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REQUIREMENTS TO SESAME (*SESAMUM INDICUM* L.) CULTIVARS BREEDING FOR MECHANIZED HARVESTING

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Abstract

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In 2004-2006, a cultivar trial was carried out with 22 Bulgarian sesame lines with indehiscent capsules, tested for 17 morphological and biological indexes such as components of seed production and suitability for mechanical harvesting. It was found that seed yield had a significant positive correlation only with the total number of capsules in a plant and duration of vegetation period. The indexes of stem height, lower and middle stem thickness, number, length and height of branches and capsules on them, related to the suitability of sesame plants for mechanical harvesting, did not correlate directly with the number of capsules per plant and did not affect the formation of seed yield. The higher the stem, the longer the branches, and the larger the number of empty capsules on the top and the total biomass of the plants, while the number of branches and height at first branch from soil surface decreased. This combination of stem indexes did not completely satisfy the requirements and parameters of the mechanized harvesting model without losses.

Combining these contradictory requirements in the breeding of highly productive sesame cultivars with indehiscent capsules adapted to mechanize harvesting, can be achieved with reasonable compromise and balance by optimizing plant height and related indexes at the expense of increasing the number of branches and capsules on them.

Key words: sesame, *Sesamum indicum* L., mechanized, harvesting

Introduction

Sesame cultivars grown all over the world have dehiscent capsules; therefore, 99% of the fields are harvested manually. The USA, Venezuela, South Korea and Bulgaria have been working seriously on complete mechanization of sesame harvesting and threshing. In different methods of mechanized harvesting as two-phase swathing, direct harvesting and threshing or shocking (without harvesting), seed loss in dry weather is significant - 60 - 70 % and even bigger after rainfalls (Langham and Wiemers, 2002; Georgiev, 2000; 2002; Georgiev and Stamatov, 2005). The substantial costs of manual harvesting and the seed losses in mechanization are the main reason to look for a solution by breeding. This requires the development of a new type of cultivars with indehiscent capsules. They have to be characterized with high productivity, early ripening, disease resistance and good seed quality as well as satisfy the high requirements of mechanized harvesting, which is a new direction in breeding.

Is it possible to combine both requirements of this direction of sesame breeding in the new cultivars with indehiscent capsules? We found little and contradictory information about the achievements of breeding activities in the new direction in literature.

This article intends to investigate the combination of morphological and biological indexes of Bulgarian sesame lines with indehiscent capsules in view of the requirements for high yield and suitability for mechanized harvesting.

Material and Method

In 1987, a breeding program was compiled at the IPGR – Sadovo for the development of a new type of sesame cultivars with indehiscent capsules, suitable for mechanized harvesting (Georgiev, 2000, 2002). According to the criteria, indexes and parameters of this type, the cultivars should have an upright habitus with a limited number of branches, strong and lodging resistant stem. In order to decrease the losses in mechanized harvesting, the height at first branch and pod should be 25 – 30 cm from soil surface. Capsules should be closed at the time of harvesting but should open easily during threshing and release all seeds without visible damage in order to prevent deterioration of product quality and decrease of germination rate of seeds.

The above obligatory requirements to the morphological indexes of the sesame type intended for mechanized harvesting by combine should come in a package with high yields of 150–200 kg/da, short vegetation period of about 85-90 days for the conditions of Bulgaria, disease resistance and high fat and protein content of seeds.

For this purpose, in 1989 a sesame sample No. 08710 with indehiscent capsules was imported by the Russian Scientific Institute of Oil-Bearing Plants, Krasnodar, Russia. It was propagated and included in the hybridization program with other Bulgarian sesame cultivars and lines. As a result of the program, Georgiev (2002) announced that there were stable sesame lines with indehiscent capsules developed in Bulgaria. Of them, 22 perspective lines of 6 crosses were included in cultivar trials for the study of productivity and suitability for mechanized harvesting in 2004-2007. Every year, 20 plants from each line (5 plants of 4 replications) were collected from the cultivar trials before harvesting for testing and biometrical measurements for 17 indexes. There was a hailstorm in 2005 during mass flowering and seed formation of plants included in the cultivar trials and in 2007 they were destroyed by a flood during germination and resowed later far beyond optimal timing. For this reason, data on biometric measurements are available for 2005 and 2007, those with great deviations being not included in the analysis of the results. The table presents phenotypic correlation coefficients, calculated on the basis of average data on biometric measurements in 2004 and 2006 that had optimal climatic conditions for sesame development.

