Asian Journal of Advances in Research

Volume 7, Issue 1, Page 346-353, 2024; Article no.AJOAIR.3666

Study of the Inheritance of Several Morphological and Chemical Traits of Several Genotypes of Tobacco (*Nicotiana tabacum* L.)

Qamar Sufan [a*]

[a] *Department of Crops, College of Agricultural Engineering, Tishreen University, Syria.*

Author's contribution

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

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/3666

Original Research Article

Received: 28/04/2024
Accepted: 30/06/2024
Published: 16/07/2024

ABSTRACT

The experiment was carried out during the year 2024 to determine the genetic behavior of many different traits of the three parents of the oriental tobacco in kassab village, Lattakia, Syria, by cultivating three oriental tobacco genotypes (Basma, Prilep, and Gob-Hasan). A half-diallel cross was made between different genotypes of tobacco using random complete block design (R.C.B.D) with three replicates, to estimate the nature of gene action for many important characteristics of tobacco plants and identifying the best parents to include in breeding programs to obtain tobacco with high productivity and high quality.

Traits such as leaf length (cm), leaf width (cm), specific leaf weigh (g/cm^2), nicotine (%) and sugar content in leaves (%) were measured.

The results show high differ significantly for all traits, which refer to differ among the parents. Thus increasing the effectiveness of the hybridisation programme.

**Corresponding author: Email: 123qamar456@gmail.com;*

Cite as: *Sufan, Qamar. 2024. "Study of the Inheritance of Several Morphological and Chemical Traits of Several Genotypes of Tobacco (Nicotiana Tabacum L.)". Asian Journal of Advances in Research 7 (1):346-53. https://jasianresearch.com/index.php/AJOAIR/article/view/461.*

The genetic analysis show the additive gene action dominated the inheritance of: leaf width (cm). But the non-additive gene action dominated the inheritance of leaf length (cm), specific leaf weigh (g/cm^2), nicotine (%) and sugar content in leaves.
The Basma parent P_1 exhibited a lowest means for: nicotine content in leaves (0.22)%, The Prilep parent P_2 exhibited a high means for: leaf length (23.3) cm and specific leaf weigh (0.22) g/cm^2. However, The Gob-Hasan parent P_3 exhibited a high means for: leaf width (11.7) cm. The hybrid Prilep × Gob-Hasan exhibited the highest means for sugar content in leaves (10.67)%.

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

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 F_1 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].

The aim of these investigations was to study the mode of inheritance for: length and width of the leaves from the middle belt, and yield of green leaf mass per stalk and per hectare.

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:

Crosses= n(n-1)/2 = 3(3-1)/2 = 3 [5]

Table 1. Half-diallel crossing

Parents	**P_1**	**P_2**	**P_3**
P_1	$P_1 \times P_1$	$P_1 \times P_2$	$P_1 \times P_3$
P_2	-	$P_2 \times P_2$	$P_2 \times P_3$
P_3	-	-	$P_3 \times P_3$

(P_1, P_2 and P_3) 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 F_1 hybrids), according to a complete Randomized block design in three replications.

Many different traits were measured during flowering:

a) Leaf Length (cm).

b) Leaf Width (cm).

c) Specific Leaf Weight (g/cm2): The leaf specific weight (SLW) was determined after measuring the dry weight of the leaves at the beginning of the technical maturity of the leaves according to the researcher [6]:

   SLW = dry leaf weight (g/plant)/leaf area (cm2/plant).

d) Nicotine Content in leaves (%): Tobacco alkaloids were extracted using a mixture (benzene + chloroform) in the presence of barium water, then nicotine in the extract was determined using a standard acid, which is prochloric acid [7].

e) Total Soluble Sugar Content (%): The total soluble sugar content of tobacco leaves was analyzed according to [8]. 100 mg of dry tobacco leaves were crushed in 4 ml of 80% ethanol, then the tubes were placed in a hot water bath at 80°C for 10 minutes until Dry the alcoholic extract, then add 5% phenol and concentrated sulfuric acid (96%, K = 1.86) to the mixture, resulting in a yellow-brown color, then measure the optical absorption at a wavelength of 490 nm using a spectrophotometer.

