Kazakhstan

Technical Assistance to the Sunflower Seed Sector

Study Supported Under the Japan-Europe Cooperation Fund
# TABLE OF CONTENTS

**Acronyms** .............................................................................................................................. iv

**Acknowledgments** .................................................................................................................. v

**Disclaimer** ................................................................................................................................ vi

**Introduction** .............................................................................................................................. 1

1. **Farmer training** ......................................................................................................................... 4
   1.1 Indoor training .......................................................................................................................... 4
   1.2 Field day ................................................................................................................................ 5

2. **Demonstration trials** ............................................................................................................... 8
   2.1 Demonstration test methodology and selection of sunflower seed hybrids/varieties .......... 8
       2.1.1 Information recording protocol ....................................................................................... 10
       2.1.2 Soil type .......................................................................................................................... 11
       2.1.3 Agro-meteorological conditions in the 2008 spring crop season .................................... 11
   2.2 Soil preparation and seeding ..................................................................................................... 13

3. **Analysis of trial results** .......................................................................................................... 14
   3.1 Earliness .................................................................................................................................. 14
   3.2 Yields ...................................................................................................................................... 14
   3.3 Phenological observations ........................................................................................................ 17
   3.4 Dynamics of productive humidity and water consumption .................................................... 18
   3.5 Biological characteristics and productivity ............................................................................ 19
   3.6 Oil content and productivity .................................................................................................... 19

4. **Recommended measures for improving yields** ...................................................................... 20
   4.1 Varieties .................................................................................................................................. 20
   4.2 Planting .................................................................................................................................... 20
   4.3 Weed control ............................................................................................................................ 20
   4.4 Fertilisation ............................................................................................................................... 21
   4.5 Soil tillage .................................................................................................................................. 22
   4.6 Harvesting ................................................................................................................................. 22

5. **Economic consideration of yield intensification based on the tested hybrids** ...................... 23

6. **Considerations for demonstration trials in the 2009 crop season** ...................................... 24

**Annex 1**: Details on the 2007–2008 agricultural year at the test sites .................................... 25

**Annex 2**: Characteristics of sunflower hybrids and yields, 2008 ............................................ 31

**Annex 3**: Short descriptions of certain sunflower hybrids tested in the demonstration trials in 2008 ........ 34

**Annex 4**: Training participants, presentations and materials .................................................. 42
## ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS</td>
<td>Commonwealth of Independent States</td>
</tr>
<tr>
<td>EBRD</td>
<td>European Bank for Reconstruction and Development</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>N</td>
<td>nitrogen</td>
</tr>
<tr>
<td>P$_2$O$_5$</td>
<td>phosphorus oxide</td>
</tr>
<tr>
<td>KZT</td>
<td>Kazakh tenge</td>
</tr>
<tr>
<td>TC</td>
<td>Technical Cooperation</td>
</tr>
</tbody>
</table>
FOREWORD

Sunflower oil is by far the major vegetable oil consumed in Kazakhstan. The growing consumer demand has been largely met by imports rather than local production. From 2005 to 2007, the EBRD provided loans totalling USD 26 million to Turkuaz Edible Oil Industries, a subsidiary of Savola Group, to develop its vegetable oils production business in Aktobe. Results illustrated soon that sunflower yields could be increased if farmers used new sunflower seed hybrids even under low rainfall conditions. In 2007, FAO and the EBRD, with funding from the Government of Japan, agreed to provide technical assistance to help farmers in the region increase production and processing of sunflower seed using more efficient techniques.

To ensure that the best international expertise was provided to local farmers, FAO worked together with CETIOM/Agropol to transfer know-how and provide training. Topics covered included planting, fertilization, weed control and harvesting. Sunflower seed hybrids were provided from seed companies in France and Ukraine and partners in Kazakhstan provided locally available and imported hybrids for demonstration trials. In 2008, demonstration trials were conducted in two locations in the Aktobe region and 30 hybrids from different seeds companies were tested.

ACKNOWLEDGEMENTS

This report was prepared by the Investment Centre Division of the Food and Agriculture Organization of the United Nations (FAO) under the FAO/European Bank for Reconstruction and Development (EBRD) Cooperation Programme. The Japan-Europe Cooperation Fund graciously made funds available to the EBRD for this project. The report summarises the results of a series of activities undertaken by FAO in North-Western Kazakhstan in cooperation with the EBRD and the Savola Group, its client.

The main authors of this report were Mr Dmitry Prikhodko, Economist, FAO, and Mr Alexander Nikishkov, FAO Consultant and Researcher from the Aktobe State Agricultural Research and Experiment Station. Mr Yannick Herbaudière, Mr Pierre Jouffret, Mr Frank Duroueix, Mr André Merrien and Mr Jean-Pierre Palleau from CETIOM, a French-based technical centre for oilseed crops, provided training materials and status reports. Their activities and the overall project were coordinated by Mr Jean-Louis Benassi from Prolea.

This project and report would not have been possible without the partnership and support provided by Mr Adil Kurmanaj, Deputy Director, and Mr Sagingaliy Zhuvanishev, Raw Materials Specialist of the Savola Edible Oil Plant in Aktobe, Kazakhstan.

Mr Emmanuel Hidier, Senior Economist, FAO provided overall guidance from the FAO side. Mr Mehmet Ilkin, EBRD Operation Leader for the project, and Ms Saida Abdushkurova, EBRD Analyst, coordinated the project from the EBRD side. Ms Nada Zvekic, Communications Officer, FAO, and Mr Massimo Latini, Communications Specialist (consultant), provided valuable communications support to the project.

The authors would like to thank Mr Ersain Azhibayev, Director, Department of Agriculture of Aktobe oblast, and Mr Amangos Tuleuov, Director of Stepnoye and Aktobe State Agricultural Experiment Station, for providing support and facilities for the training sessions and Mr Giovanni Adduci, Ms Eliane DiCinto, Ms Christiane Bosi, and Ms Lucia Farina for the effective administrative support rendered to the project team.
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Director
Investment Centre Division
FAO
Viale delle Terme di Caracalla, 00153 Rome, Italy
or by e-mail to: Investment-Centre@fao.org
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INTRODUCTION

Sunflower seed oil is by far the major vegetable oil consumed in Kazakhstan. Sunflower production in Kazakhstan has been relatively small compared with Russia and Ukraine, which are the other major agricultural producers in the Commonwealth of Independent States (CIS).

Despite increasing domestic demand for sunflower seed oil, there have been no increases in sunflower seed area harvested, production, and yields.

Figure 1. Sunflower seed production and yields in Kazakhstan, 2001-2007

Imports of both sunflower seeds for further processing and sunflower seed oils have increased in recent years in response to growing domestic demand. Russia is the main supplier of sunflower seeds and oil to Kazakhstan. Ukraine and Moldova are also important suppliers of sunflower seed oil.

