Selection of Ideal Characters of Oil-bearing Sunflower Self-lines

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Utilization of sunflower heterosis was begun in 1975 in China. Though the work was started late, but a complete set of A-line, B-line, and restoring line had been formed and the first hybrid sunflowers, such as Liaokuiza No. 1, Baikuiza No. 1, Shenkuiza No. 1, and Neikuiza No. 1, had been bred in the early eighties because of Chinese breeders' efforts, and now some new hybrid sunflowers have also been released for production.

With their significant superiority in yield and integrated characters (plant height, head form, uniformity in flowering and ripening time) superior over normal sunflower varieties, hybrid sunflowers had found favour in farmers' eyes since their being put into production, among which early-ripening sunflower hybrids were especially welcomed and were developed rapidly in Northeast, Northwest, North China and Inner Mongolia and their multiple cropping acreage had amounted to about 200 thousand hectares in Xinjiang of China during 1991-1995, because their vegetative period were short (about 85-90 days), their yields were high, and they were suitable for multiple cropping in wheat-growing areas with 160 days of frost-free period, thus doubling the crop in a year and increasing the oilseed production without competing for land with grain crops.

In order to develop our sunflower production and breeding, and to screen out high-yielding and excellent sunflower hybrids as early as possible, the breeding of parent self-lines of high quality should be put on the first place.

Most characters of sunflower are quantitative and liable to environmental influence, hence direct selection based on phenotypes will be interfered seriously, so intensive selection should be made on major characters heavily relevant to the yield to effect genetic improvement and aim-oriented breeding. The criteria for selection of ideal characters of oil-bearing sunflower are as following:

1. Compatibility and quantity of pollen

Seed setting rate of self-lines is intimately relevant to the self-compatibility of their pollen. Self-lines with high seed setting rate are not only easy to maintain and to identify, but also are able to give hybrids which possess high self fertility. Fick (1983) reported that there was great difference in the ability of self pollination between sunflower selfs and hybrids in absence of honey-bees, and self compatibility in some types of selfs is near to perfection. His findings showed that the seed yield of the hybrids derived from the self-lines

with high self compatibility is normally higher than that of the hybrids derived from the self-lines with low compatibility in the presence of less bees or when the climatic conditions are not advantageous to the bees' activity. Identification and selection of pollen compatibility of self-lines, therefore, is very important.

Pollen quantity in father self-lines, being dominant genetically, has tremendous influence on F1. Pollen quantity of F1 derived from the combination of self-lines with less pollen is near to that of fathers, hence impairing the seed yield. Fathers with less pollen fail to supply enough pollen for mothers, resulting in low seed setting rate, therefore, attention must be paid to the selection and breeding of self-lines with more pollen and higher self compatibility. According to the selection criteria, our academy has bred in succession Liao-68, s7601-6-2, s7601-2, 7602-15, 8411, 8425 which as father self-lines possess great quantity of pollen, high compatibility and perfect restoration of fertility.

2. Head size, weight per 1000 grains and seed form

Head size is determined by its diameter and the yield per plant is determined by seed number per head and weight per 1000 grains. Generally, the head of more size gives more seeds, hence the plant will yield more if the weight per 1000 grains is also high. Heritability of head size appears not high: it is mere 0.15 based on Schuster's research (1964). According to the result of research on character manifestation and regularity of sunflower heterosis carried out in our academy during 1978-1980, average heterosis in the three years is 47.0% and 15.9% respectively for seed number per head and head diameter, and the heterosis of the yield per plant amounted up to 75.9% , indicating that the heterosis of head diameter and seed number per head determine the heterosis of yield. The ideal selection criteria, therefore, are the single head with diameter of 18-24 cm, and the seed of long form with more than 70 grams of weight per 1000 grains.

3. Head form and inclination

They are direct relevant to the yield. Head form varies greatly because of different genes resulting in five types of convex, less convex, flat, less concave and concave forms. Based on the actual observations and research, it is most desirable to select flat or less concave head. In these two types of head, the rationally distributed vascular bundles can supply normal nutrition to central seeds, thus reducing empty and unfilled grains, while in convex and concave heads the form abnormality would change vascular bundles, and the resulted physiological handicaps would impair nutrition supply to central seeds, hence increasing the number of empty and unfilled seeds and decreasing the yield.

