

EVALUATION OF SOME SOYBEAN GENOTYPES UNDER DIFFERENT SOWING DATES BY EXPLORATORY FACTOR ANALYSIS

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ABSTRACT

A field trial was conducted in the 2022 and 2023 seasons at Mallawy Agric. Res. Station, El-Minia Governorate, Middle Egypt, to study the effect of different sowing dates (May 5th, May 20th, and June 5th) on earliness, seed yield, and some of the attributes of six soybean genotypes. The experimental design used was a split-plot design in a randomized complete block arrangement with three replications. Results showed a significant effect of sowing date on all studied traits, and the interactions between sowing dates and soybean genotypes were significant for all traits, except for plant height. The highest seed weight/plant and seed yield (ton/fed) were obtained from the second planting date on May 20th, with the soybean cultivar Giza 22, followed by Giza 111. The factor analysis technique divided the studied variables into two main factors at the three dates, accounting for 78.3%, 79.2%, and 76.7%, respectively, of the total variability in the dependence structure of soybean seed weight/plant for the three dates. The superior genotype across the three sowing dates was Giza 22, suggesting that this cultivar was the best under the late sowing date. Early maturity was in favor of Giza111 and hybrid 30 at the three planting dates. The behavior of the genotypes was similar across different dates, but the rate of crop change varies depending on each variety, as evident in the interaction between dates and varieties.

Key words: Soybean, Sowing date, Yield and its components, Exploratory factor analysis.

INTRODUCTION

At a global level, soybean (*Glycine max* L.) is one of the most important legume species in animal feeding and human nutrition due to its high protein and oil contents. In the 2018-2019 period, the worldwide soybean area was 125.33 million hectares (USDA, 2020). However, in Egypt, the acreage and economic importance of soybeans have increased rapidly during recent years, where the area has increased progressively from 32000 feddan in 2020 to 133500 feddan in 2024. During the same period, the average seed yield increased from 1.298 tons/fedan in 2020 to 1.350 tons/fedan in 2024 (Naser *et al.*, 2024).

Mourtzinis *et al.* (2019) reported that climate change had a major impact on crop production. Therefore, the identification of factors limiting crop yields, including climatic ones, is of great importance. The optimal soybean sowing date is an important factor affecting plant growth and yield, where it changes depending on the climate conditions and the accompanying behavior of cultivars to the day length. The soybean seed yield decreases with a delay in the sowing date after May (Licht and Huffman 2017). One of the most important soybean cultivation conditions is the earliness of the

cultivars grown, as plant development and maturity are closely related to the day length.

Nico *et al.* (2019), Jaybhay *et al.* (2019), Mandić *et al.* (2020), and Borowska and Prusiński (2021) studied the impact of delayed sowing date on soybean growth, especially under unfavorable humidity conditions. They found that the date of sowing is particularly important in soybean cultivation because it affects the proper formation of vegetative growth and the development of organs and final biomass.

Generally, the time of planting depends on the climatic conditions of the region and the variety to be grown. Planting date is a main factor affecting soybean growth, development, and yield (Anshuman *et al.* 2020).

Bateman *et al.* (2020) mentioned that the day length and temperature for early and late planting differ greatly, and final plant height may be affected by these factors.

Ewais (2021) reported that the sowing date in May is the best, and the sowing date in June should be avoided due to a reduction in yield and yield components. Morris *et al.* (2021) concluded that planting date is one of the most important agronomic decisions affecting soybean yields.

Borowska and Prusiński (2021) and Vann (2021) reported that the planting date and maturity group were the most important soybean cultivation conditions for high yield, because it has a significant impact on the growth and development, where planting dates earlier than mid-May often lead to increasing yield.

El-Hawary *et al.* (2022) reported that the sowing date influences seed quality primarily by determining the thermal conditions during the seed-filling period because late-sown genotypes push the grain filling time to coincide with high temperatures and water stress. Delayed sowing date had a significant impact on the seed protein contents and carbohydrates, which might be related to the changes in heat conditions during seed filling.

Factor analysis turns on the concept that measurable and observable variables can be reduced to fewer latent variables that share a common variance and are unobservable, which is known as reducing dimensionality (Bartholomew *et al.*, 2011).

Factor analysis is commonly used to reduce variables into a smaller set of factors to save time and facilitate easier interpretations. Each factor is a linear combination of the original variables. Also, factor analysis allows us to look at the relationship between large numbers of variables and see whether they can be grouped and summarized into a smaller number of factors (Yong and Pearce 2013).

