Relationship between hybrid productivity and main physiological index under summer cropping sunflower

Cui Liangji, **Xin Huajun**, **Liang Guozhan** and **Wang Dexing**
Oil Crop Institute, Liaoning Academy of Agricultural Sciences
No. 84 Dongling Road, Shenyang 110 161 P.R. China

Abstract : Under summer cropping in 1997, the leaf area index of the sunflower production showed great differences among hybrids. The maximum index was 2.23 for sunflower hybrid LKZ3. The average net photosynthetic rate was 8.97 g/m2.d., not only higher than soybean in C3 crop (3.88 g/m2.d), but also higher than corn (7.6-7.76g/m2.d) in C4 crop. Therefore, sunflower is a crop of high photosynthetic rate. The sustained time of leaf area for sunflower population is an important factor to have an effect on physiological yield. A great positive relation was shown between the photosynthetic time, physiological yield and economic yield for all different sunflower hybrids.
Key-words : sunflower, physiological yield, photosynthetic rate, summer cropping

Sunflower crops were widely grown in many countries due to its characteristics of satine-alkali tolerance, poor soil tolerance, drought resistance, and wide adaptability. Sunflower hybrids yield was influenced by many factors, but photosynthesis was the major one. On basis of the 1997-result, we studied three physiological indexes of photosynthetic character and potential suck as leaf area, photosynthetic rate and photosynthetic potential on yield production of sunflower hybrid.

1. Materials and methods

1. Varieties and experimental design

Experiments were conducted at the Liaoning Academy of Agricultural Sciences in 1997 and 5 varieties were used based on different sources, type and maturity.

Table 1 : Testing Variety (Hybrids)			
Variety	Maturity	Type	Source
Lkz no.3	early	oil	China
Lkz no.5	middle	oil	China
ACAOBEL g 10	middle	inter	Argentine
Lkz no.1	middle	seed	China
ALINKA	middle	oil	France

The field trial was planted on June 10, 1997, and the precious crop was soybean. The soil had middle level of fertility. The soil was turned up after the autumn harvest with 3,000kg of farmyard manure applied. 10 kg of phosphorous fertilizer was drilled on each plot at the time of sowing. During the squaring period, 15 kg urea were applied.

The experiment was laid out in a block design with 3 replications. Plots 5 m long consisted of single rows 0,6 m apart. 16 rows per plot. Plant density was 2222 plants per mu.

1.2 Sampling method

Sampling started from seedling stage, 15 days for early growing period and 10 days for later growing stage interval to get sample. A total of sampling times was 7 times for early maturity varieties and 8 times for middle maturity varieties. Sample size was 5 plants at the squaring period and 3 plants after squaring period.

1.3 Test item and method

Leaf area index : each time to get sample, leaf areas were measured by using the method of weighing leaf, and then calculated. The total photosynthetic potential of whole period of duration is the photosynthetic potential of summation of individual period of duration.

Photosynthetic potential was calculated using the following formula :
where : L1 = leaf area index of first time tested
L2 : leaf area index of second time tested
T1 : time of first tested
T2 = time of last tested.

Estimating of the biomass over the whole period of duration : when sunflower seeds at physiol ogical ripening, three plants were taken from field plot, and weighed after plants had dried with natural conditions, then the biomass was converted per mu.
Grain yield : when seeds reached the physiological maturity stage, twenty floral discs were harvested from the field per plot, dried and the grain yield per mu was calculated.

2. Results and discussion

2.1. Leaf area index and yield

A reasonable leaf area is an important physiological index for organic matter production and accumulation of crops. A proper increase in leaf area index is a key way to increase sunflower yield. As a result of different arrangements of individual plants in the field, the leaf area index has to vary between 3 - 4 to intercept and capture 95% of sunlight (3). In 1997, the leaf area was tested for five sunflower hybrids in the experimental field of Liaoning Acad. of Agric. Sciences and we could describe developmental tendencies. The results appear on Table 2 and Fig. 1.