Statistical analyzes include the following:

a) Analysis of Variance And Compare Means: Analysis of variance was performed using the L.S.D5%. Diallel analysis were conducted according to Griffing's method 2 and model 1 [9].

b) The ratio of the variance of general combining ability to the variance of specific combining ability σ2 GCA/ σ2 SCA: A measure that determines the contribution of both additive and non-additive genetic actions to the inheritance of the studied traits, as follows:

- σ2 GCA/ σ2 SCA >1: It indicates that the additive genetic action controls the inheritance of the genes responsible for this trait.
- σ2 GCA/ σ2 SCA <1: It indicates that the non-additive genetic action controls the inheritance of the genes responsible for this trait.
- σ2 GCA/ σ2 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 Leaf Length (cm)

Analysis of variance Table 2 shows that there are significant differences between the different genotypes for the leaf length trait, and this indicates genetic divergence between the parents included in the hybridization program for this trait. Therefore, there is a greater possibility of improving tobacco plants based on the genetically divergent parents included in the hybridization programs [10], leaf length is an important characteristic because it affects the yield of tobacco leaves through its direct effect on increasing the leaf area and thus increasing the production capacity of this crop.

This was consistent with the ratio between the variance of the general combining ability to to the variance of specific combining ability σ2GCA/ σ2SCA, which gave a value smaller than one (0.2), and in this context the results of the study [11] of Seyyed-Nazari et al. confirmed. The non-additive gene action controls the inheritance of the tobacco leaf length trait to a greater extent than the additive gene action.

Table 2. Analysis of variance for leaf length trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	19.2	P_1P_2	18.6	3.7	**8,15**
P_2	23.3	P_1P_3	14.1	σ^2 GCA/σ^2 SCA	
P_3	20.2	P_2P_3	18.8	0.2	
L.S.D 5%	1.48	Genotype	26.5**		

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

Table 3. Analysis of variance for leaf width trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	8.3	P_1P_2	9.2	1.1	0.002
P_2	10.8	P_1P_3	9.5	σ^2 GCA/σ^2 SCA	
P_3	11.7	P_2P_3	10.1	190.98	
L.S.D 5%	1.7	Genotype	4.3**		

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

Table 4. Analysis of variance for specific leaf weigh trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	0.15	P_1P_2	0.13	0.0006	0.001
P_2	0.22	P_1P_3	0.10	σ^2 GCA/σ^2 SCA	
P_3	0.18	P_2P_3	0.14	0.17	
L.S.D 5%	0.002	Genotype	0.005**		

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

3.2 Leaf Width (cm)

The analysis of variance Table 3 indicates that there are significant differences between the six genotypes, which indicates genetic divergence between the parents involved in the semi-reciprocal hybridization program. With regard to leaf width, plant breeders use the variation between genetically divergent parents to derive and develop new, improved varieties of plants. The same desirable characteristics, according to researchers [12].

The plants of Gob-Hasan P3 gave leaves width (11.7) cm, followed by P2 parent, whose leaves reached a width of (10.8) cm. As for parent P1, he gave the lowest value for this trait compared to the remaining genotypes, which amounted to (8.3) cm. As for The P2P3 hybrid gave leaves with a width of up to (10.1) cm, followed by the P1P3 hybrid (9.5) cm, and the P1P2 hybrid (9.2) cm came in last place**.**

The value of the components of the variance of the additional genetic action was high (1.1) compared to the value of the components of the variance of the dominant gene (0.002), that is, the control of the additive gene action on the inheritance of the leaf width trait. This result confirmed the ratio between the variance of general combining ability to the variance of specific combining ability. On the consensus ơ2GCA/ ơ2SCA, which gave a value greater than one, and in this context.

The results of the study of both researchers [11] and Seyyed-Nazari et al. The leaf width trait in tobacco is under the control of additional genetic action, which indicates the possibility of improving this trait through direct selection [13].

This result was not consistent with the study of Bharathi et al. [14]. On ten varieties of tobacco, non-additive gene action dominated the genes responsible for leaf width, so these traits can be improved using the pedigree method of breeding.