There are fundamentally two types of factor analysis: exploratory and confirmatory. Exploratory factor analysis (EFA) is used when a researcher wants to discover the number of factors influencing variables and to analyze which variables go together (DeCoster, 1998). The primary objectives of exploratory factor analysis are to determine the number of common factors influencing a set of measures (variables). The strength of the relationship is between each factor and each observed measure (variable). Also, some common uses of EFA are to determine what traits are most important when classifying a group of items or traits. As well as generating “factor scores” representing values of the underlying constructs for identifying an individual’s placement or ranking on the factor (s), we use the information with hypothesis tests to determine how factor scores differ between groups (varieties), or to incorporate factor information as part of a regression or predictive analysis (DiStefano *et al.*, 2009).

The objective of the present study is to estimate the effect of different sowing dates on seed yield of six soybean genotypes and some traits by using exploratory factor analysis, and to rank genotypes by factor scores as effective selection criteria for soybean genotypes.

MATERIALS AND METHODS

A field trial was conducted in the 2022 and 2023 summer seasons at Mallawy Agric. Research, Station (latitude of 28 N, longitude of 30 E, and altitude of 49 m above sea level), El-Minia Governorate, Middle Egypt, to study the effect of different sowing dates on seed yield and some attributes of six soybean genotypes. A split-block design in a randomized complete block was used, in three replicates. Sowing dates were randomly assigned in the main plots, while the six soybean genotypes Giza 111, Crawford, hybrid 30, hybrid 12, Giza 22, and Line105 were randomly allocated to the sub-

plots. The plot area was 9 m² and consisted of 5 ridges, 3 m in length and 60 cm in width. The seeds were sown in hills 15 cm apart. Soybean genotypes were planted on three dates, 5th, 20th of May, and 5th of June in both seasons. The pedigree, maturity group, flower color, and origin of the tested genotypes are presented in Table 1. Average monthly meteorological data during the two growing seasons are given in Table 2.

Table 1. The pedigree, maturity group, flower color, and origin of the tested soybean genotypes.

Genotypes	Pedigree	Maturity group	Flower color	Origin
Giza111	Crawford x Celest	IV	Purple	FCRI *
Crawford	Williams x Columbus	IV	Purple	USA **
Hybrid 30	Crawford x L62-1686	III	Purple	FCRI *
Hybrid 12	Crawford x Celest	IV	Purple	FCRI *
Giza22	Forest x Crawford	IV	Purple	FCRI *
Line105	Giza 35 x Lamar	V	White	FCRI *

* FCRI = Field Crops Research Institute, Giza, Egypt.

** USA = U. S. Regional Soybean Laboratory at Urbana, Illinois, and Stoneville, Mississippi.

Table 2. Average monthly meteorological data during the two growing seasons of 2022 and 2023.

Month	2022					2023				
	Temperature (C ^o)		Relative humidity (%)	Rainfall (mm)	Wind speed (km/h)	Temperature (C ^o)		Relative humidity (%)	Rainfall (mm)	Wind Speed (km/h)
	Max.	Min.				Max.	Min.			
April	29	15	46	0.5	17.7	31	12.3	51	0.5	16.7
May	35	22	38	0.1	18.3	37	15.7	46	0.1	17.1
June	39	25	53	0.1	16	39	19.4	51	0	16.2
July	40	27	56	0	13.4	41	21.9	59	0	14
Aug.	42	27	57	0	12.6	41	22.5	60	0	13.9
Sept.	35	21	63	0.1	13	39	22.3	63	0	14.6

All cultural practices for growing soybeans were done as recommended. Data on days to flowering date (FD) (flowering starts when 50% of the flowers are open), days to maturity (DM) were recorded on a plot basis at harvest.

Ten guarded plants were randomly taken from each plot to measure plant height (PH) (cm), number of branches/Plant (NB/P), number of pods/plant (NP/P), number of seeds/plant (NS/P), and seed weight/plant (SW/P) (g). Also, data on seed yield were determined from the central area (8.4 m²) in each plot, then transformed to ton/fed seed yield (SY).

Statistical analysis

The collected data were tested for normal distribution using the Kolmogorov-Smirnov normality test applied for all studied variables (Kozak and Piepho 2018). The Levene (1960) test was run before the combined analysis to test the homogeneity of individual error terms. When the data satisfied the tests, subsequently, a combined analysis of variance (ANOVA) procedure was carried out for the data of the two seasons for each observed trait. The least significant difference test (LSD) was performed at the 0.05 level to detect the differences among treatment means.

