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Genetic Effects of Some Phenotypic Characteristics in Tobacco

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Original Research Article

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ABSTRACT

The lifespan of tobacco seeds ranges from 5-7 years, and then they begin to deteriorate genetically as a result of hybridization and the occurrence of mutations naturally. Therefore, an genetic improvement process for this crop must be carried out continuously.

The experiment was carried out during the years 2023-2024 in kassab village, Lattakia, Syria, by cultivating three tobacco genotypes (Basma, Prilep, and Gob-Hasan). A half-diallel cross was made between different genotypes of tobacco.

In the following season, an evaluation of the genotypes was performed, which were distributed according to the randomized complete block design (R.C.B.D) with three replicates to estimate the nature of gene action for: plant height, leaves number, internodes length, plant leaf area and leaf area index.

The results show high differ significantly for all traits, which refer to differ among the parents. The genetic analysis shows important both additive and dominant effects to heredity in all studied characteristics. The additive gene action dominated the inheritance of: plant height, internodes length, plant leaf area and leaf area index. But the non-additive gene action dominated the inheritance of leaves number.

The prilep parent exhibited a high means for: leaves number (22 leaf/plant), plant leaf area (192 cm^2). However, The Gob-Hasan parent exhibited a high means for: plant height (75.60 cm), internodes length (3.5 cm), leaf area index (1.26).

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The hybrid Basma × Gob-Hasan exhibited the highest means for: plant height (72.70 cm), internodes length (3.46 cm). The hybrid Prilep × Gob-Hasan exhibited the highest means for: leaves number (24.6 leaf/plant), plant leaf area (136.20 cm^2), leaf area index (1.3). We conclude that the hybridization method can be adopted to obtain new tobacco varieties with high leaf yield.

Keywords: Half-diallel cross; gene action; oriental tobacco.

1. INTRODUCTION

"Tobacco plant is the second most commonly used psychoactive substance worldwide, with more than one billion smokers globally" [1], Historically, tobacco was used in some cultures as part of traditional ceremonies, but its use was infrequent and not widely disseminated in the population. However, since the early twentieth century, the use of commercial cigarettes has increased dramatically

"The species Nicotiana tabacum, known as tobacco, is one of the crops with the highest economic value in the world among non-food species" [2].

"Breeders aim to develop more productive and superior quality varieties compared to the existing ones. The introduction of these superior varieties into tobacco production is expected to have a positive economic impact, enhancing the livelihoods of producers and boosting financial inflow into the country" [3].

"A new cultivar will only be widely adopted if it meets the requirements of producers, industry, and consumers. These players have very different needs and their interests may not necessarily coincide in many cases. A difficulty therefore faced by plant breeders is that selection is hardly ever directed for a single trait. In the case of tobacco, numerous correlated traits are important, making development of new cultivars improved for multiple traits challenging" [4].

"Although tobacco is typically considered an autogamous plant, the generation of commercial F1 hybrids can be viewed as desirable even though heterosis levels are of low magnitude for this species. Breeding programs already carry out manual hybridization to combine traits of interest present in different lines" [4].

"For a number of reasons, tobacco is one of the easiest self-pollinated crop species to manipulate from a reproductive standpoint. First, as a perennial species, tobacco has the potential to continue flowering for several years in permissive environments (such as greenhouse settings) once flowering is initiated" [5].

"The development of superior tobacco varieties can be through plant breeding programs. The assembly of tobacco varieties in plant breeding can be done through a deeper study of the agronomic traits" [6].

Diallel has been utilized in investigation of gene action effects in tobacco [7] and many other crops for instance wheat [8], sunflower [9], cotton [10], and tomato [11]. Diallel crosses are widely used to assess the potential of lines to obtain hybrids [12].

Aleksoski et al. [3], in a three-year study of four parent tobacco genotypes of different types and their six diallel F1 hybrids found weak inheritance of the leaf number.

The aim of these investigations was to study the mode of inheritance for: plant height, leaves number, internodes length, plant leaf area and leaf area index. The F_1 generation obtained by diallel crosses of tobacco varieties from different types will give us an important guidance for future selection programs in tobacco breeding.

2. MATERIALS AND METHODS

2.1 Plant Materials

Three oriental tobacco lines or cultivars Obtained from General Organization of Tobacco -G.O.T- Lattakia- Syria:

1. Basma: Greek origin, aromatic.
2. Prilep; Yugoslav origin, oriental, aromatic.
3. Gob-Hasan: Bulgarian hybrid, semi-aromatic).

The number of hybrids:

= 3(3-1)/2 = 3 [13] Crosses= n(n-1)/2

Table 1. Half-diallel crossing

Parents	P1	P2	P3
P1	P1×P1	P2×P1	P3×P1
P2	-	P2×P2	P3×P2
P3	-	-	P3×P3

(P1,P2 and P3) refers to Basma, Prilep and Gob-Hasan respectively

In 2023, in field conditions, by applying the half-diallel method of crossing, using hand castration and pollination method, three-way half-diallel crosses were made: Basma x Prilep, Basma x Gob-Hasan and Prilep x Gob-Hasan.