3.3 Specific Leaf Weight (g/cm2)

Table 4 shows that there are differences between the genotypes, and they were highly significant, and thus there is genetic divergence between the tested parents involved in the crossbreeding program. Parents are selected in the different crossbreeding programs mainly based on the presence of differences in their characteristics, as current studies have indicated that the parents genetically divergent, they result in distinct hybrids with different characteristics [15].

The leaves of the plants of the second parent P_2, ranked first in terms of specific leaf weight compared to the leaves of the other parents (0.22) g/cm^2, followed by the parent P_3, whose leaves reached a specific gravity of (0.18) g/cm^2, while the specific gravity of the leaves of the plants of the parent P_1 was the lowest compared to The rest of the parents were (0.15) g/cm^2. As for the P_2P_3 hybrid, the specific weight of its leaves was the highest compared to the rest of the hybrids (0.14) g/cm2, followed by the P1P2 hybrid (0.13) g/cm2, and the P1P3 hybrid came in last place (0.10) g/cm2.

Table 5. Analysis of variance for nicotine content in leaves trait

Parents	Means	Hybrids	Means	Additive	Dominance
P1	0.22	P1P2	0.91	0.04	0.06
P2	0.88	P1P3	1.11	σ2 GCA/σ2 SCA	
P3	0.81	P2P3	1.28	0.31	
L.S.D 5%	0.67	Genotype	0.39**		

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

Table 6. Analysis of variance for sugar content in leaves trait

Parents	Means	Hybrids	Means	Additive	Dominance
P_1	8.54	P_1P_2	9.11	1.32	1.37
P_2	9.91	P_1P_3	7.86	σ^2 GCA/σ^2 SCA	
P_3	6.56	P_2P_3	10.67	0.48	
L.S.D 5%	0.18	Genotype	6.47**		

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

The value of the components of the variance of the dominance gene action was high (0.001) compared to the value of the components of the variance of the additive gene (0.0006), that is, the control of the non-additive gene action on the inheritance of the specific leaf weight trait. This result confirmed the ratio between the variance of general combining ability to the variance of specific combining ability. On the consensus σ^2GCA/ σ^2SCA, which gave a value lesser than one (0.17).

Genetic divergence leads parents to increase the effectiveness of the hybridization program used to determine the mechanism of inheritance of the genes responsible for the traits and to obtain hybrids with desirable and distinct characteristics [16].

3.4 Nicotine Content in Leaves (%)

Analysis of variance Table 5 shows that there are significant differences between the tested genotypes, and this is evidence of genetic divergence between the parents regarding the nicotine content of the leaves.

The leaves of the parent plants contained the lowest percentage of nicotine compared to the resulting hybrids, as follows:

P_1 gave the lowest percentage of nicotine compared to the rest of the genotypes (0.22)%, P_3, whose nicotine content in its leaves reached (0.81)%, followed by the parent. P_2 (0.88)%, as for the P_1P_2 hybrid, it gave leaves with a nicotine content that reached (0.91)%, followed by the P_1P_3 hybrid (1.11)%, and the P_2P_3 hybrid (1.28)% came in first place.

The hybrid P_1P_2, which contained the lowest percentage of nicotine, resulted from the parent P_1, which also had the lowest percentage of nicotine in the leaves of its plants. This parent was able to transfer the genes responsible for the trait of low nicotine content to the hybrid in which it participated.

This hybrid can be invested in obtaining plants whose leaves contain a low percentage of nicotine, as this hybrid is used to make various cigarettes to protect human health due to the low nicotine content of its leaves [17].

The value of the components of the variance of the non-additive gene action was high (0.006) compared to the value of the components of the variance of the additive gene (0.04), that is, the control of the non-additive gene action on the inheritance of the nicotine content in leaves trait. This result confirmed the ratio between the variance of general combining ability to the variance of specific combining ability. On the consensus σ^2GCA/ σ^2SCA, which gave a value lesser than one (0.39).

The nicotine content in leaves is one of the most important characteristics and quality of oriental tobacco. Therefore, in order to improve the quality of the tobacco produced, work must be done to reduce the nicotine content of the leaves through breeding and genetic improvement processes to significantly reduce its content in the leaves, which in return is reflected in the quality of the tobacco [18].