Exploratory factor analysis (EFA) was performed by using the principal components method. Initially, the Kaiser-Meyer Olkin (KMO) index is computed to measure the homogeneity of variables (Sharma 1996). When the KMO value is greater than 0.5, it indicates that the data are suitable for EFA. Secondly, Bartlett's test of sphericity tests whether the correlation matrix is an identity matrix, and the significance (P value) is smaller than 0.05, which would indicate that the factor model is appropriate. Due to differences in the units of variables used in exploratory factor analysis, the variables were standardized, and a correlation matrix of variables was used to obtain eigenvalues. Select Varimax as it is a recommended rotation technique to use when we start exploring the dataset. Varimax minimizes the number of variables that have high loadings on each factor and works to make small loadings even smaller (Tabachnick and Fidell 2007). Factor loadings were obtained and interpreted to determine the strength of the relationships. Factors can be identified by the largest loadings. The signs of the loadings show the direction of the correlation and do not affect the interpretation of the magnitude of the factor loading or the number of factors to retain (Kline, 1994). Main component factors, whose eigenvalues were >1, were selected since they best define the variabilities (Brejda *et al.* 2000). Factor coefficients were used to obtain factor scores.

Since the research aims to discover the yield potential of six genotypes, to classify them under different sowing dates under Egyptian environmental conditions, the data were automated for all kinds of analysis, using IBM SPSS Statistical Software Package, version 21.

RESULTS AND DISCUSSION

Analysis of variance

Results of the Levene test confirmed the homogeneity of variances for all studied characters, which allowed applying the combined analysis.

Effect of sowing dates

Results in Table 3 showed a significant effect of sowing date on all studied traits of soybean. The second sowing date (Date 2 = 20th May) had frequently higher mean values for all studied traits, except DF, DM, and PH, which recorded the highest mean values in the early sowing date (Date 1 = 5th May). The mentioned traits, DF, DM, and PH, decreased as the sowing date was delayed.

The main reason for this result might be due to the abbreviated photoperiod and warm temperature, which induced early flowering and the pod filling stage. The obtained results are compatible with those observed by Abdel Reheem *et al.* (2018), Krisnawati *et al.* (2021), Jarecki and Bobrecka-Jamro (2021), Ewais (2021), Morris *et al.* (2021), and El-Hawary *et al.* (2022).

The maximum seed yield (ton/fed) was produced from sowing on 20th May, followed by sowing on 5th May, which might be due to increasing yield attributes such as number of branches/plant, number of pods/plant, and seed weight/plant as shown in Table 3.

The percentage of reduction in seed yield (ton/fed) on the first and third dates was 6.18% and 41.57%, respectively, compared to the date (20th May). The high-yield potential and seed attributes resulting from the optimum and early planting dates may be due to the appropriate temperature and day length, leading to greater development of these attributes of soybean plants. Also, it has been found that Plant height increases when soybean is planted early, but starts to decrease with plantings in early June. (Bateman *et al.*, 2020), Borowska and Prusiński (2021) and Vann (2021).

Table 3. Mean performance of some yield traits under the three sowing dates (combined over 2022 and 2023 seasons).

Sowing dates	DF	DM	NB/P	NP/P	NS/P	PH	SW/P	SY
5 th May	35.47	119.08	3.28	49.03	117.85	125.22	15.75	1.67
20 th May	33.22	116.97	4.54	56.98	135.50	121.53	17.82	1.78
5 th June	31.97	115.36	2.42	28.77	54.39	111.00	9.79	1.04
LSD _{0.05}	0.52	0.55	0.19	1.98	3.29	1.25	0.42	0.06

DF :Days to flowering, DM : days to maturity, NB/P = no. of branches/plant, NP/P: no. of pods/plant, NS/P = no. of seeds/plant, PH = plant height (cm), SW/P = seed weight/plant (g), and SY = seed yield (ton/fed).

Contrariwise, early planting leads to increasing yield as it allows for longer vegetative and reproductive periods (Knott *et al.*, 2019). A longer vegetative stage allows a greater number of nodes to form before flowering, increasing the likelihood of more fruiting sites per plant, and thus more pods per plant.