Figure 2. Kazakhstan: Sunflower seed and sunflower seed oil imports and exports, tons

Exports and imports of sunflower seeds*

Exports and imports of sunflower seed oil**

Source: UNCOMTRADE, *HS 1206: Sunflower seeds, broken or unbroken. Source: UNCOMTRADE, ** HS 1512: Sunflower seed, safflower, or cotton seed oil.
In 2008, farmers significantly increased the area under sunflower seed in response to high oilseed prices. Official statistics report an increase from 365,000 hectares in 2007 to 570,000 hectares in 2008.

Vostochno-Kazakhstan (East Kazakhstan) and Pavlodar oblast are the major sunflower seed producing regions in the country.

Table 1. Sunflower seed area planted in 2008, '000 hectares

<table>
<thead>
<tr>
<th></th>
<th>All types of farm</th>
<th>Including:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agricultural</td>
<td>Private/individual</td>
</tr>
<tr>
<td></td>
<td>companies</td>
<td>farmers</td>
</tr>
<tr>
<td>Republic of Kazakhstan</td>
<td>570</td>
<td>183</td>
</tr>
<tr>
<td>Oblasts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akmola</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Aktoobe</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>Almaty</td>
<td>45</td>
<td>4</td>
</tr>
<tr>
<td>Atyrau</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Eastern Kazakhstan</td>
<td>259</td>
<td>75</td>
</tr>
<tr>
<td>Zhambyl</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Western-Kazakhstan</td>
<td>26</td>
<td>8</td>
</tr>
<tr>
<td>Karaganda</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Kostanai</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Kyrgyzorda</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pavlodar</td>
<td>168</td>
<td>52</td>
</tr>
<tr>
<td>Northern Kazakhstan</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Southern Kazakhstan</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td><strong>2007 total, for comparison</strong></td>
<td><strong>365</strong></td>
<td><strong>107</strong></td>
</tr>
</tbody>
</table>

Source: Statistics Agency of Kazakhstan

In 2005, EBRD provided a loan totalling EUR 18,495 million to the Savola Group, to develop its vegetable oil production business in the Aktoobe oblast of Kazakhstan. At that time, only 5,000 hectares were under sunflower seed in the Aktoobe region. As Savola increased its oilseed processing capacity, it experienced difficulties procuring sufficient quantities of sunflower seeds and began implementing various programmes with farmers, including cooperative efforts with seed and machinery suppliers to encourage farmers to grow sunflower instead of the dominant cereal crops.

In July 2007, FAO and the EBRD agreed to provide farmers in North-Western Kazakhstan with technical assistance in increasing the production and processing of sunflower seeds in the region. The objectives of the EBRD/FAO technical assistance project, implemented from July 2007 to December 2008 were:

- to train farmers in the Aktoobe and Uralsk regions on best practices for growing sunflower and generating high production yields at harvest, and educate them on sunflower seed physiology, nutrient requirements, and the latest technologies and equipment for growing and harvesting sunflower seed;
- to organise variety tests and diagnostics of productivity on experimental fields and disseminate the results of these trials among farmers in Aktoobe and Uralsk regions;
KAZAKHSTAN: Technical Assistance to the Sunflower Seed Sector

- to provide farmers with visual evidence of how different sunflower seed hybrids and varieties perform under different soil and climate conditions and to educate them on the sources of different hybrids of seed.


Under this project, in 2008, FAO utilised experts from Prolea and CETIOM and arranged the supply and delivery of sunflower seed hybrids from well-known suppliers in France and Ukraine. Two seminars (one indoors and the other one in the experimental fields) were organised in Uralsk and Aktobe regions. Although the average sunflower yield in the Aktobe region is a rather low 0.5–0.6 tonnes/hectare, some hybrids tested in the demonstration trials in 2008 showed far better yield potentials of 1.0–1.4 tonnes/hectare. It is expected that farmers who have benefited from training will increase the area under sunflower seed and improve their production efficiency.

Sunflower seed currently accounts for about 60% of the total area planted with oilseeds in Kazakhstan. As sunflower seed has become a profitable alternative crop to cereals, the sunflower seed area expanded out of the major producing areas, including into the Aktobe and Uralsk regions, largely owing to the presence of local processors. The area under sunflower seed in Aktobe region has increased from 5,000 to nearly 24,000 hectares over the last four years and farmers in the regions neighbouring Aktobe are now interested in sunflower seed production. This interest has been supported by the Savola Group, which offers competitive prices for locally produced sunflower seed.
1. FARMER TRAINING

1.1 Indoor training

An indoor training session for farmers was conducted on 29 February–1 March 2008 in Uralsk by Mr André Merrien and Mr Jean Pierre Palleau of Agropol-CETIOM. The training lasted a day and a half over a two-day period and was organised with the support of the local Department of Agriculture and the Savola Group. It covered the following major topics:

- the sunflower seed crop: the growth cycle, key periods and growth stages; yield components; soil preparation, focusing on minimum vs. conventional tillage; chemical and mechanical weed control; variety selection; planting; nitrogen, phosphate, boron, magnesium, and molybdenum fertilisation; growth regulators; and irrigation – (one presentation of 54 slides in total;)

- aspects of sunflower crop physiology: days required to reach different levels of maturity; identification of growth stages; flowering; seed filling; dry matter accumulation; leaf area establishment; dessication; efficient water use and adaptation to water shortage; photosynthesis; yield improvement; and irrigation strategy – (three presentations of 76 slides in total;)

- sunflower seed diseases

To improve efficiency for trainees, trainers, and translators, the presentations were projected simultaneously in Russian and English and participants received handouts prior to the training.

About 25 farmers and local government officials attended the training session. The participants represented very different profiles and technical levels, ranging from farmers to professional agronomists. Every effort was made to adapt the talks and presentations to a mixed audience, which proved challenging, given the very different profiles of the participants.

The participants showed great interest in all the topics covered. Debates focused on water, nitrogen (N) fertilisation and phytosanitary issues, mildew, sclerotinia, and the situation with Orobanche infestation.

The following were some of the main questions identified during the meeting:

- Is nitrogen a limiting factor for sunflower in Kazakhstan, given the uptake of 4.5 kg of N per 100 kg of seed produced?

  **Answer:** Water is so scarce that N requirements are low; application of only phosphorus oxide (P$_2$O$_5$) may be sufficient. (Note: A quick balance shows that, depending on N availability in the soil, the maximum yield obtainable is 1–1.5 tons/hectare).

- Why do farmers apply the Agrostimulis* (a cocktail of fertilisers including macro- and micronutrients) at the four to six leaves stage?

  **Answer:** We do not believe that this practice is very useful.

1.- The original training schedule included a session for farmers in Aktobe, but this could not be conducted owing to a severe and extended snow storm on 26 February–1 March in the Aktobe region.