In 2024 an experiment was set with 6 genotypes (3 parents and 3 F1 hybrids), according to a complete Randomized block design in three replications.

Many different traits were measured during flowering:

1. plant height (cm): This is done by measuring the plant height (cm), starting from the soil surface level up to the growing top as the plants enter the flowering stage.

2. leaves number (leaf/ plant): This is done by counting the leaves (leaf/plant) from each experimental treatment.

3. internodes length (cm): Measure the distance between every two successive nodes on the plant in the pre-flowering stage.

4. plant leaf area (cm^2): leaf length (cm) × leaf width (cm) × 0.6443

5. leaf area index [14]: plant leaf area (cm^2) × The area of land occupied by a plant (cm^2).

2.2 Statistical Analyzes Include the Following

1. Analysis of Variance And Compare Means: Analysis of variance was performed using the $L.S.D_{5\%}$. Diallel analysis were conducted according to Griffing's method 2 and model 1 [15].

2. The ratio of the variance of general combining ability to the variance of specific combining ability σ^2 GCA/ σ^2 SCA: A measure that determines the contribution of both additive and non-additive genetic actions to the inheritance of the studied traits, as follows:

a) σ^2 GCA/ σ^2 SCA >1: It indicates that the additive genetic action controls the inheritance of the genes responsible for this trait.

b) σ^2 GCA/ σ^2 SCA <1: It indicates that the non-additive genetic action controls the inheritance of the genes responsible for this trait.

c) σ^2 GCA/ σ^2 SCA =1: It indicates the contribution of both additive and non-additive genetic actions to the equal inheritance of the genes responsible for this trait.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Analysis of variance showed significant differences among genotypes for Plant height (Table 2). The results of the study of this trait concluded that the plants of both parents P_3 and P_1, had the highest heights, reaching (75.60 and 63.33) cm, respectively. They were able to inherit from the hybrid they participated in, which is P_1P_3 (72.70), the genes responsible for the trait of high plant height.

The ratio between general combining ability variance to specific combining ability variance σ^2GCA/σ^2SCA gave value (5.40), and this result confirmed that the plant height trait is determined by additive gene action.

This result Agreed with Bharathi et al. [16] on tobacco plants, it has been reported that plant height trait is determined by genes which have additive effects, in contrast, Dyulgerski et al. [17] study on several tobacco genotypes showed that plant height trait is determined by genes which have non-additive effects. This indicated presence of adequate genetic variability among oriental tobaccos, which could be exploited in different crossing programs [18].

Table 2. Analysis of variance for plant height trait

Parents	Means	Hybrids	Means	Additive	Dominance
P1	63.33	P1P2	47.33	147.72	13.67
P2	45.20	P1P3	72.70	σ2 GCA/σ2 SCA	
P3	75.60	P2P3	58	5.40	
L.S.D 5%	**1.032**	**Genotype**	**479.07****		

(P1,P2 and P3) refers to Basma, Prilep and Gob-Hasan respectively

Table 3. Analysis of variance for leaves number trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	19.2	P_1P_2	18.46	1.80	5.06
P_2	22	P_1P_3	21.86	σ^2 GCA/σ^2 SCA	
P_3	20.3	P_2P_3	24.6	0.18	
L.S.D 5%	**1.11**	**Genotype**	**14.89****		

(P_1,P_2 and P_3) refers to Basma, Prilep and Gob-Hasan respectively

Table 4. Analysis of variance for internode length trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	3.2	P_1P_2	2.26	0.44	0.02
P_2	1.8	P_1P_3	3.46	σ^2 GCA/σ^2 SCA	
P_3	3.5	P_2P_3	2.9	9.27	
L.S.D 5%	**0.31**	**Genotype**	**1.42****		

(P_1, P_2 and P_3) refers to Basma, Prilep and Gob-Hasan respectively

Table 5. Analysis of variance for plant leaf area trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	80.20	P_1P_2	107.05	1517.17	618.40
P_2	192	P_1P_3	103.07	σ^2 GCA/σ^2 SCA	
P_3	173	P_2P_3	136.20	1.23	
L.S.D 5%	**0.10**	**Genotype**	**5664.65****		

(P_1, P_2 and P_3) refers to Basma, Prilep and Gob-Hasan respectively

Table 6. Analysis of variance for leaf area index trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	1.1	P_1P_2	1	0.01	0.001
P_2	1	P_1P_3	1.2	σ^2 GCA/σ^2 SCA	
P_3	1.26	P_2P_3	1.3	3.35	
L.S.D 5%	**0.04**	**Genotype**	**0.03****		

(P_1, P_2 and P_3) refers to Basma, Prilep and Gob-Hasan respectively

3.2 Leaves Number (Leaf/plant)

Analysis of variance showed significant differences among genotypes for leaves number (Table 3). The results trait concluded that the plants of both parents P_2 and P_3, had the largest number of leaves per plant, reaching (22 and 20.3) leaf/plant, respectively. They were able to inherit from the hybrid they participated in, which is P_2P_3 (24.6) leaf/plant, the genes responsible for the trait of leaves number.