Effect of genotype

Results obtained indicate a highly significant effect of genotype for all studied characters (Table 4). It has been found that genotype hybrid 12 recorded the shortest days to flowering (29 days), while Line 105 recorded the highest number of days to flowering (42 days). Furthermore, genotype Giza111 had the lowest number of days to maturity (114 days); on the contrary, Line105 had the highest number of days to maturity (122 days).

Genotype Giza 22 had the heaviest seed weight/plant (17.62 g) and gave the highest number of branches/plant, number pods/plant, and number of seeds/plant, being 4.25, 55.48, and 123.64, respectively, followed by Giza 111, which recorded 3.76, 51.32, and 116.54 for the corresponding traits, respectively.

On the other side, Line 105 had the lowest seed weight/plant, number of branches/plant, number of pods/plant, and number of seeds/plant being 11.76 g, 2.63, 35.19, and 79.86, respectively. The tallest plants were recorded by Hybrid 30, being 124.72 cm, while Crawford produced the shortest plants of 115.33 cm. Bateman *et al.* 2020 reported that the length of the day and temperature for early and late plantings differ significantly, and

these factors may influence the final heights of the plants. These findings are in agreement with those reported by others (Akram *et al.* 2011; Abdel Reheem *et al.* 2018; Ewais, 2021).

Table 4. Mean performance of some yield traits for six soybean genotypes under the three sowing dates (combined across the 2022 and 2023 seasons).

Genotypes	DF	DM	NB/P	NP/P	NS/P	PH (cm)	SW/P (g)	SY (ton/fed)
Giza111	32.56	114.89	3.76	51.32	116.54	117.89	15.77	1.64
Crawford	30.44	115.17	2.95	42.19	100.10	115.33	13.53	1.32
hybrid 30	31.67	115.00	3.65	48.34	113.02	124.72	15.22	1.38
hybrid 12	29.44	116.00	2.96	37.02	82.31	120.22	12.82	1.39
Giza22	34.94	118.89	4.52	55.48	123.64	120.78	17.62	1.87
Line105	42.28	122.89	2.63	35.19	79.86	116.56	11.76	1.40
LSD _{0.05}	0.59	0.49	0.25	1.99	2.35	4.25	0.31	0.06

DF = days to flowering, DM = days to maturity, NB/P = no. of branches/plant, NP/P = no. pods/plant, NS/P = no. of seeds/plant, PH = plant height (cm), SW/P = seed weight/plant (g) and SY = seed yield (ton/fed).

Interaction effect

The interactions of sowing dates with soybean genotypes were significant for all studied traits, except for plant height (Table 5). These significant interactions are mainly attributed to the different ranking of soybean genotypes from one sowing date to another, revealing that the studied genotypes behaved differently from one planting date to another. According to the interaction effect shown in Table 5, hybrid 12 had the lowest number of days to flowering (28.20) at the third planting date on 5th June, while the highest number of days to flowering, 44.83, was recorded by planting soybean line 105 on 5th May.

Maturity was also significantly affected by the interaction of planting dates (Table 5). Across three planting dates, soybean line 105 took the longest duration (126.0, 122.2, and 120.5 days) to mature, and genotypes Giza 111 and hybrid 30 were the earliest to mature.

Table 5. Mean values of some yield traits for six soybean genotypes grown under the three sowing dates during the two growing seasons 2022 and 2023.

Genotypes	DF			DM			NB/P			NP/P		
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
Giza111	35.2	32.0	30.5	116.8	114.8	113.0	3.6	5.2	2.4	56.2	63.9	33.9
Crawford	31.2	30.7	29.5	116.3	115.0	114.2	2.8	4.3	1.9	44.5	54.8	27.3
hybrid 30	33.5	31.7	29.8	116.7	114.8	113.5	3.5	4.5	2.9	53.7	59.1	32.3
hybrid 12	31.3	28.8	28.2	117.7	116.2	114.2	3.0	3.6	2.3	41.7	47.0	22.4
Giza22	36.8	34.7	33.3	121.0	118.8	116.8	4.1	6.0	3.5	59.0	70.6	36.8
Line105	44.8	41.5	40.5	126.0	122.2	120.5	2.6	3.6	1.6	39.1	46.6	19.9
LSD	1.03			0.91			0.43			3.58		
Genotypes	NS/P			PH			SW/P			SY		
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
Giza111	131.6	147.8	70.2	125.0	120.8	107.8	17.3	19.2	10.8	1.8	2.0	1.1
Crawford	117.1	138.9	44.3	118.8	119.2	108.0	15.5	17.6	7.60	1.4	1.6	1.0
hybrid 30	130.6	142.7	65.8	132.5	126.7	115.0	17.1	18.5	10.1	1.7	1.5	0.9
hybrid 12	96.1	114.7	36.1	124.7	120.3	116.2	13.4	16.2	8.9	1.7	1.5	1.0
Giza22	138.0	159.6	73.4	130.0	123.3	109.0	18.5	21.4	13.0	2.0	2.3	1.4
Line105	93.8	109.3	36.5	120.8	118.8	110.0	12.8	14.1	8.4	1.5	1.7	1.0
LSD	4.73			NS			0.61			0.11		