3.5 Sugar Content in Leaves (%)

Analysis of variance Table 5 shows that there are significant differences between the tested genotypes, and this is evidence of genetic divergence between the parents regarding the sugar content of the leaves.

The leaves of the P_3 parent plants contained the lowest percentage of sugars compared to the other parents (6.56%), followed by the P_1 parent, whose leaves gave a sugar content of (8.54)%, followed by the P_2 parent (9.91%). As for the hybrids, it The P_1P_3 hybrid gave leaves with a sugar content of (7.86)%, followed by the P_1P_2 hybrid (9.11)%, and the P_2P_3 hybrid (10.67)% came first.

The P_2P_3 hybrid can be used to obtain tobacco plants with a high content of sugars, which means obtaining tobacco plants of high quality. This hybrid resulted from the father P_2, which contains a high content of sugars, and who in turn was able to pass on the genes responsible for this trait to the hybrid that shared with it.

The value of the non-additive genetic action variance components was higher than the value of the additive genetic action variance components, as both of them reached (1.37 and 1.32) respectively, which confirms that the sugar content of leaves is subject to the control of non-additive genetic action, as it gave the ratio between σ^2GCA/σ^2SCA is a value smaller than one (0.48). This result agreed with the findings of researchers Bai et al. [19] in his study of the sugar content of tobacco leaves, where this trait was inherited under the control of non-additive genetic action.

The type and quality of tobacco are determined by analyzing some chemical indicators, such as the content of nicotine and sugars in the leaves [18], and sugars have a direct role in the taste and palatable smell of tobacco [20], thus giving better characteristics to the consumer while smoking. Therefore, the sugars content in the leaves is seen as having a positive effect for the smoker [21-25].

4. CONCLUSION

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

1) Analysis of variance shows that there are significant differences between the different genotypes for all trait (leaf length, leaf width, specific leaf weigh, nicotine and sugar content in leaves), and this indicates genetic divergence between the parents included in the hybridization program for studied traits.
2) The additive gene action dominated the inheritance leaf width.
3) The non-additive gene action dominated the inheritance of leaf length, specific leaf weigh, nicotine and sugar content in leaves.

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.

REFERENCES

1. Reitsma MB, Kendrick PJ, Ababneh E, Abbafati C, Abbasi-Kangevari M, Abdoli A, Abedi A, Abhilash ES, Abila DB, Aboyans V, Abu-Rmeileh NM. Spatial, temporal, and demographic patterns in prevalence of smoking tobacco use and attributable disease burden in 204 countries and territories, 1990–2019: A systematic analysis from the Global Burden of Disease Study 2019. The Lancet. 2021; 397(10292):2337-2360.
2. Pscheidt A, Lemos RC, Souza JC, Oliveira VB, Souza AM, Pádua JMV. Feasibility of using tobacco hybrids of the Dark tobacco type. Genetics and Molecular Research. 2021;20(4):1-4.
3. Aleksoski JA, Milenkoski ZJ, Korubin AT. Inheritance of yield-related morphological characteristics in F1 tobacco hybrids. Journal of Agricultural Sciences (Belgrade). 2023;68(2):187-200.
4. Carvalho BL, Lewis R, Pádua JMV, Bruzi AT, Ramalho MAP. Combining ability of standardized indices for multi-trait selection in tobacco. Ciência e Agrotecnologia. 2021;45.
5. Singh RK, Chaudhary BD. Biometrical methods in quantitative genetic analysis. New Delhi: Kalyani Publishers., Ludhiana; 1985.