*.- a locally available plant growth regulator
What is the optimum plant density? Could slightly increased plant density lead to earlier and more homogenous maturity? What is the effect of plant heterogeneity on the line? Is sunflower able to compensate?

*Answer:* Trials have established an optimum plant density of 5.5–6 plants per square metre: farmers need to be advised more clearly about this. (Note: We do not agree that reducing the density is a good strategy under water shortage; when density is too low, the root system does not exploit the soil in the inter-row and plants remain green at maturity, delaying harvest. It also produces bigger heads with a greater sterile spot in the centre and delays maturity).

How can the risk of *Orobanche cumana* in sunflower be managed in Kazakhstan?

*Answer:* There are only two ways of reducing this risk: i) through genetic resistance, although the durability of this is low given the multiple types of races; and ii) through the use of sunflowers that are resistant to herbicides (IMI or sulfonylureas). Contact should be made with BASF, Pioneer, and Dupont, which have representatives in Kazakhstan.

Questions were asked about the structure of the settlement.

*Answer:* The structure of the settlement could be improved by reducing the distance between rows (from 70 to 55–60 cm), increasing plant density (by 15%), and reducing the speed of the drill (from 8–10 to 5–6 km/hour). This would lead to more regular plant distribution in a row. No more than five plants should be settled per linear metre.

Questions were asked about the duration of the cycle and climatic considerations.

*Answer:* The maximum length of the growing cycle is 100–110 days in the concerned areas of Kazakhstan, which require very early varieties. Regarding water availability (soil reserves and rains), from crop management descriptions, it seems that more than 200 mm is available for the crop, mainly from soil reserves (100–150 mm). Sunflower is grown during a period of very low rainfall (18–42 mm according to available data); more precise data are needed about the exact distribution of rains during the cycle and in particular how they are positioned with regard to the flowering stage.

Other issues discussed included: What kind of driller is used in France? What are the gross margins for sunflower (and others crops) in France compared with Kazakhstan? What is the level of auto-fertility for hybrids in France? What role do bees have in sunflower fecundation?

### 1.2 Field day

The field day training was delivered in two parts in Stepnoye, Aktobe oblast, on 25 September 2008:

- a condensed version of the indoor training, focusing on fundamentals, particularly for trainees who had not been able to attend the indoor training in March;

- an outdoor training session at the demonstration plots, focusing on soil preparation, nutrition and fertilisation, plant density, weed control, plant protection, water requirements, yield, harvesting aspects, and variety behaviour, based on evaluation of the demonstration trials.

About 40 participants attended this training, most of whom were farmers, with a few farm agronomists from Aktobe Experimental Station.

The indoor session lasted for about two hours and had the following main speakers:
- Mr Vladimir Livochenko, Aktobe oblast Department of Agriculture;
- Mr Amangos Tuleulov, Director of Stepnoye Farm and Aktobe Experimental Station;
- Mr Sagingaly Zhuvanishev, Turkuaz/Savola;
- Mr Alexander Nikishkov, FAO Consultant, Aktobe Experimental Station;
- Mr Franck Duroueix and Mr Pierre Jouffret, CETIOM, France;
- Mr Yermagambetov Agybay, Syngenta Seeds;
- Mr Nurken Assanov, official distributor for Dupont and Pioneer.

The representatives of the Ministry of Agriculture and Turkuaz covered sunflower seed production trends and Mr Nikishkov presented 2007–2008 meteorological data and information on sunflower phenological development (Annex 1). The representatives of seed companies presented summary information on their varieties.

The Agropol-CETIOM presentation

The Agropol-CETIOM presentation focused participants’ attention on planting, fertilisation, weed control, and harvesting:

- Mr Jouffret emphasised the importance of sowing early and using very early varieties (100-day varieties, when possible). These two conditions are necessary for making the best use of the water stored in the soil during autumn and winter and for ensuring that harvesting is carried out under good conditions. Mr Jouffret said that the trials carried out this year in Kazak conditions were very important in helping to identify the varieties that were best adapted to local conditions in terms of earliness and productivity. He also stressed the need to ensure an even distribution of plants in rows to avoid yield losses; trials have shown that a 20% shortage of plants leads to a 10% decrease in yield.

- The need to apply mineral fertilisers was noted. Fields should be fertilised to improve wheat and sunflowers yields in the near future. Applications of nitrogen and phosphorus are required to avoid deficiencies. The micronutrient boron is also very useful for sunflowers, particularly under warm and dry conditions.

- Mr Duroueix noted that weed control is very important, especially under the dry weather conditions of Kazakhstan, where sunflowers and weeds compete for water and mineral nutrients. French trials have demonstrated that yield losses are higher under dry conditions (e.g. sandy soils) than when there is no water stress (e.g. deep clay soils). He also announced that a new and efficient technology for weed control – herbicide-tolerant varieties – will likely soon be available from major seed suppliers.
- **Harvesting**: Combine harvesters must be properly adjusted to avoid losses. Mr. Duroueix had observed several non-harvested fields where the sunflowers had overmatured. The consequences of late harvesting are losses to wind and birds. He described the best time for harvesting as being when the sunflower head is a yellow to brown colour, a few leaves are still green, and the stalk colour is beige.

The field training that followed the indoor seminar and was carried out in the demonstration field by Mr. Alexander Nikishkov was especially beneficial in demonstrating the benefits of using early and very early hybrids with concrete examples.

All the presentation materials and the list of participants are provided in English and Russian in Annex 4 to this report.
2. DEMONSTRATION TRIALS

2.1 Demonstration test methodology and selection of sunflower seed hybrids/varieties

Demonstration trials of 32 approved and new hybrids were conducted in May–October 2008 to provide farmers with visual evidence of performance under Kazak conditions. Of the 29 hybrids approved by the Kazakhstan State Register of Plant Varieties, the following seven were tested in demonstration trials: Zarya variety (approved in 1969), Sibisrkiy 91 hybrid (1995), Printasol hybrid (2007), Arena hybrid (2008), NK Rocky, Sanluca, PR 63 and A90 hybrids (conditional approval in 2008, final approval expected in 2009). The following hybrids were obtained by FAO, CETIOM, and Savola from seed companies and used for testing and demonstration trials under the project (Table 2): A-90, A-91, Ant, Arena, Dariy, ES Isabella, Etyud, Frankasol, Harkovskiy-49, Kiy, Kovcheg, Kronos, Leila, Mas 94c, Mas 97A, Milonga, NK Rocky, Oskil, Pacific, Poglyad, PomarRM, Printasol, RA 1001735, RA 1001753, RA 1004049, Sanay, Sanluca, Sibirskiy 91, Siver, Svitoch, Yason.

The trials were carried out at Stepnoye LLC in Kargalinskiy district and Kyzyl Zhar PK in Martukskiy district, Aktobe region by the Savola Group representatives and Mr Alexander Nikishkov, researcher from the Aktobe Agricultural Research and Experiment Station.