D1=5th May, D2 =20th May and D3= 5th June, DF = days to flowering, DM= days to maturity, NB/P = no. of branches/plant, NP/P = no. of pods/plant, NS/P = no. of seeds/plant, PH = plant height (cm), SW/P = seed weight/plant (g) and SY = seed yield (ton/fed), and NS = Non Significant.

A delayed planting date shortened the maturity of soybean genotypes. Delaying soybean sowing date by 20 days concerning the earliest date, caused a decrease in the total length of the day during vegetative development and the entire growing period by 18 and 8%, respectively, which resulted in an average increase in the length of the day during vegetative by 0.84 hours and a decrease in the length of the day during development by 0.27 hours, the most favourable dates for high seeds yield was the early date (end of April) and the medium date (mid-May), where the

greatest sum of mean daily temperatures were noted (Ksiezak and Bojarszczuk 2022).

The highest number of branches and pods per plant was reached with the soybean genotypes Giza 22 and Giza 111 planted on the second planting date. On the other hand, the soybean Line105 gave the lowest values in the number of branches/plant and number of pods/plant, by sowing on the 3rd date of planting (5th June).

Regarding plant seed weight and seed yield ton/fed, results in Table 5 clearly showed that the highest seed weight/plant and seed yield (ton/fed) were obtained by planting soybean cultivar Giza 22 on 20th May (21.35 g and 2.27 ton /fed), followed by Giza111 (19.22 g and 2.27 ton/fed). Sowing soybean cultivar Crawford on the 5th of June (3rd date) produced the lowest seed weight/plant and seed yield, being 7.60 g and 0.9 ton/fed, respectively.

Similar results were obtained by Egli and Cornelius (2009), Kandil *et al.* (2012), Abdel Reheem *et al.* (2018), Kessler *et al.* (2020), and Ewais (2021). Those authors recorded that delaying the sowing date of soybean resulted in a decrease in the number of pods, seed weight per plant, and finally seed yield in tons.

Kessler *et al.* (2020) showed that delaying the sowing date resulted in a decrease in seed yield by 0.17 ton/ ha⁻¹ because of losing suitable time for the growth. Likewise, earlier sowing of soybean causes a significant increase in yield, while delaying it until the turn of June significantly reduces it. According to Mandić *et al.* (2020), sowing time and genotype are important management strategies to improve yields of soybean and the benefits associated with it.

Exploratory factor analysis (EFA)

Implementation of exploratory factor analysis (EFA) was chosen from the wide range of statistical methods to analyze data because it is a statistical approach that is extensively used to describe the general relationships between several observed variables in terms of a potentially lower number of variables, which are called factors, with minimal loss of the original information. Two tests were applied to evaluate the adequacy of data: the Kaiser–Meyer Olkin (KMO) test and Bartlett’s sphericity test. The KMO statistic is a proportion of variance among variables that might be

common variance: it varies from zero to one, where zero is inadequate, while close to one is adequate (Field *et al.*, 2012).

The results of the KMO test (Table 6) were 0.67, 0.65, and 0.62 for the three sowing dates, respectively, which are classified as good, meaning that the sample is adequate for the application of factor analysis. KMO values above 0.50 and $p < 0.05$ for Bartlett's test are considered acceptable (Table 6).

Table 6. Summary of Kaiser-Meyer-Olkin Measure of Sampling Adequacy.

Kaiser-Meyer-Olkin Measure	Sowing dates		
	5 th May	20 th May	5 th June
KMO and Bartlett's Test	0.67	0.65	0.62
Significance level	0.00	0.00	0.00

Principal factor matrix after orthogonal rotations and summary of factor loading for some studied traits of soybean (across two seasons) are presented in Table 7. The factor analysis technique divided the studied variables into two main factors at the three sowing dates: Date1 = 5th May, Date2 = 20th May, and Date3 = 5th June. These two factors are significant factors with eigenvalues higher than 1 (Table 7), and accounted for about 78.3%, 79.2%, and 76.7%, respectively, of the total variability in the dependence structure of soybean seed weight/plant for the three sowing dates.