The studied morphological parameters, related to stem, branches and capsules, are treated as components of seed production. The most important of them for the yield are – total number of capsules in the plants, number of capsules on the main stem and branches, capsule density measured as their number on 1 cm of stem, number of empty capsules at the top of the stem and seed weight in one capsule (g). The following morphological indexes for mechanized harvesting were included in the study – plant height (cm), branch number and length (cm), height at first branch (cm) and base and middle stem thickness (cm), all related to stem strength and lodging resistance. The following biological indexes were included – seed yield (kg/da), days to 50% flowering and duration of vegetation period (days). Calculations were performed on a computer with Statistic Edition 97 software. The interpretation of results and correlation rate between the indexes were based on Genchev (1968).

Results and Discussion

Correlation coefficients are given in Table 1. The indexes of importance to breeding should be statistically significant, therefore the analysis of results was

Table 1

Correlation coefficients between some components and seed yield in sesame lines with indehiscent capsules, average for 2004 -2006

Indexes Yield components	Total umber of capsules	Number of capsules along the main stem	Number of capsules on the branches	Density of capsules	Stem top with empty capsules, cm	Empty capsules on the top, number	Weight of seeds in a pod, g	Days to 50% flowering	Duration of vegetation period, days
Seed yield per plant	**0.59**	0.15	0.35	-0.05	-0.35	-0.29	0.34	0.08	**0.50**
1. Plant height, cm	-0.39	**0.45**	-0.34	**-0.46**	0.41	**0.63**	0.04	-0.30	-0.22
2. Stem thickness at base, cm	0.32	0.37	0.03	-0.33	-0.31	-0.05	0.05	-0.40	0.41
3. Stem thickness in the middle, cm	0.15	0.38	-0.06	-0.38	-0.30	0.00	0.08	-0.38	0.29
4. Number of branches	**0.70**	-0.35	**0.71**	0.37	-0.37	-0.40	**-0.47**	0.41	0.07
5. Branch length, cm	0.03	0.41	-0.08	-0.25	0.21	0.38	-0.36	**-0.54**	-0.16
6. Height at first branch, cm	-0.07	**-0.61**	0.16	0.40	**-0.44**	-0.14	0.03	**0.54**	-0.22
7. Height at first capsule along the main stem, cm	0.21	**-0.65**	0.42	**0.43**	-0.26	-0.16	-0.17	**0.46**	-0.17
8. Height at first capsule on branches, cm	0.07	0.35	-0.05	-0.03	**0.44**	**0.54**	**-0.48**	-0.41	-0.12
9. Total number of capsules		0.25	**0.65**	-0.06	-0.21	-0.17	**-0.48**	0.06	0.29
10. Number of capsules along the main stem			-0.15	-0.76	0.28	0.36	-0.03	-0.36	0.34
11. Number of capsules on the branches				0.17	-0.14	-0.15	**-0.45**	0.42	-0.03
12. Density of capsules					-0.21	-0.33	-0.08	0.07	-0.42
13. Empty capsules on the top, number						**0.67**	0.02	-0.39	-0.13
14. Stem top with empty capsules, number							-0.14	-0.30	-0.27
15. Weight of seeds in a pod, g								-0.14	0.28
16. Days to 50% flowering									-0.14
17. Duration of vegetation period, days									

Number of lines N=22

* Correlation coefficients were proved at P = 0.05 and bolded

limited to correlations with rate of significance P=0.05%.

The most important index, i.e. seed yield in Bulgarian sesame lines with indehiscent capsules was in positive correlation only with the number of capsules on the plant (r = 0.70) and the duration of the vegetation period (r = 0.70). All indexes that were positively interrelated and accounted for the increase of capsule number in the plant also contributed to the increase of seed yield.