The trials were conducted using standard farm equipment. No fertilisers or plant protection chemicals were applied, in accordance with prevailing farm practices in the region. The protocols for these trials were discussed by FAO and CETIOM experts after their missions to Kazakhstan in September 2007 and February 2008 and were closely monitored and followed by Mr Nikishkin and the Savola Group.

*Kyzyl Zhar demonstration plot*
Table 2 lists the sunflower hybrids tested at each location, the number of rows and the time of planting. All the varieties/hybrids were tested at both demonstration sites, apart from Sibirsky 91, which was planted at Kyzyl Zhar only, and NK Rocky and Zorya, which were planted at Stepnoy only, owing to limited seed availability and/or technical issues at the time of planting. All hybrids were planted in 4, 12, or 24 rows in one replication at each location.

Table 2. Demonstration plots at Stepnoye and Kyzyl Zhar

<table>
<thead>
<tr>
<th>Commercial name of hybrid</th>
<th>Company/country of origin</th>
<th>Registered in Kazakhstan (year)</th>
<th>Stepnoye, number of rows</th>
<th>Kyzyl Zhar, number of rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-90 Pioneer</td>
<td>Pioneer</td>
<td>2008 provisional; 2009 final (pending)</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>A-91</td>
<td>Pioneer</td>
<td></td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Ant</td>
<td>Ukraine/Yuriev Institute UAAN, Kharkov</td>
<td></td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Arena</td>
<td>Syngenta</td>
<td>2008</td>
<td>12</td>
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<tr>
<td>Dariy</td>
<td>Ukraine/Yuriev Institute UAAN, Kharkov</td>
<td></td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>ES Isabella</td>
<td>Euralis/France</td>
<td></td>
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<td>12</td>
</tr>
<tr>
<td>Etyud</td>
<td>Ukraine/Yuriev Institute UAAN, Kharkov</td>
<td></td>
<td>12</td>
<td>12</td>
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<tr>
<td>Frankasol</td>
<td>Monsanto</td>
<td></td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Harkovskiy-49 (Har.-49)</td>
<td>Ukraine/Yuriev Institute UAAN, Kharkov</td>
<td></td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Kiy</td>
<td>Ukraine/Yuriev Institute UAAN, Kharkov</td>
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<td>Kovcheg</td>
<td>Ukraine/Yuriev Institute UAAN, Kharkov</td>
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<td>Kronos</td>
<td>Ukraine</td>
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<tr>
<td>Leila</td>
<td>Euralis/France</td>
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<tr>
<td>Mas 94c</td>
<td>Maisadour/France</td>
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<td>12</td>
</tr>
<tr>
<td>Mas 97A</td>
<td>Maisadour/France</td>
<td></td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Milonga</td>
<td>Maisadour/France</td>
<td></td>
<td>24</td>
<td>12</td>
</tr>
</tbody>
</table>
Sunflower hybrids were planted at Stepnoye LLC on 7 May 2008, according to the following scheme:

Area of plot:  
- 24 rows, 16.8 m x 125 m = 2,100 m²  
- 12 rows, 8.4 m x 125 m = 1,050 m²

Planting at Kyzyl Zhar PK was done in May 26 in accordance with the following scheme:

Area of plot (depending on seeding rate):  
- 12 rows, 8.4 m x 250 m = 2,100 m²  
- 4 rows, 2.8 m x 250 m = 700 m²

A short description of some of the sunflower seed hybrids tested in 2008 is provided in the Annexes (in Russian only).

### 2.1.1 Information recording protocol

The following data recording protocol was established for demonstration trial tests and observations:

- determination of the soil humidity before seeding, at the flowering stage, and before sunflower harvesting in different soils layers (at 10 cm–1 m depth);  
- phenological observations of plant growth and development;  
- calculation of plant density based on seeding rates and plant density before harvesting;  
- record of meteorological data in each phase of sunflower growth;  
- determination of sunflower biometric values;  
- determination of the humidity of sunflower seeds at full ripeness;  
- record of sunflower seed yield from each demonstration plot;  
- determination of oil content in the seeds (at the Savola laboratory).
2.1.2 Soil type

Soils at the Stepnoye LLC test plot are dark-chestnut, solonetzic, and medium loamy. Humus content is about 2.8%, with low phosphorous and potassium content.

Soils at Kyzyl Zhar PK are southern chernozem (black soil). These are medium loamy with humus content of 3.6%, medium phosphorous and high potassium contents.

2.1.3 Agro-meteorological conditions in the 2008 spring crop season

The Aktobe region (oblast) is situated in North-Western Kazakhstan. Its climate is characterised by great temperature contrasts: cold winters and hot summers with low precipitation levels. The sum of the effective temperatures over 10 °C is 2,600–2,800 °C. About 127–160 mm of precipitation falls during this period and average annual precipitation is 135–320 mm. The frost-free period is 127–140 days per year. Relative air humidity during daylight hours in the summer drops to 30–35%, and there are 13–15 days of intensive hot winds over the warm period, with southern and south-eastern winds dominating.

Information on the major meteorological indicators for 2008 is provided in the Annexes and is based on the data from the Martukskiy and Badamshinskiy meteorological centres of the Aktobe Regional Meteorological Station.

In 2008, precipitation was not distributed evenly through the growing season. Substantial precipitation deficit was observed in autumn, with only 44.4 mm compared with a normal level of 77 mm. The average daily air temperature in autumn was 5 °C and was lower than normal in the winter. At 69.5 mm, however, winter precipitation levels were within the norm, based on long-term data for the winter months.

The main meteorological factor in 2008 was that 42–44% of total precipitation fell in spring, totalling 136.5–155.2 mm, compared with a normal rate of 82 mm. The average daily air temperature in spring was 5.5 °C higher than that established from long-term data. The warmest months were March and April.

At Stepnoye LLC, the summer month with the most favourable hydrothermal conditions was June. Average daily temperatures were similar to the long-term norm and, at 40.4 mm, precipitation exceeded
the normal rate. July’s precipitation was similar to the long-term norm and August was arid and hot. Precipitation over the vegetative period was 324.6 mm, 27.6 mm more than the long-term average. The average daily temperature exceeded the long-term average by 1.8 °C.

Information on meteorological conditions at Stepnoye and Kyzyl Zhar is provided in the Annexes.

At Kyzyl Zhar PK, the monthly distribution of precipitation was similar to that observed at Stepnoye LLC, but the general precipitation level was higher. Cumulative precipitation over the year was 352.9 mm, 55.9 mm higher than the long-term average. In general, the hydrothermal conditions for the 2007–2008 agricultural year can be considered average for sunflower plant development.
**2.2 Soil preparation and seeding**

The pilot tests on sunflower hybrids at Stepnoye LLC and Kyzyl Zhar PK were performed on fallow fields. Spring harrowing was carried out on 23–28 April 2008 to break the upper soil layer and prevent moisture evaporation. Tooth harrowing to a depth of 6–8 cm was performed before seeding with the SPCh-6 seeder. The speed of the seeder was 5 km/hour. The seeding rate was 64,900 seeds per hectare or 4.5 seeds per linear metre. Rows were spaced 70 cm apart.