The ratio between general combining ability variance to specific combining ability variance σ^2GCA/σ^2SCA gave value (0.18), and this result confirmed that the leaves number trait is determined by additive gene action. This indicates that non-additive genetic action is more important in controlling the inheritance of the genes responsible for the trait of the number of leaves, and therefore it can be improved through hybridization and selection [19].

In this context, Seyyed-Nazari et al. [20] in their study on six parents of oriental tobacco hybridized together with a half-crossed hybridization system, showed that the differences were significant between these genotypes, which indicates genetic divergence between them.

This result Agreed with Korubin-Aleksoski [21] on tobacco plants, it has been reported that leaves number is determined by genes which have non-additive effects, in contrast, Dyulgerski et al. [17] study showed that leaves number trait is determined by genes which have additive effects.

3.3 Internode Length (cm)

Analysis of variance showed significant differences among genotypes for internode length (Table 4). The results trait concluded that the plants of both parents P_3 and P_1, had the longest Internode length, reaching (3.5 and 3.2) cm, respectively. They were able to inherit from the hybrid they participated in, which is P_1P_3 (3.46) cm, the genes responsible for the trait of Internode length. Therefore, they can be used as donor parents for this trait in the breeding program, according to a study [22].

The ratio between general combining ability variance to specific combining ability variance σ^2GCA/σ^2SCA gave value (9.27), and this result confirmed that the Internode length trait is determined by additive gene action.

The results showed that there are significant differences between the genotypes, and this is due to the genetic divergence of the parents. The role of selecting the parents involved in the hybridization program is the most important point, as plant breeders use the variation between genetically divergent parents to derive and develop new, improved varieties of plants with desirable characteristics, according to researchers' findings [23].

3.4 Plant Leaf Area (cm^2)

Analysis of variance showed significant differences among genotypes for plant leaf area (Table 5). The results trait concluded that the plants of both parents P_2 and P_3, had the biggest plant leaf area, reaching (192 and 173) cm^2, respectively. They were able to inherit from the hybrid they participated in, which is P_2P_3 (136.20) cm^2, the genes responsible for the trait of plant leaf area. Therefore, they can be used as donor parents for this trait in the breeding program, according to a study [22].

The ratio between general combining ability variance to specific combining ability variance σ^2GCA/σ^2SCA gave value (1.23), and this result confirmed that the plant leaf area trait is determined by additive gene action, The additive effect of the leaf area trait genes had a greater role in its inheritance compared to the non-additive genetic action, in Aleksoski's [3] study on several varieties of oriental tobacco.

If there is an increase in the number of leaves, the plant leaf area and height of the plant, this will also be followed by an increase in the production of tobacco leaves, and thus they can be used as direct selection criteria for the leaf yield of the plant [6].

3.5 Leaf Area Index

Analysis of variance showed significant differences among genotypes for leaf area index (Table 6). The results concluded that the both parents P_3 and P_1, had the biggest leaf area index (1.26 and 1.1), respectively. They were able to inherit from the hybrid they participated in, which is P_2P_3 (1.3), the genes responsible for the trait of leaf area index.

The ratio between general combining ability variance to specific combining ability variance σ^2GCA/σ^2SCA gave value (3.35), and this result confirmed that the leaf area index trait is determined by additive gene action, these results agreed with Muraya et al. [24] study.

The leaf area index is an important indicator in estimating plant productivity. The results of the study of this trait concluded that the plants of both parents P_3 and P_2 gave the largest value for the average leaf area index, which also gave the leaves of their plants the largest leaf area, which gives it great importance as it is of practical benefit in future breeding programs aimed at improving crops. field [16,25,26].

4. CONCLUSION

According to the results of the two-year investigations, the following conclusions have been made:

1) Analysis of variance showed significant differences among genotypes for all studied traits plant height, leaves number, internodes length, plant leaf area and leaf area index.

2) The additive gene action dominated the inheritance of (plant height, internodes length, plant leaf area and leaf area index) The ratio between general combining ability variance to specific combining ability variance σ^2GCA/σ^2SCA gave value (5.40, 9.27, 1.23 and 3.35) respectively. Thus, the best parents can be used to improve tobacco yields.

3) the non-additive gene action dominated the inheritance of leaves number, The ratio σ^2GCA/σ^2SCA gave value (0.18), Thus, hybridization and selection are used to improve these traits.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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