Table 2. Leaf area index of the sunflower hybrids collected over the specimen period (1997)

Collect time LAI Hybrid	17	27	37	47	28	68	77	87	Days of emergence to physiological maturity
LKZ3	0,085	0,69	1,99	2,23	2,10	0,67	0,32	0	71
LKZ1	0,110	1,10	2,41	3,87	3,58	2,94	2,38	0,60	85
Alinka	0,090	0,80	2,03	3,01	2,05	1,67	0,98	0,39	80
LNZ5	0,072	0,71	1,99	2,79	3,24	2,51	1,98	0,52	84
Acaobe 1910	0,090	0,68	1,98	2,74	3,10	2,31	2,01	0,61	88

Fig. 1. Leaf Area development tendency for different Sunflower hybrids (1997)

From the result from Table 2 and Fig. 1, we see that the leaf area increasing tendency showed no difference for all varieties of sunflower before 30 days /seedling. After 30 days, the leaf area index of early maturity varieties was lower all along the whole growing stage comparing with middle maturity varieties. The total biomass of early maturity varieties was also lower because of the short period of duration. For early maturity varieties, cultivation, increasing plant density and leaf area index properly in order to capture more sunlight will increase crop biological yield and economic production.
The Figure also shows that the absolute value of leaf area index for Liaokeza No 1 was higher, and its biological yield was higher also.
For sunflower, the leaf area index was not the bigger, the better. Saugier (3) reported that k value of sunflower population was between 0,6 and 0,9. Hernandez and Orioli (3) found that between different sunflower hybrids, K value varied between 0,72 and 0,99. The previous result shows that sunflower population had not received light enough to pass through. E. Zaffaroni (3) considered that the leaf area index was between 3,4 - 3,7, the population could capture quite good sunlight, decrease photosynthetic rate, thereby reducing the dry matter and grain production. Therefore, in order to increase the leaf area index, we need to pay attention to develop the variety with compact plant type and resistance to disease, so that to get higher yield.

2.2. Mean net photosynthetic rate and grain yield.
Sunflower if one of C3 crops with more dry matter production. AH II pee Ba et al (4) reported that maximum photo-synthetic rate could reach 120 to 130 mg Co≤dm-2h-1. Hu, c.H; (5) for high yield maize at the blooming stage, maximum photosynthetic rate was 100,48 mg Co2 dm-2h-1. Zhang, x...z.. (6) reported that for soybean, photosynthetic rates changed between 15 and 30 mg Co2 dm-2h-1. Comparing with other crops, sunflower has a higher activity of photosynthesis.

Table 3. Average net rate of photosynthesis and yield for different sunflower hybrids during growing

Hybrids	Average net rate photosynthesis g/m≤.d	Physiological yield (kg/ha)	Kernel yield (kg/ha)
LKZ3	11,13	8713,5	2352,0
LKZ5	7,57	9906,0	2593,5
ACAOBEL910	8,32	11200,5	2244,0
LKZ1	8,80	14479,5	4074,0
ALINKA	9,02	9664,5	1821,0
Average	8,97		

Table 3 shows that mean net photosynthesis rate was tested in five sunflower hybrids.
From Table 3, we see that there were significant differences between mean net photosynthetic rates of hybrids. For example, LKZ3, which is an early maturity variety, had the highest photosynthetic rate (11,13 g/m≤) and LKZ5, which is a middle maturity variety, had the lowest rate. The difference between two varieties was 3,56.

On the basis of Ma H.T (3) report, the net photosynthetic rate over the whole growing stage was 4,89 - 5,57 g/m≤.d in sorghum, and 3,88 g/m≤ .d in soybean. However, our experimental result shows that mean value of net photosynthetic rate of all growing stages was 8,97 g/m≤.d in 5 sunflower hybrids that summer planted in 1997. From the result, we note that sunflower is a higher light utilization ratio crop among field crops, because sunflower grows and develops rapidly and has much accumulation in unit time.