The total number of capsules in a plant was in positive correlation only with the number of capsules on branches (r = 0.60) and the duration of vegetation period (r = 0.70) and strong negative correlation with the number of capsules on the main stem (r = -0.80). This means that seed yield of Bulgarian sesame lines with indehiscent capsules is formed almost entirely by the number of capsules on the branches and requires longer vegetation period for the ripening of capsules and seeds.

In order for the capsules to be more densely positioned on the stem, the stem top should be shorter and with smaller number of empty pods (r =-0.60) because there is a negative correlation between those two indexes.

The morphological indexes related to the requirements for mechanized harvesting of sesame such as stem height and base and middle stem thickness, number, length and height at branches and their pods were not related to the number of capsules in a plant and seed yield formation. However, they were directly related to plant biomass, loss reduction during harvesting and related costs.

Plant height was strongly positively related to branch length (r=0.80) and had a significant positive correlation with the number of empty pods on the top (r =0.60), therefore the combination of these indexes was undesirable. Plant height was in negative correlation with the number of branches (r = -0.80), height at first branch (r = -0.70) and height at first pod on the main stem (r = -0.60). Therefore, the increase of stem height lead to the increase of branch length and total biomass, the number of branches decreased and branch nodes were closer to soil surface. The combination of these indexes did not satisfy the requirements of loss reduction in mechanized harvesting.

Stem thickness at the base of the plant, which related to stem strength and its resistance to lodging, was in highly significant positive correlation only with middle stem thickness (r = 0.92) and vice versa.

Number of branches was in positive correlation with the height at first branch (r=0.70) and first capsule on the main stem (r = 0.70) and negative correlation with branch length (r = 0.80). With the increase of branch number, they started growing at a higher location on the main stem, so did the first pod, which did not correspond to the requirements of the type for reduced loss mechanized harvesting.

Branch length was in strongly expressed negative correlation with the height at first branch (r = 0.80) and the height at first capsule on the main stem (r = 0.80).

The height at first branch was in positive correlation with the height at first pod on the main stem (r = 0.90) and in negative correlation with the height at first pod on branches (r = -0.60).

The height at first capsule on the main stem was in significant negative correlation with the height at first capsule on the branches and vice versa (r = -0.60).

The combination of morphological and biological indexes in the studied sesame lines with indehiscent capsules allowed for mechanical harvesting but did not satisfy completely the high requirements of the type for mechanized harvesting. Breeding should continue in the future for the elimination of unwanted indexes and parameters and improvement of plant structure for its complete adaptation to the requirements of mechanized harvesting as well as the combination of these indexes with the ones that increase the number of pods in a plant.

In order to increase seed yield in the breeding of future lines with indehiscent capsules, the selection of parent couples and hybrid plants should be limited to types with lower stem and more and shorter branches instead of higher plants. This will increase the number and density of capsules in a plant, hence, seed yield and decrease total biomass of the plants, therefore, less energy costs for mechanized harvesting. Thus the requirements of both directions in breeding for the development of high yielding cultivars adapted to mechanized harvesting will be satisfied.

Due to the lack of research and publications of authors from other countries, we can not compare or discuss our results. We assume that future publications may show some differences due to the great diversity in this field, the indexes and parameters of breeding and most of all the combination of morphological indexes of created lines and cultivars with indehiscent pods.

Conclusions

·Seed yield is in significant positive correlation only with the total number of pods in a plant and the vegetation period.

·The indexes of stem height, base and middle stem thickness, branch and capsule number, length and height from soil surface do not correlate directly with the formation of seed yield. The increase of stem height leads to the increase of branch length, number of empty pods on the top and total plant biomass, on the one hand and decreases the number of branches and branch node height from soil surface. The combination of these indexes does not correspond completely to the requirements and parameters of the type for mechanized harvesting without losses.

·The combination of morphological and biological indexes in the breeding for new high yielding sesame cultivars with indehiscent capsules, adapted to mechanize harvesting, can be achieved by optimizing plant height and related indexes at the expense of increasing branch and pod number on them.

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