The first factor for sowing dates one and two included four variables and accounted for 45.8 % and 47.0 %, respectively. These variables were plant height, number of branches/plant, number of pods/plant, and number of seeds/plant. It is clear that these variables had high loading coefficients and contributed much more to the seed weight/plant. Likewise, these attributes were important in the selection of superior soybean genotypes. Sina *et al.* (2018) and Hassanvand *et al.* (2022) reported that the previous attributes had a direct effect on seed weight/plant. Concerning variable coefficients, it was found that the first factor coefficients covered most of

the data and contained the large and positive coefficients of seed product (Table 7) at the three planting dates.

Table 7. Factor coefficients of yield traits after Varimax rotation at three sowing dates.

Factor parameters	Sowing Date					
	5 th May		20 th May		5 th June	
	F1	F2	F1	F2	F1	F2
Eigenvalue	2.9	2.1	2.8	1.9	2.6	2.0
Variance (%)	45.8	32.4	47.0	32.2	42.8	33.9
Cumulative of variance (%)	45.8	78.3	47.0	79.2	42.8	76.7
Traits						
DF		0.95		<u>0.96</u>		0.92
DM		<u>0.96</u>		0.95		<u>0.94</u>
PH	0.66		0.36		- 0.54	
NB/P	0.79		0.93		0.85	
NP/P	<u>0.91</u>		<u>0.96</u>		<u>0.88</u>	
NS/P	0.88		0.92		0.84	

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. (F1: First factor, F2: Second factor), DF = days to flowering, DM = days to maturity, PH = plant height, NB/P = no. of branches/plant, NP/P = no. pods/plant, and NS/P = no. of seeds/plant.

The second factor in the three sowing dates consists of two variables and accounted for 32.4%, 32.2%, and 33.9%, respectively, of the total variability of soybean seed weight/plant. These two variables were days to flowering and days to maturity (Table 7). On the third date, all studied traits in the first factor showed positive loading except PH (- 0.54).

Factor 1 seems to comprise items referring to the importance of several branches/plant, the number of pods/plant, and the number of seeds/plant in the skip or exceeds dealing status (Date 3 = 5th June). However, increasing the aforementioned traits would be the most effective way of increasing soybean yield.

Factor Analysis Score (FAS)

Globally, climate change is one of the massive challenges. It's causing a significant change in the average values of meteorological elements, such as temperature and rainfall, while negatively affecting crops. Due to that, it became a necessity that researchers, breeders, and producers make genetic diversity information available to secure information and improve such elite soybeans in the future. So, after employing exploratory factor analytic tools, our results describe for the first time regression factor scores for six soybean genotypes at each planting date (Date 1 = 5th May, Date 2 = 20th May, and Date 3 = 5th June), respectively.

Considering the factor coefficients as shown in Table 7, the regression factor score was established for each genotype according to the two factors for each planting date.

For fast and easy visual evaluation of genotype performance concerning yield productivity and maturity trait, the authors supposed to diagrammatically plot the regression factor scores one (yield productivity traits) on the vertical axis against the regression factor scores two (maturity traits) on the horizontal axis in scatter plot graph (Fig. 1). The supposed graph shows the high yielding ability and mature parameter in the same time which facilitates the decision making about the high yielder soybean genotypes and early or lately genotypes under each planting data.

The zone under the graph is divided into four rectangles representing the interrelationship between yield ability and maturity parameter. The upper right rectangle contains the genotypes characterized by high-yielding ability of pod yield (positive score values) and late maturity (positive score values).

Across the three planting dates, it is obvious that one out of the six genotypes, being Giza 22, was located in this class, as shown in Fig 1. Accordingly, the check cultivar, Giza 22, is still the highest seed-yielding genotype at the three planting dates compared to the other tested genotypes.

In the upper left rectangle, early mature (negative score values) and high pod yields, two out of the six genotypes were located in this class, namely: Giza111 and hybrid 30 (Fig 1) at the three planting dates of soybean. It is noted that the behavior of the genotypes was similar on the

different dates, but the rate of change of the crop varies from one date to another, depending on each variety, as a general average for all the traits, and this is also evident in the interaction table between the dates and the varieties.