6. Pearce RB, Brown RH, Blaser RE. Photosynthesis of alfalfa leaves as influenced by age and environment. Crop Science. 1968;8:677-680.
7. CORESTA. Recommended Method N 39: Determination of the purity of nicotine and nicotine salts by gravimetric analysis-Tungstosilicic acid method. CORESTA Inf. Bull. 1994;94(3-4):87-90.
8. Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances. Analytical Chemistry. 1956; 28:350-356**.**
9. Griffing B. Concept of general and specific combining ability in relation to diallel crossing systems. Australian J. Bio, Sci. 1956;9(4):463–93.
10. Singh P, Cheema DS, Dhaliwal MS, Garg N. Heterosis and combining ability for earliness, plant growth, yield and fruit attributes in hot pepper (*Capsicum annuum* L.) involving genetic and cytoplasmic-genetic male sterile lines. Scientia Horticulturae. 2014;168:175–188.
DOI:10.1016/j.scienta. 2013.12.031.
11. Seyyed-Nazari R, Ghadimzadeh M, Darvishzadeh R, Alavi SR. Diallel analysis for estimation of genetic parameters in oriental tobacco genotypes. Genetika, 2016;48(1):125-137.
12. Swarup S, Cargill EJ, Crosby K, Flagel L, Kniskern J, Glenn KC. Genetic diversity is indispensable for plant breeding to improve crops. Crop Science. 2021;61(2): 839-852.
13. Hadid, Maha Lutfi. Estimating some genetic parameters for crop traits and components in varietal and specific cotton hybrids (*Gossypium spp* L.), Scientific Journal of King Faisal University (Basic and Applied Sciences), Volume Fifteen, Issue One; 2014.
14. Bharathi Y, Jaffarbasha S, Manjunath J. Line × tester analysis for yield and quality characters in Natu tobacco (*Nicotiana tabacum* L). Electronic Journal of Plant Breeding. 2020;11(03):765-768.
15. Reslan N, Hassan K, Ihab A. Study of quantitative and qualitative traits of half diallel crosses of some tomato varieties, Department of Horticulture, Faculty of Agriculture, Tishreen University; 2008.
16. Hassan, Ahmed Abdel Moneim. Basics of plant breeding. Arab Publishing and Distribution House. 1991;682.
17. Camlica M, Yaldiz G. Analyses and evaluation of the main chemical components in different tobacco (*Nicotiana tabacum* L.) genotypes. Grasas y Aceites. 2021;72(1):e389-e389.
18. Tong Z, Fang D, Chen X, Jiao F, Zhang Y, Li Y Xiao B. Genome-wide association study of leaf chemistry traits in tobacco. Breeding Science. 2020;70(3):253-264.
19. Bai PP, Babu KS, Gayathri NK, Sarala K, Chandrasekhar C. Genetic variability, correlation path analysis for cured leaf yield and its components in Bidi Tobacco (*Nicotiana tabacum* L.); 2021.
20. Nagai A, Yamamoto T, Wariishi H. Identification of fructo- and malto-oligosaccharides in cured tobacco leaves (*Nicotiana tabacum* L.). Journal of Agricultural and Food Chemistry. 2012;60: 6606-6612.
21. Banožić M, Jokić S, Ačkar D, Blažić M, Šubarić D. Carbohydrates—Key players in tobacco aroma formation and quality determination. Molecules. 2020;25(7): 1734.
22. Akkati, Vineeth Reddy, Charupriya Chauhan, SK Verma, Omkar Mane. Exploring Genetic Variability Parameters for Yield and Its Contributing Traits in Lentil (*Lens Culinaris* L. Medik)". Journal of Experimental Agriculture International. 2024;46(7):1-7.
Available:https://doi.org/10.9734/jeai/2024/v46i72550.
23. Umamaheswar, Naderla, Suvendu Kumar Roy, Avijit Kundu, Lakshmi Hijam, Moumita Chakraborty, Shubhrajyoti Sen, Bimal Das, Ratul Barman, S. Vishnupriya. Genetic Variability and Character Association Studies in Diverse Rice (*Oryza Sativa* L.) Genotypes for Agro-Morphological Traits in Terai Region of West Bengal. Journal of Advances in Biology & Biotechnology. 2024;27(5):805-20.
Available:https://doi.org/10.9734/jabb/2024/v27i5843.
24. López-Caamal A, Tovar-Sánchez E. Genetic, morphological, and chemical patterns of plant hybridization. Revista

Chilena de Historia Natural. 2014 Dec; 87: 1-4.

25. Levy A, Milo J. Inheritance of morphological and chemical characters in interspecific hybrids between Papaver bracteatum and Papaver pseudo-orientale. Theoretical and Applied Genetics. 1991 Apr;81:537-40.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/3666