Raising the net photosynthetic rate is a key way to increase economic production of sunflower, but the higher photosynthetic rate must pass through the process of photosynthetic matter transmission, distribution and storage to play a high yield role. If the crops do not have an economic character, stress resistance, as well as good methods of cultivation, only concentrate on high photosynthetic rate could not reach the goal.

2.3. Photosynthetic potential energy and yield.

Generally speaking, the longer period of duration of sunflower varieties which were planted under same cultivation and within the limit of frost free days often produced higher yields. An early maturity variety LKZ3 had higher net photosynthetic rates ; its biological yield was lower than other middle maturity varieties because of the lower leaf area index and short growing period.

Table 4. Photosynthetic time and yield for different sunflower hybrids.

Hybrids	Photosynthetic time potential g/m≤.d	Physiological yield (kg/ha)	Kernel yield (kg/ha)
KZ3	52199,42	8713,5	2352,0
LKZ5	87223,59	9906,0	2593,5
ACAOBEL 910	89738,18	11200,5	2244,0
LKZ1	109708,16	14479,5	4074,0
ALINKA	71422,36	9664,5	1821,0

Fig. 2 Relation between photosynthesis time and physiological yield as also kernel yield (1997)

Table 4 shows the data of photosynthetic potential, and yield in different varieties of sunflower on basis of the information of biological yield, economic yield and photosynthetic potential, we set up regression model as given below. (Fig.2) $y = 3069 + 0{,}0945x$, $r=0{,}9003$

Thus, we can see that the correlation between total of photosynthetic potential and biological yield have reached significant levels. The total of higher photosynthetic potential means bigger photosynthetic area, longer photosynthetic time and more accumulated photosynthetic matter, and of course the biological yield was clearly higher.

The equation of regression between seed yield and photosynthetic potential was as follows : $y = 241{,}5 + 0{,}02854$, $r = 0{,}724$

The result shows that the coefficient of correlation between photosynthetic potential and seed yield was lower than that of between photosynthetic potential and biological yield in sunflower plant populations.

The photosynthetic potential is an important physiological index of sunflower production. In order to obtain higher photosynthetic potential, the flowing word should be done first. To select suitable variety to grow and plant in the light of local weather conditions, second, to determine a suitable plant population and cultivated measure according to the condition of soil, fertilizer and worse condition. The overall plan is to enlarge the leaf area index and prolong the photosynthetic time of plants. Otherwise, an over density of plants could lead to a negative correlation to photosynthetic potential.

2. Conclusion and Discussion

Many factors have an influence on sunflower hybrid yields, but the photosynthesis is a major factor.
The higher or lower leaf area index has a direct effect on biological yields of sunflower hybrids.
As compared with medium varieties, the early variety LKEZ3 has a lower leaf area index and short growing period, as well as a lower biomass. It is thus clear that biological yields are increased by enlarging leaf area of plants, which is an important, efficient, simple and convenient method.

The mean net photosynthetic rate in sunflower was higher that that in C3 crops of soybean, wheat and so on, as well as C4 crops of maize and sorghum. Sunflower is a high photosynthetic rate crop since it has a fast growing and development, and accumulates more dry matter in unit time.

The coefficient of correlation between total of photosynthetic potential and biomass has reached a significant level. However, the coefficient of correlation in total photosynthetic potential and seed yield was significantly lower than that of photosynthetic potential and biomass, that because of the relationship of photosynthetic potential and seed yield happened by transfer rate (economic index).

From the relation of photosynthesis organ, ``souse'' and fruit set organ ``storage'' of sunflower crops, biological yield increase did not correspond to seed yield increase. Two varieties with rather similar biological yields had different seed yield, due to the difference in the economic index. Although sunflower was a higher biological yield in C3 crops, its economic index was lower as well as seed yield. Therefore, to enhance the process of the matter transferring and distribution, maintaining a rational balance in plant organ was a very important way.

Sunflower is great for using light. In order to enlarge leaf area index to get higher yields, we had to develop the erect leaf and compact plant types of sunflower hybrids.