At Stepnoye LLC, harrowing and two inter-row cultivations were conducted after the sunflower emerged, using a KRN-4.2 harrow. Pre-emergence harrowing and one inter-row cultivation were performed at Kyzyl Zhar PK. Mineral fertilisers and herbicides were not applied, in line with prevailing farming practices in the region. Yields were assessed/measured on 8 October at Kyzyl Zhar PK and on 29 October at Stepnoye LLC, using the direct combining method (SK-5 combine) and the sunflower harvesting equipment (header) produced by MTS Traktor JSC.
3. ANALYSIS OF THE TRIAL RESULTS

3.1 Earliness

Due to the late planting date at Kyzyl Zhar PK (May 26), this site was particularly interesting for testing the earliness of sunflower seed hybrids. When the trial field was visited on 23 September, late maturity and significant variation among different hybrids planted at the same time were observed. This made it possible to identify hybrids with the potential for planting without significant risk in Aktobe region.

As the trial field in Stepnoye was sown in early May, all the hybrids were mature by 23 September. Early and very early hybrids/varieties are well adapted to the Aktobe region; the following hybrids should be considered:

Early varieties: Sanluca, PomarRM, A90, Es Isabella, and Milonga.
Very early varieties: A91, Printasol, Kharkiv-49, Kiy, and others.

Other varieties (middle–early) should be considered only for planting in late April–early May or if they have specific characteristics such as herbicide or disease tolerance. According to the information available, the first herbicide-tolerant hybrids to become commercially available to farmers in Kazakhstan will be Express (Pioneer/Dupont) and Eurolighting/Intervix (BASF), which are middle–early varieties (as is the Sanay hybrid tested in 2008).

3.2 Yields

Although the average sunflower yield in the Aktobe region is 0.5–0.6 tonnes/hectare, some hybrids tested in the demonstration trials in 2008 showed yield potentials of 1.0–1.4 tonnes/hectare. The average yield in Kyzyl Zhar was 1.1 tonnes/hectare, compared with 0.7 tonnes/hectare at Stepnoye. This is owing to the higher soil moisture and weight of 1,000 seeds at Kyzyl Zhar.

Figure 3. Average yields at Stepnoye and Kyzyl Zhar in 2008, ´00 kg/ha

* Average yield = simple average.

Median yield = mid-point of a set of yields; half the yields at the location had values that are greater than the median, and half had values that are less.

Table 3. Summary of yield results at Stepnoye and Kyzyl Zhar in 2008
The following varieties performed well at both locations: PomarRM, Milonga, Sanay, Es Isabella, Leila, Sanluca, A90, Arena, Kiev, and Siver. There was no evident link in the trials between hybrid/variety earliness and yields, apart from very early varieties, which did not perform well under dry conditions. Detailed yield results for each hybrid tested are provided in Figure 4 and Annex 2.

From the varieties that are currently commercially available, A90, Sanluca, and Arena showed the best performance. The very early varieties (100-days) did not appear to perform well under dry weather conditions. It will be necessary to continue identifying very-early and early hybrids in the future. 100-day varieties can be sown in the last decade of May and still ripen before harvesting time. The use of early hybrids is justified by the need to harvest the crop before the first freezing temperatures in October (see following photos).

<table>
<thead>
<tr>
<th>Location</th>
<th>Indicator</th>
<th>Results, (’00 kg/ha)</th>
<th>Description/explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyzyl Zhar</td>
<td>Average yield, 100 kg/ha</td>
<td>11.10</td>
<td>Simple average</td>
</tr>
<tr>
<td>Kyzyl Zhar</td>
<td>Median yield, 100 kg/ha</td>
<td>10.25</td>
<td>Half the yields were greater than this, and half were less</td>
</tr>
<tr>
<td>Kyzyl Zhar</td>
<td>Mode yield, 100 kg/ha</td>
<td>10.10</td>
<td>The most frequently occurring yield in the range of yields</td>
</tr>
<tr>
<td>Kyzyl Zhar</td>
<td>Standard deviation of yield,</td>
<td>1.87</td>
<td>The dispersal of the yield values from the average value (the mean)</td>
</tr>
<tr>
<td></td>
<td>tonnes/ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stepnoye</td>
<td>Average yield, 100 kg/ha</td>
<td>7.01</td>
<td>Simple average</td>
</tr>
<tr>
<td>Stepnoye</td>
<td>Median yield, 100 kg/ha</td>
<td>6.60</td>
<td>Half the yields were greater than this, and half were less</td>
</tr>
<tr>
<td>Stepnoye</td>
<td>Mode yield, 100 kg/ha</td>
<td>6.50</td>
<td>The most frequently occurring yield in the range of yields</td>
</tr>
<tr>
<td>Stepnoye</td>
<td>Standard deviation of yield,</td>
<td>1.00</td>
<td>The dispersal of the yield values from the average value (the mean)</td>
</tr>
<tr>
<td></td>
<td>tonnes/ha</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Although A90, Sanluca, and Arena showed the best performance, farmers should follow the results of official trials in Kazakhstan and select hybrids that pass these trials and best suit their conditions for plantings, fieldwork, harvesting, and other needs. For instance, it is likely that sunflower broomrape-resistant hybrids (e.g. Leila, which was tested in the demonstration trials) will become commercially available in the near future.

The densities observed in the demonstration trials were 40,000–60,000 plants/hectare, which was sufficient to obtain an estimated yield of 1.5–2 tons/hectare in the dry climatic conditions of Kazakhstan. Great attention should be paid to the proper adjustment of seeding equipment to avoid doubles or losses of plants in a row. Under large-scale farming conditions in Kazakhstan, sowing equipment seems to be a limiting factor. Even the most modern six-row sowing units are not well suited to planting sunflower on fields of 400 hectares and more.

Two low-cost ways of completing sunflower seed sowing as quickly as possible should be considered after local trials:

- increasing the number of row units (to 8–10) on existing drills, with a corresponding switch to more powerful tractors to enable sowing at greater speed (7–10 km/hour). Row spacing of 60–70 cm would allow harrowing between the rows;
- testing wheat drills for sunflower sowing, as few drills are already adapted to this purpose; however, to avoid uneven seed distribution in rows, row spacing would have to be reduced to 30–40 cm, which would make harrowing between rows impossible and chemical weed control methods essential.