Early planting allows for greater accumulated solar radiation throughout germination during the growing season, providing greater yields comparatively (Rattalino Edreira *et al.* 2020). Although it provided better germination and establishment.

Also, on the opposite side at the bottom, one genotype (Line105) occupied the lower right class, having positive high score values (Late mature) and poor pod yield. Delaying planting far reduces yields and consequently results in a 9% decrease in partial net profit (Schmitz and Kandel, 2021).

Planting three weeks later than the optimal date decreased soybean yield due to reduced node production and slower canopy development. However, delaying planting can shorten vegetative and reproduction growth stage periods, resulting in less radiation accumulation when planting after 20 May.

Two genotypes fall in the lower left class, i.e., Crawford and hybrid 12. They have a low score value (Early Mature) and the lowest scores for pod yield. According to the regression factor score of measures, Giza 111, hybrid 30 was selected as a high-seed-yielding and early genotype, while Giza 22 was selected as a high-seed-yielding and late genotype.

Results obtained showed that genotype hybrid 30 was very sensitive to different planting dates, as the regression factor score one (yield productivity characters) decreases at the late planting date (Fig 1), so the best suitable planting date for it was the early date (Date 1 = 5th May), and it is recommended at early cultivation. As previously shown from the interaction (Table 5), the pod yield decreased in the optimal and late dates.

Abdelghany *et al.* (2021) confirmed the usefulness of factor scores measurements for the assessment of soybean genotypes. The number of pods per plant was higher after sowing at an early date compared to the optimal date. Mourtzinis *et al.* (2019) discussed that the correct sowing date depended on the climate of a given region.

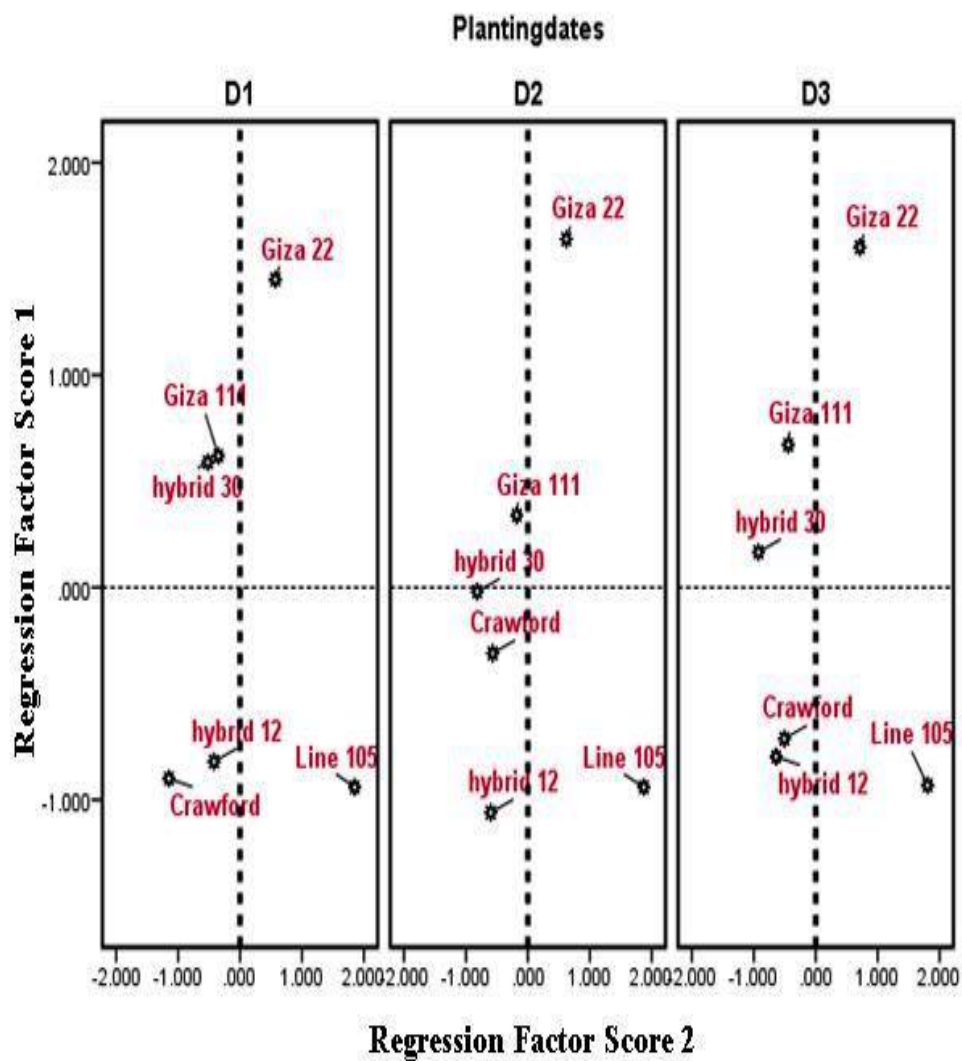


Fig. 1. Scatter plot displaying the genotype performance regarding the regression factors at the three planting dates.

