding the plant, and therefore selection is effective on the basis of external appearance values (Al-Mukhtar, 1988). It is clear that the values of the phenotypic coefficient of variation were much higher than the values of the genetic coefficient of variation for all traits, which indicates the significant role of the environmental effect (soil coverage) in the phenotypic change of traits

to varying degrees. This genetic, phenotypic and environmental diversity of the studied traits leads to a high heritability of these traits under the influence of the studied coverage coefficients. This may also be attributed to the presence of large variations between the two cultivars. The heritability values in the broad sense ranged between 0.478 for the total tuber yield trait and 0.908 for the plant height trait. It is noted that they were high for plant height, total number of tubers per plant, number of marketable tubers per plant and average total tuber weight, and medium for the rest of the other traits. This high heritability indicates the importance of additive and non-additive effects of genes controlling the inheritance of these traits (Mather and Jinks, 1982). High heritability is evidence that the individual's appearance is closely related to its genetic makeup, which indicates the possibility of making direct improvements to these traits in the following seasons, and is also useful in choosing the appropriate method of breeding (Allard, 1960). This is consistent with the findings of Luthra et al. (2018), Hunde et al. (2022), Rohit et al. (2022), and Singh et al. (2024) regarding high heritability. It is noted that the expected genetic improvement as a percentage of the mean of the trait ranged between 2.427 for the trait of average tuber weight and 17.598 for the trait of plant height, where the values were low only for the traits of number of aerial stems and average tuber weight, while the values were average for the rest of the other traits. This is consistent with what was indicated by Singh et al. (2020), Zeleke et al. (2021), Seid et al. (2023), and Likeng-Li-Ngue et al. (2023).
The high heritability rate, which is consistent with the high values of genetic improvement, gives an indication of the prediction that we will obtain by selection, and thus it can be said that the method of total selection achieves the desired success (Welsh, 1981)

Table (5): The overall mean and components of phenotypic variation (genetic and environmental) and genetic parameters for the studied traits in potatoes.

G f	h p (cm)	N a s (s. p-1)	T n t(t. p-1)	N m t(t. p-1)	A t w (g. p-1)	A m w t (g. p-1	T y p (g. p-1)	T y t (t. ha-1)	M y p (g. p-1)	M y t (t. ha-1)
G V	33.881 14.835±	0.014 0.006±	1.384 0.614±	0.358 0.162±	45.022 19.751±	6.035 2.920±	5354.430 2605.060±	15.173 7.385±	4193.207 1989.225±	11.931 5.658±
E V	3.418 1.291±	0.013 0.004±	0.306 0.115±	0.155 0.058±	5.303 2.004±	6.257 2.364±	5821.022 2200.140±	16.567 6.261±	3541.356 1338.507±	10.048 3.797±
P V	37.299	0.027	1.690	0.513	50.325	12.292	11175.452	31.740	7734.563	21.979
G C V	8.966	4.580	13.695	9.018	5.665	1.681	7.179	7.166	6.675	6.675
P C V	9.407	6.361	15.134	10.795	5.990	2.400	10.372	10.364	9.065	9.060
H B S	0.908	0.518	0.819	0.698	0.894	0.491	0.479	0.478	0.542	0.542
E G A	11.424	0.175	2.193	1.030	13.065	3.546	104.312	5.548	98.194	5.234
% E G A	17.598	6.775	25.530	15.524	11.032	2.427	10.234	10.207	10.122	10.115
G A	64.916	2.583	8.590	6.635	118.428	146.081	1019.222	54.356	970.111	51.743

Genetic features / G f
Genotypic Variance / G V
Environmental Variance / E V
Phenotypic Variance / P V
Genotypic Coefficients of Variance / G C V
Phenotypic Coefficients of Variance / P C V
Heritability Broad Sense / H B S
Expected Genetic Advance / E G A
% Expected Genetic Advance E G A
General Average

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