The yield results of the tested varieties are largely explained by their potential resistance to harsh weather conditions (heat stress and moisture deficit) rather than their yield potential. PomarRM is a good illustration of this. In the demonstration trials, this relatively old variety from Western Europe surpassed the new hybrids in terms of yields, while other old varieties (registered between 1980 and 1990) such as SF 013 (Frankasol) and SC 082 (Printasol) did not produce high yields. It is believed that PomarRM performed well at both locations because of its tolerance to harsh weather, which can be explained by the depth and strength of its root system.
The results of the trials in 2008 suggest that the new hybrids performed better than existing approved hybrids at both locations. For example, the median yields of new varieties were 36%–51% higher at Kyzyl Zhar and 22%–56% higher at Stepnoye. The lowest-yielding of the top five new hybrids, Leila, performed better (14.1 tonnes/hectare) than the best performing existing variety, A-90 (13.2 tonnes/hectare).

The full list of hybrids used and yields produced at both locations is presented in Annex 2. The results of the trials and recommendations were summarised and disseminated to the farmers through the leaflet presented in Annex 3 (in Russian only).

### 3.3 Phenological observations

Sunflower varieties and hybrids were divided into four groups: very early-maturing, in 100–104 days; early-maturing, in 111–114 days; middle–early-maturing, in 116–118 days; and middle–late, in 120–126 days. Harkovskiy 49 hybrid was included in the early-maturing group.

The sunflower sprouted 14 days after planting on 7 May, with average daily temperature of 14.2 °C. The seeds sown on May 25 emerged after 12 days, with average daily temperature of 17.2 °C. The amount of precipitation in the period between seeding and emergence was 21.4–48.5 mm.

Favourable weather conditions for sunflower growth and development were observed between the emergence and flowering stages. Average daily temperatures were 19.2–23.9 °C; precipitation at Stepnoye LLC was 71.3 mm and at Kyzyl Zhar PK 75.2 mm. Information on the weather conditions at the main development stages in each location is provided in the Annexes.

The critical period for sunflower in terms of moisture availability is during the flowering and seed filling stages. The period from flowering to complete ripeness of Harkovskiy 49 hybrid was 50–51 days. For the early-maturing group it was 48–51 days, the middle–early group, 49–50 days, and the middle–late group, 53–57 days. Precipitation over this period, depending on its duration, was 15.8–25.8 mm at Stepnoye LLC and 23.6–41.6mm at Kyzyl Zhar PK. In general, the sunflower’s vegetative period was characterised by relatively high average daily temperatures and insufficient precipitation. The sums of the effective temperatures over 10 °C during sunflower growth and development were as follows: for very early-maturing hybrids, 2,276–2,325 °C; for early-maturing hybrids, 2,380–2,498 °C; for middle–early hybrids, 2,404–2,538 °C; and for middle–late hybrids, 2,452–2,680 °C. At Kyzyl Zhar, seeds of the middle–late hybrids Mas 97A, Mas 94 C, RA 1004049, and RA 1001753 PK were frost-damaged (-3– -6 °C) before harvesting.

Phenological observations of its development indicate that sunflower can tolerate the impact of the air drought in Northern Kazakhstan, making it one of the most promising crops for the Aktobe region.

Detailed information on sunflower seed development stages for the different maturing rates of hybrids, and the corresponding weather information for both testing locations is provided in Annex 1.

3.4 Dynamics of productive humidity and water consumption

Sunflower is a more drought-resistant crop than cereals. It can use soil moisture that is not accessible to other crops because of its well-developed root system, which reaches depths of 150–250cm. The productive soil moisture content in the 1 m soil layer at Stepnoye LLC was 114 mm, compared with 126 mm in the southern chernozem of Kyzyl Zhar PK.

The researchers estimated total water consumption to be 228.4–249.6 mm at Stepnoye LLC and 246.9–264.2 mm at Kyzyl Zhar PK. The lack of precipitation in August resulted in maximum use of available soil moisture at the seed ripening/maturity phase.

The most effective use of soil humidity and precipitation over the vegetative period was observed in the crops of early-maturing and middle–early hybrids. Water consumption to produce 100 kg of seeds from the sunflower crops at Kyzyl Zhar PK was far lower than that at Stepnoye LLC (see the yield and water use tables in Annex 1). A high water consumption ratio indicates that the temperature regime during the
vegetative period promoted greater evaporation, moisture loss, and low nutrient supply from the dark-chestnut soil. The most efficient water consumption to produce 100 kg of seeds was observed for the hybrids PomarRM, Milonga, Leila, ES Isabella, Sanay, Sanluca, and A 90. The water consumption of these hybrids at Kyzyl Zhar PK was 17.3–20.0 mm/100 kg of seeds.

### 3.5 Biological characteristics and productivity

The biological characteristics of sunflower hybrids from different environmental and geographical origins were more diverse in the soil and climatic conditions of Stepnoye LLC. The greatest productivity was associated with PomarRM (1,021 kg of seeds per hectare) and the Syngenta Company’s Sanay hybrid (960 kg per hectare). Yields from these hybrids exceeded those from Zarya (the reference variety used for official trials in Kazakhstan) by 370 and 310 kg per hectare, respectively. Plants of PomarRM hybrid were 108 cm in height, head diameter was 13.2 cm, the mass of seeds from each head was 37.5 g, at 1,036 seeds per head, and 1,000 seeds had a mass of 36.2 g. The corresponding figures for plants of Sanay hybrid were 124 cm, 14.8 cm, 36.5 g, 892, and 40.9 g. Harkovskiy 49, Kiy, Milonga, and Leila also exceeded the performance of Zorya.

The productivity of all hybrids was higher in the southern chernozem of Kyzyl Zhar PK than at Stepnoye LLC, and their potential was more clearly demonstrated in Kyzyl Zhar PK. The yields of PomarRM hybrids and Milonga were 1,520 and 1,500 kg per hectare, respectively, which were higher than those of Sibiriskiy 91 (the reference hybrid in this demonstration trial) by 570 and 550 kg per hectare. Plants of PomarRM hybrid were 136 cm in height, head diameter was 13.7 cm, the mass of seeds from each head was 39.2 g, at 1,059 seeds per head, and 1,000 seeds had a mass of 37.0 g. Corresponding figures for plants of Milonga hybrid were 120 cm, 15.6 cm, 41.6 g, 1,134 and 36.7 g. ES Isabella, Leila, Euralis, and Sanay hybrids exceeded the standard varieties. Hybrids A90 and Sanluca also showed fairly good productivity at 1,320 and 1,280 kg per hectare. According to the seed companies, these hybrids will be listed in the State Register of Plant Varieties to be used in Kazakhstan from 2009. The reference hybrid yield was exceeded by between 200 and 260 kg per hectare by hybrids A91, Printasol (registered in 2007), and Pacific.

Annex 2 provides more information about hybrids’ characteristics and yields at both testing locations.