Head inclination is the angle between head and the main stem

and is classified in six classes. Head form and head inclination are intimately relevant between them so they are put together to discuss. For inclination class 0-3 and 5, the seed on the head of all five types are too exposed to noxious birds, and they may be eaten up when pest birds are too many because of the lack of self-protection. The convex heads in class 0-5 are apt to the adhesion of pathogenic spores. The pit on the back of the convex head parallel to the ground is usually filled with rain, hence it is liable to rot because of early infection of pathogens. The class 4, therefore, is most ideal as to the selection of head inclination, because that the seeds on flat or less concave head belonging to class 4 are relatively concealed themselves from noxious birds, furthermore, flat or less convex back of the head of these two types could not retain water, which helps to alleviate disease damage and guarantee the normal yield of seed.

4. Plant height

The output per unit area is determined by the yield per plant and cultivation density, therefore, desirable are the dwarf hybrids resistant to lodging and suitable to be grown in the population of high density, thus light energy and nutrients could be utilized to the greatest extent and the superiority of population output would change into the highest output per unit area. Liaokuiza No. 2, bred in our academy, characterized of early maturation (about 95 days for the crop sown in spring and 90 days for that sown in summer), dwarf plant (plant height of 1.60 m) and sturdy stem is grown on large area mechanically in Hami and Changjizhou Prefectures of Xinjiang, and , with the population density of 75,000-99,000 per hectare which overwhelming that of 4500 per hectare for normal cultivars, it increased yield twofold. In 1990, a record-marking yield of 5250 kg had been achieved in a hectare planted to Liaokuiza No. 2 in spring in Changjizhou Prefecture. It could give a yield of 3300-3750 kg per unit area when grown as a succeeding crop in multiple cropping in Hami area of Xinjiang - the main sunflower-growing area.

Plant height in F1 exhibits strong heterosis and breeders home and overseas have made great deal of report about it. Marinkovic (1982) pointed out that inheritance of plant height appeared to be superdominant, dominant and partially dominant. Based on result of our academy, heterosis of plant height averaged 18.4% in three years, and the heterosis decreased to 10% in 1980 because of use of more dwarf fathers and 13 negative heterosis appeared, indicating that heterosis of plant height is significantly influenced by that of parents though it is strong.

Lerqlercq (1968) in his research showed that average plant height of hybrids is more than that of their parents by 46 cm, therefore, the self-lines are needed whose plant height is less than the ideal by about 40 cm in order to breed out the hybrids which are in accordance with the ideal pattern. For hybrid

Liaokuiza No. 2, the plant height of its father self-line is 120 cm, and that of its mother self-line is 105 cm, for hybrid Liaokuiza No.3, the two values are 130 cm and 110 cm, and in F1 of these two hybrids plant height are 160 cm and 150 cm, more than the average value of their parents by 47.5 cm and 30 cm respectively, indicating that the ideal plant height should vary between 95-130 cm for the self-lines to be selected in order to breed out the hybrids with plant height of about 150 cm.

5. Kernel rate and oil content of kernel

To gain high oil output from unit area is another important, and indeed, the ultimate aim in the selection and breeding of oilbearing sunflower hybrids. The oil content of sunflower seed consists of the kernel rate and the oil content of kernel which are correlative positively.

The sunflower hybrids whose oil content of seed amounts up to 56-60% have been bred in some advanced breeders such as Soviet Union and United States so far, while the hybrids bred in China yield seeds of which oil makes up only 38-40%. As to the oil content of kernel, there is not great difference between that of the hybrids bred in our academy (45.71-55.67) and that of foreign hybrids for commercial production (40.33-56.62), but the kernel rate of most foreign hybrids is more than 70%, and even the hybrids whose kernel rate is more than 80% have been bred in Soviet Union and United States, which explained why Chinese sunflower hybrids yield less oil -- high percentage of husk and low percentage of kernel. Therefore, we must put the emphasis on the selection and breeding of the self-lines with low rate of husk and high rate of kernel.

The conclusion deduced from the research on the oil content is that the oil content of mother self-lines is most fundamental for the breeding of the hybrids with high percentage of oil. Miller et al (1982) carried out a regression analysis with multiple variables and showed that 50.5 percent of variation in the oil content of hybrid seed could be attributed to the variation of the oil content in the seed of mother self-lines, indicating that mother self-lines possess high heritability.

