ВЗАИМОВРЪЗКА МЕЖДУ СЕИТБЕНАТА НОРМА, ПРОДУКТИВНОСТТА НА КУТИЙКИТЕ И ВЛИЯНИЕТО НА КОМПЛЕКСНИТЕ УСЛОВИЯ ВЪРХУ ДОБИВА ОТ СЪНОТВОРЕН МАК (*PAPAVER SOMNIFERUM L.*)
INTERRELATIONSHIP BETWEEN SEED AND CAPSULE YIELD AND YIELD CONTRIBUTING CHARACTERS IN OPIUM POPPY (*PAPAVER SOMNIFERUM* L.)

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Резюме

Целта на настоящото проучване е да се получи информация относно асоциирането на различни представители в една колекция от 49 генотипа сънотворен мак, както и да се определят признаци, които имат най-пряко въздействие върху добива от семена и добива от кутийки. Наблюдавани са значителни положителни корелации между добива от семена, височината на растенията, броя на централните кутийки, диаметъра на основната кутийка, теглото на главната кутийка, теглото на семената в кутийката и добива от кутийката. Добивът от семена е положително и значително свързан с добива от кутийки от растение. Най-висока корелация е открита между семената и добива от кутийки от растение (p = 0.817). Пат коефициент анализът показа, че добивът от кутийки и теглото на семената от основната кутийка имат най-голям положителен пряк ефект върху добива от семена от едно растение (p = 0.567 и 0.564, съответно). Противоположно, теглото на семената от основната кутийка има значително отрицателно пряко въздействие върху добива от кутийки от растение. Добивът от семена (p = 0.558), броят на кутийките за всяко растение (0,389) и диаметърът на основната капсула (p = 0.364) имат най-пряко въздействие върху този показател. Следователно тези символи може да се използват за подобряване на добива от семена и кутийки при сънотворния мак.

Abstract

The aim of this study was to obtain information on the association of different characters in a collection of 49 opium poppy genotypes, as well as to determine the traits that have the highest direct effect on the seed and capsule yield. Significant positive correlations were observed between the seed yield and plant height, number of capsules per plant, diameter of main capsule, weight of main capsule, weight of seed of main capsule and capsule yield per plant. The plant height, number of capsules per plant, number of stigma lobes, diameter of main capsule and seed yield per plant were positively and significantly associated with the capsule yield per plant. The highest correlation was detected between the seed and capsule yield per plant (r=0.817). A path coefficient analysis showed that the capsule yield per plant and the main capsule seed weight had the highest positive direct effect on the seed yield per plant (p=0.567 and 0.564, respectively). On the contrary, the main capsule seed weight had a significant negative direct effect on the capsule yield per plant. The seed yield per plant (p=0.558), number of capsules per plant (0.389) and diameter of main capsule (p=0.364) had the highest direct effect on that trait. Consequently, these characters could be used for the improvement of the seed and capsule yield in opium poppy.

Ключови думи: сънотворен мак, добив.
Key words: opium poppy, yield.

INTRODUCTION

Opium poppy (*Papaver somniferum* L.) is an important medicinal plant known to produce more than 80 alkaloids (Weid et al. 2004). This plant is highly valued by pharmaceutical industries as a source of phenantherene alkaloids including morphine, thebaine and codeine (Facchini and Park, 2003; Facchini et al., 2005; Singh et al., 1995a; 1999; Pushpangadan and Singh, 2001; Ziegler et al., 2005; Hevel et al., 2001; Shukla and Singh, 2004). Recently the global trends show increased demand for opium alkaloids and its derivatives. In addition, poppy seed has highly valuable nutritive value. It contains 35-50% edible oil (Nergiz and Qtles, 1994; Sharma et al., 1999) with high amounts of linoleic acid (up to 68%) and up to 24% high quality proteins (Singh et al., 1990, 1995b). The oil cake with a high percentage of digestible protein (32.5%) is used as a concentrate in animal feed (Verma et al., 1999; Pushpangadan and Singh, 2001).

The present trend in opium breeding is to create a variety for specific alkaloids on one hand and to develop variety for two purposes: opium and seed yield. The success of any breeding program relies mainly on a selection of material from available germplasm collections, information on genetic base, and inheritance of characteristics, so that appropriate breeding techniques may be undertaken (Singh et al., 2004). The working material should be tested for inter-relation of quantitative characters with seed and capsule yield, which represents a pre requisite in establishing suitable breeding program.

Several studies are reported on correlations and indirect association of characters (Sharma et al., 1981; Shukla and Khanna, 1987; Singh and Khanna, 1993; Singh et al., 2003; Singh et al., 2004), however such information based on germplasm of diverse geographical and genetic origin, including genotypes from Macedonia are lacking.

MATERIALS AND METHODS

The material assessed in this study comprised of 49 opium poppy genotypes, including Macedonian land races and advanced breeding lines as well as genotypes of different geographic origin. These genotypes were evaluated in randomized block design with 2 replications during 2010-2011 at experimental field near Skopje, Macedonia, situated between 42°05'N latitude and 21°23' E longitude, 402 m above sea level. Each plot consisted of two rows, 2 m long, with spacing of 30 cm between rows and 5 cm within row. During the vegetative cycle different growth stages were observed, as well as the morphology of the genotypes. After the harvest, ten plants from each plot were collected for analyses of quantitative traits. Agro-morphological traits were described according to UPOV descriptor (1999).

The observations were recorded on plant height (cm), number of capsules per plant, number of stigma lobes, diameter of stigmatic disc (cm), diameter of main capsule (cm), length of main capsule (cm), weight of main capsule (g), weight of seed of main capsule (g), seed yield per plant (g) and capsule yield per plant (g).