### 3.6 Oil content and productivity

As processors of sunflower seed face shortages of the raw material for processing, they do not yet apply premiums or discounts for the seeds’ oil content mostly to avoid discouraging farmers from producing sunflower seeds. It is likely that processors will differentiate prices based on oil content as local production increases.

High oil content was observed in seeds from the hybrids of Maisadour (50.5–52.3% oil content), Euralis (50.3–52.5%) and Ragt (49.8–52.5%) measured as a percentage of absolute dry matter. The best combinations of oil content and yield were provided by hybrids PomarRM, Milonga, ES Isabella, and Euralis (as indicated in the Table “Oil yield in Stepnoye and Kyzyl Zhar”Annex 2). Overall, weather conditions in 2008 favoured the production of seeds with a high oil content.

2.- See Table 2 for the sources of these hybrids and Annex 2 for more detailed characteristics.
4. RECOMMENDED MEASURES FOR IMPROVING YIELDS

To obtain stable yields, it is necessary to adopt agricultural methods that comply with the biological requirements of sunflower and the local soil and climatic conditions and to introduce new varieties and hybrids adapted to conditions in Aktobe region. Hybrid demonstration tests by seed companies from France, Switzerland, the United States, Ukraine, and Russia were useful in promoting visual demonstration of potential results.

The following issues are very important in improving sunflower yields under the conditions of North-Western Kazakhstan.

4.1 Varieties

It is necessary to continue identifying very early and early hybrids. Variety trials must be carried out every year under regional conditions. 100-day varieties allow harvesting at the right time, even when planting occurs in the last decade of May.

It is also recommended that new herbicide-tolerant varieties be tested. This new technology seems very efficient according to recent experiences in other countries.

4.2 Planting

The densities observed in the demonstration trials were between 40,000 and 60,000 plants per hectare. This was probably sufficient to obtain 1.5 to 2 tonnes per hectare in the dry climatic conditions of Kazakhstan. Concerning plant distribution in the rows, farmers must be careful when adjusting their drills to avoid doubles or losses of plants.

For large-scale farming, the sowing equipment available to farmers in the region seems to be a limiting factor. New drills (most of which are made in Romania) with only six row units do not seem suitable for sunflower fields of 400 hectares and more.

To complete sunflower seed planting as quickly as possible, the following two possible solutions should be considered, after further local trials:

- Increasing the number of row units (to 8–10) per drill and switching to more powerful machinery to sow at faster speeds (7–10 km/hour): in these conditions, fields can be sown with row spacing of 60–70 cm, which would allow harrowing between the rows.

- Testing the use of certain wheat drills for sowing sunflowers: only a few wheat drills would be appropriate, but they are worth testing. However, to avoid uneven seed distribution in the rows, it would be necessary to decrease the row spacing to 30–40 cm, which would make harrowing between rows impossible and chemical weed control essential.

4.3 Weed control

Sunflower is very sensitive to competition with weeds, especially under dry conditions. Herbicides are rarely used in Kazakhstan; farmers use mainly mechanical control, but this is not always sufficiently efficient. Chemical and mechanical controls should complement each other for good weed management.
If farmers plant sunflower in fields where it has been planted previously, they will have to pay particular attention to two weeds that are very competitive and already exist in Kazakhstan:

- **Sunflower broomrape**: This weed can multiply very quickly. If this happens, the use of broomrape-resistant varieties (e.g., Leila) or herbicide-resistant varieties such as Eurolightning/Intervix (BASF) will be necessary.

- **Wild sunflower**: This weed is easy to control in wheat fields, but very difficult to control in sunflower fields. In the future, it would be useful to control this weed by using herbicide-resistant varieties such as Eurolightning/Intervix (BASF) or Express (Pioneer/Dupont).

### 4.4 Fertilisation

It will be necessary to apply light rates of nitrogen and phosphorus, especially on chestnut soils, to avoid nutrient deficit and the consequent yield losses. The climatic conditions of Kazakhstan (cold winters and dry summers) do not permit the high mineralisation of nitrogen, so sunflowers are likely to have insufficient nitrogen to produce more than 1.5 tons per hectare (70 units of N are necessary). After 20 or 30 years without phosphorus application, soils are generally deficient in this nutrient.

Field trials have proven the efficiency of applying small quantities of N-P fertiliser in the rows, with special equipment adapted to the drills.
4.5 Soil tillage

The structure of the soil is good for sunflower seed, as no compaction is observed. The rooting system of all hybrids is well developed and deep. The traditional practice of deep cultivation before winter and top cultivation in spring seems well adapted for sunflower seed production in North Eastern Kazakhstan.

4.6 Harvesting

Some fields with overmatured sunflowers were observed. Farmers will need to pay particular attention to identify plants that are at the right stage for harvesting to avoid losses to wind and birds (see following photo).

*Crow damage to overmatured sunflowers*
5. ECONOMIC CONSIDERATIONS OF YIELD INTENSIFICATION BASED ON THE TESTED HYBRIDS

An increase in yield of 310–370 kg per hectare from the existing average yields would generate additional income of KZT 14,700–17,600 per hectare; increases of 460–480 and 550–570 kg per hectare would generate income increases of KZT 21,800–22,800 and KZT 26,100–27,000 per hectare respectively.

Table 4: Economic efficiency of sunflower varieties and hybrids in Aktubinsk district

<table>
<thead>
<tr>
<th>Variety/hybrid</th>
<th>Company, origin</th>
<th>Yield, kg/ha</th>
<th>Revenue, T/ha</th>
<th>Costs, T/ha</th>
<th>Net income, T/ha</th>
<th>Profitability (revenue/cost, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sibirsky 91</td>
<td>Russia</td>
<td>950</td>
<td>45,125</td>
<td>12,876</td>
<td>32,249</td>
<td>250.4</td>
</tr>
<tr>
<td>PomarRM</td>
<td>Euralis</td>
<td>1,520</td>
<td>72,200</td>
<td>17,426</td>
<td>54,774</td>
<td>314.3</td>
</tr>
<tr>
<td>Milonga</td>
<td>Maisadour</td>
<td>1,500</td>
<td>71,250</td>
<td>17,386</td>
<td>53,864</td>
<td>309.8</td>
</tr>
<tr>
<td>ES Isabella</td>
<td>Euralis</td>
<td>1,430</td>
<td>67,925</td>
<td>17,246</td>
<td>50,679</td>
<td>293.8</td>
</tr>
<tr>
<td>Leila</td>
<td>Euralis</td>
<td>1,410</td>
<td>66,975</td>
<td>17,226</td>
<td>49,749</td>
<td>288.8</td>
</tr>
<tr>
<td>Sanay</td>
<td>Syngenta</td>
<td>1,410</td>
<td>66,975</td>
<td>17,226</td>
<td>49,749</td>
<td>288.8</td>
</tr>
<tr>
<td>A-90</td>
<td>Pioneer</td>
<td>1,320</td>
<td>62,700</td>
<td>16,746</td>
<td>45,954</td>
<td>274.4</td>
</tr>
<tr>
<td>Sanluca</td>
<td>Syngenta</td>
<td>1,280</td>
<td>60,800</td>
<td>17,026</td>
<td>43,774</td>
<td>257.1</td>
</tr>
</tbody>
</table>
6. CONSIDERATIONS FOR DEMONSTRATION TRIALS IN THE FUTURE

The future demonstration trials programme should have the following two objectives:

● **Objective 1: continue identifying the varieties that are best adapted to local conditions.**

It seems very useful to go on testing early and very early varieties to identify the varieties best suited to Kazakhstan conditions.