According to the research carried out by Stoyanova et al (1971) on heterosis of oil content, the estimate of oil content of hybrid seed is above the average of parents' oil content by 5%, which is similar to our findings about the relationship between oil content of hybrids' seed and that of their parents' seed bred in our academy. For example, the oil content of mother self-lines Liaokuiza No. 2 and Liaokuiza No. 3 is 40% and 41.1% respectively, and that of their father self-lines is 28% and 25%, while the two hybrids' oil content is 38% and 39.30%, higher than the average of their parents' by 4% and 6.21% respectively. Based on the analysis of this kind of relationship it could be concluded that heterosis of oil

content of hybrid seed would be restricted by fathers' low oil content even if mothers' oil content is high, therefore, the selection of father self-lines with high oil percentage of seed is also important. According to the present level and advance of sunflower breeding in China, the selection criteria for ideal kernel rate and oil content of kernel should be 75-80% and 55-65% respectively.

6. Disease resistance

Disease resistance is a main limiting factor for sunflower yield. Among more than 90 sunflower diseases occurring in the world are more than 30 diseases which attack sunflower cultivars, and the main threat to sunflower production in China is sclerotium rot, downy mildew, black spot, stem rot, grey rot and broomrape parasitism. Specifically, sclerotium rot and downy mildew trend to outbreak more and more seriously. In 1990, of 30.6 thousand hectares of sunflower crop more than 90 percent was infested by sclerotium rot and 17.3 thousand hectares of crop totally failed in Hulunbeir League of Inner Mongolia, while the disease attacked 50 percent of 67.3 thousand hectares of sunflower crop in Xing'an League. Because of the damage caused by sclerotium rot, the acreage planted to sunflower decreased greatly in Inner Mongolia, for example, from more than 180 thousand hectares in 1985 decreased to 73 thousand hectares in 1988 only in Hulunbeir League, Xing'an League and Chifeng area; and the average yield of 1500 kg per hectare in 1985 decreased to 660 kg in 1988 in Wengniute Banner, Chifeng city.

The most effective way to alleviate the disease damage to sunflower is the selection and breeding of resistant varieties for production, so the resistance breeding is imperative. Chinese breeders of sunflower have begun the work in this aspect and made advance. The high-yielding hybrid Liaokuiza No. 2 has been proved to be high resistant to downy mildew and black spot, therefore, it has been introduced and grown on large area in many Provinces and municipalities such as Xinjiang, Ningxia, Gansu, Inner Mongolia, Shanxi and Beijing.

It should be pointed out that little result has been achieved in breeding of resistance to sclerotium rot so far. There are some reasons about it , among which the first is the lack of resistant sunflower cultivars as the resource of breeding, and similarly, main wild sunflower species are also short of the resistance. A lot of literatures and data showed that various inoculation methods failed to give positive results. Some countries reported that sunflower genotypes high tolerant even resistant to sclerotium rot had been found, cultivars and hybrids derived from them, however, did not behave satisfactorily under production conditions. It has been proven that the susceptibility of sunflower cultivars to sclerotium rot varies to some extent (Pogorleckiy, 1970), but the

resistance is still too low. The resistance may be enhanced by recurrent selection, and, as the research carried out by Soviet breeders showed, the susceptibility of sunflower cultivar Peredovik (Pioneer) had decreased twofold as a result of recurrent selection and test on phenotypes for three years.

In Soviet Institute of Oilbearing Crops named after Pustovoit (VNIIMK), extended and thorough researches on sclerotium rot resistance appeared in the selections of the combination Helianthus tuberosum X VNIIMK 8931 had resulted in a sunflower variety resistant to nine strains of Sclerotinia sclerotiorum, and its resistance degree amounted to 80-90%, which is reflected in its resistance to sclerotium rot occurring in the head and the upper part of stem.

Despite the great difficulty in the research of resistance to sclerotium rot tremendous breakthrough had been made in the world. In order to select and identify as early as possible Chinese sunflower self-lines resistant to sclerotium rot the test on the resistance should be put on the first place. Firstly, general inoculation test should be carried out on small area, and, secondly, sunflower varieties and hybrids adopted and to be adopted in production should be arranged in the area seriously infected by sclerotium rot such as Inner Mongolia on an integrated plan to examine. Recurrent selection on the identified varieties with high resistance or tolerance is the promise for getting the ideal self-lines.