The plot mean value per replication for each trait was used for statistical analysis. The correlation coefficients were estimated using R statistical package. Path coefficient analysis was performed by partitioning the phenotypic correlation into direct and indirect effect according to Dewey and Lu (1959).

RESULTS

Phenotypic correlation coefficients between 10 analyzed characters are presented in Table 1. Plant height showed significant positive correlation with number of stigma lobes and seed yield per plant. Weight of main capsule was positively and significantly associated with weight of seed of main capsule (0.954). These two traits also exhibited highly significant correlation with the diameter and the length of the main capsule, as well as with the seed yield per plant. Similar findings were reported by Singh and Khanna (1993), Singh et al. (2003) and Singh et al. (2004). Number of capsules per plant and diameter of the main capsule were positively associated with both seed yield (0.628 and 0.562, respectively) and capsule yield per plant (0.805 and 0.485, respectively), which indicates the importance of the number of capsules that will be formed and their size for increasing seed and capsule yield in opium poppy. A significant positive correlation between seed yield per plant and capsule yield per plant (0.817), and their significant association with the other analyzed quantitative traits suggest that selection of components jointly or individually may enhance the productivity of seed and capsules. The above findings are in agreement with the results of Saini and Kaicker (1982), Singh et al. (2003) and Singh et al. (2004).

The advantage of path analysis is that it permits the partitioning of the correlation coefficient into its components. The first component is the path coefficient (or standardized partial regression coefficient) that measures the direct effect of a predictor variable upon its response variable. The second component is the indirect effect(s) of a predictor variable on the response variable trough the predictor variables (Dewey and Lu, 1959). The proportion of variance in the response variable explained by the variance in the predictor variable (partial coefficient of determination) is the square of the path coefficient.

Path coefficient analysis has been performed in order to obtain and interpret information on the nature of interrelationships between seed yield (Table 2) and capsule yield (Table 3) in opium poppy and yield related characters. All investigated characters had positive direct effect on seed yield (Table 2), except for diameter of capsule which showed nonsignificant negative effect on seed yield. This could not

Table 1. Association between quantitative characters in opium poppy

Quantitative characters	Plant height	Number of capsules per plant	Number of stigma lobes	Diameter of stigmatic disc	Diameter of capsule	Length of capsule	Weight of main capsule	Weight of seed of main capsule	Seed yield per plant
Number of capsules per plant	0.045								
Number of stigma lobes	0.403**	0.224							
Diameter of stigmatic disc	0.179	0.132	0.364*						
Diameter of capsule	0.194	0.039	0.279	-0.063					
Length of capsule	-0.084	-0.242	-0.305*	-0.025	0.192				
Weight of main capsule	0.186	-0.142	0.054	-0.061	0.849**	0.441**			
Weight of seed of main capsule	0.255	-0.141	0.012	-0.012	0.711**	0.437**	0.954**		
Seed yield per plant	0.290*	0.628**	0.161	0.077	0.562**	0.195	0.569**	0.581**	
Capsule yield per plant	0.199	0.805**	0.351*	0.003	0.485**	-0.092	0.257	0.181	0.817**

Table 2. Pathways of association between seed yield per plant and its associated characters in opium poppy

Character	Direct effect	Indirect effect via						Correlation coefficient
		Plant height	Number of capsules per plant	Diameter of capsule	Weight of main capsule	Weight of seed of main capsule	Capsule yield per plant	
Plant height	0.045		0.012	-0.043	0.019	0.144	0.113	0.290
Number of capsules per plant	0.272*	0.002		-0.009	-0.014	-0.080	0.457	0.628
Diameter of capsule	-0.221	0.009	0.011		0.087	0.401	0.275	0.562
Weight of main capsule	0.102	0.008	-0.039	-0.188		0.539	0.146	0.569
Weight of seed of main capsule	0.564*	0.011	-0.038	-0.157	0.098		0.103	0.581
Capsule yield per plant	0.567**	0.009	0.219	-0.107	0.026	0.102		0.817

be seen from the simple correlation coefficients because it was strongly covered by the positive indirect effect of weight of seed of main capsule and capsule yield per plant. These two characters had highest direct effect on seed yield (0.564 and 0.567, respectively).

Considering capsule yield per plant in the analyzed poppy population (Table 3), only weight of seed of main capsule had negative direct effect on capsule yield, which was masked by the positive indirect effects of the seed yield, diameter of capsule and weight of main capsule. Seed yield per plant had highest direct positive effect on capsule yield (0.558), which is in relation with the results of Jain et al. (2005). On contrary, Singh et al. (2004) observed negative direct path between these two traits. The positive association between seed and capsule yield indicates the possibility for selection of genotypes combining these traits, which will contribute to the total plant productivity. The other characters that have positive direct effect on seed and

Table 3. Pathways of association between capsule yield per plant and its associated characters in opium poppy

Character	Direct effect	Indirect effect via						Correlation coefficient
		Plant height	Number of capsules per plant	Diameter of capsule	Weight of main capsule	Weight of seed of main capsule	Seed yield per plant	
Plant height	0.055		0.017	0.070	0.042	-0.146	0.162	0.199
Number of capsules per plant	0.389**	0.002		0.014	-0.032	0.081	0.351	0.805
Diameter of capsule	0.364**	0.011	0.015		0.191	-0.409	0.314	0.485
Weight of main capsule	0.225	0.010	-0.055	0.309		-0.549	0.317	0.257
Weight of seed of main capsule	-0.575*	0.014	-0.055	0.259	0.214		0.324	0.181
Seed yield per plant	0.558**	0.016	0.244	0.204	0.128	-0.334		0.817

capsule yield can be considered to be effective as selection criteria for their improvement in opium poppy.

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