The purpose of this investigation is to find how to connect the different characteristics and utilize them in the selection and presentation of the data that relates to each other. This was done using exploratory factor analysis (EFA), and many researchers agree with this purpose (Sina *et al.* 2018; Toloi *et al.* 2021; Hassanvand *et al.* 2022).

CONCLUSION

From our investigation, it is possible to conclude that the characteristics number of days to flowering, days to maturity, plant height, number of branches/plant, number of pods/plant, seed weight/plant, and seed yield (ton/fed) are suitable for the selection process, as they showed high genetic variability. Agronomic selection processes were identified to select elite genotypes. The selection strategy containing the variables insertion height, number of branches, number of pods, and seed yield allowed the selection of soybean genotypes with good yield components, earlier, and appropriate for delayed cultivation. The ANOVA and the applied multivariate statistics using exploratory factor analysis and factor scores helped to select suitable genotypes with high performance at different planting dates to carry on the soybean plant-breeding program. Vegetative traits can also be considered as a key in the development of early selection indices when the objective is to obtain genotypes with good performance and adaptability in this crop. Soybeans can be sown at the turn of May, depending on weather conditions.

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تقييم بعض التراكيب الوراثية من فول الصويا تحت مواعيد زراعة مختلفة

بإستخدام تحليل العامل الإستكشافي

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أجريت هذه الدراسة لتقييم إنتاجية ستة تراكيب وراثية من فول الصويا في ثلاثة مواعيد زراعية هي (٥ مايو - ٢٠ مايو و ٥ يونيو). لهذا الغرض تم إجراء تجربة حقلية بمحطة بحوث ملوي خلال موسمي ٢٠٢٢ و ٢٠٢٣ و كان التصميم التجريبي عبارة عن تصميم القطع المنشقة بتوزيع القطاعات الكاملة العشوائية في ثلاث مكررات لدراسة تأثير مواعيد الزراعة المختلفة على المحصول و مكوناته. أظهرت النتائج تأثيراً معنوياً لمواعيد الزراعة المختلفة على جميع الصفات المدروسة. كان تفاعل مواعيد الزراعة مع التراكيب الوراثية لفول الصويا معنوياً لجميع الصفات المدروسة فيما عدا طول النبات. فيما يتعلق بوزن محصول بذور النبات ووزن المحصول (طن/فدان) أظهرت النتائج بوضوح أن أعلى وزن محصول بذور للنبات ووزن المحصول (طن/فدان) تم الحصول عليه من تاريخ الزراعة الأمثل (منتصف مايو)، مع صنف فول الصويا جيزة ٢٢ ثم صنف جيزة ١١١. تم استخدام تحليل العامل الاستكشافي في الدراسة كأداة إحصائية فعالة حيث أشارت النتائج الى خفض وتقسيم المتغيرات المدروسة إلى عاملين رئيسيين في الثلاثة مواعيد الزراعة المختلفة. شكّل هذان العاملان حوالي ٧٦,٣٪ و ٨٠,٨٪ و ٧٣,٤٪ على التوالي من التباين الكلي. أيضاً تم استخدام درجات تحليل العامل بطريقة الاتحاد كمؤشر اختيار على أساس التباين في الأصناف والمحصول ومكوناته حيث كان الصنف جيزة ٢٢ هو الصنف المتفوق في تاريخ الزراعة المتأخر. وكانت الأصناف مبكرة النضج والعالية في عدد القرون هي جيزة ١١١ وهجين 30 في مواعيد الزراعة الثلاثة. ويلاحظ أن سلوك الأصناف كان متشابهاً في مواعيد الزراعة المختلفة لكن معدل تغير المحصول يختلف من ميعاد زراعة إلى آخر اعتماداً على متوسطات الأصناف لجميع الصفات وهذا واضح أيضاً في التفاعل بين مواعيد الزراعة والأصناف.

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