In 2009, the varieties that appeared most productive according to the 2008 trial results should be tested again and new varieties should be added, possibly including those adapted to Mediterranean conditions (e.g. varieties that are well-adapted to Andalusia). Some of these varieties are resistant to broomrape, a weed that exists in Aktobe region.

The type of trials carried out in 2008 – demonstration field trials without replication – are suitable for this purpose, but it would also be useful to control the soil homogeneity in the trials. For this, it is recommended that each variety be sown in three plots of the trial field, one on each outer border and one in the middle.

As in 2008, at least two trials must be carried out, one on chestnut soil and the other on deep black soil (chernozem).

● **Objective 2: test the effectiveness of mineral fertilisation**

Because of severe water shortage, nitrogen requirements are low, but it would be useful to test the effect of light rates of nitrogen (30 kg per hectare) on yields. The testing of phosphorus applications would also be very interesting.

These trials should be carried out at different locations, with at least one on poor soil such as the chestnut soils.

Trials of nitrogen and phosphorous fertilizers should be carried in two replications.

Meteorological conditions in 2007–2008 agricultural year, Stepnoye LLC

<table>
<thead>
<tr>
<th>Month</th>
<th>Average daytime air temperatures, °C</th>
<th>Precipitation, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decades</td>
<td>Monthly average</td>
</tr>
<tr>
<td></td>
<td>I II III</td>
<td></td>
</tr>
<tr>
<td>September 2007</td>
<td>19.8 13.6 12.0</td>
<td>15.1</td>
</tr>
<tr>
<td>October</td>
<td>8.0</td>
<td>7.4</td>
</tr>
<tr>
<td>November</td>
<td>-1.0</td>
<td>-5.4</td>
</tr>
<tr>
<td>AUTUMN</td>
<td>5.0</td>
<td>4.1</td>
</tr>
<tr>
<td>December</td>
<td>-11.6</td>
<td>-17.3</td>
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<tr>
<td>January 2008</td>
<td>-19.7</td>
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</tr>
<tr>
<td>February</td>
<td>-15.7</td>
<td>-14.8</td>
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<td>WINTER</td>
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<tr>
<td>March</td>
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</tr>
<tr>
<td>April</td>
<td>11.5</td>
<td>8.0</td>
</tr>
<tr>
<td>May</td>
<td>10.9</td>
<td>14.6</td>
</tr>
<tr>
<td>SPRING</td>
<td>+5.5</td>
<td>136.5</td>
</tr>
<tr>
<td>June</td>
<td>14.0</td>
<td>23.7</td>
</tr>
<tr>
<td>July</td>
<td>22.9</td>
<td>25.6</td>
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<tr>
<td>August</td>
<td>20.0</td>
<td>26.4</td>
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<tr>
<td>SUMMER</td>
<td>22.6</td>
<td>20.9</td>
</tr>
<tr>
<td>AGR. YEAR</td>
<td>5.38</td>
<td>3.55</td>
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### Meteorological conditions in 2007–2008 agricultural year, Kyzyl Zhar PK

<table>
<thead>
<tr>
<th>Months</th>
<th>Average daytime air temperatures, °C</th>
<th>Precipitation, mm</th>
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<tr>
<td></td>
<td>Decades</td>
<td>Monthly average</td>
<td>Long-term average</td>
<td>+/to the long-term average</td>
<td>Decades</td>
<td>Monthly average</td>
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<td></td>
<td>I  II  III</td>
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<td></td>
<td>I  II  III</td>
<td></td>
</tr>
<tr>
<td>September 2007</td>
<td>19.8 13.6 12.0</td>
<td>15.1</td>
<td>13.4</td>
<td>+1.7</td>
<td>0.0 10.0 0.0</td>
<td>10.0</td>
</tr>
<tr>
<td>October</td>
<td>8.0 7.4 1.7</td>
<td>5.6</td>
<td>4.4</td>
<td>+1.2</td>
<td>0.0 0.0 0.0</td>
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## Sunflower development (phenological) phases at Stepnoye LLC, 2008

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### Weather information by sunflower development periods and hybrid earliness, 2008

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## Water consumption of sunflower varieties and hybrids, and yield formation, 2008
(sorted by yield at Stepnoye)

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<td>Water consumption ratio, mm/100 kg</td>
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<td>-</td>
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## ANNEX 2: CHARACTERISTICS OF SUNFLOWER HYBRIDS AND YIELDS, 2008

Characteristics Of Sunflower Hybrids And Yields in Kyzyl Zhar, 2008

<table>
<thead>
<tr>
<th>Variety, hybrid/ Сорт, гибрид</th>
<th>Height of the plant/ Высота растения/ см</th>
<th>Diameter of the head/ Диаметр корзинки/ см</th>
<th>Weight of seeds from one head/ Масса семян с корзинки/ gram/г</th>
<th>Number of seeds per one head/ Количество семян в корзинке</th>
<th>Weight of 1000 seeds/Mасса 1000 семян/ gram/г</th>
<th>Yield, 100 kg/ha</th>
<th>Deviation from mode yield, %</th>
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<td>39,2</td>
<td>1059</td>
<td>37</td>
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<td>15,6</td>
<td>41,6</td>
<td>1134</td>
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<td>15,0</td>
<td>49%</td>
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<tr>
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<td>138</td>
<td>14,4</td>
<td>34,1</td>
<td>842</td>
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<td>14,3</td>
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<td>16</td>
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### Characteristics of sunflower hybrids and yields at Stepnoye, 2008

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<th>Variety, hybrid/ Сорт, гибрид</th>
<th>Height of the plant/ Высота растений</th>
<th>Diameter of the head/Диаметр корзинки</th>
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<th>Weight of 1000 seeds/Масса 1000 семян</th>
<th>Yield, 100 kg/ha</th>
<th>Deviation from mode yield, %</th>
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<td>108</td>
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<td>37,5</td>
<td>1036</td>
<td>36,2</td>
<td>10,2</td>
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</tr>
<tr>
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<td>892</td>
<td>40,9</td>
<td>9,6</td>
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</tr>
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<td>112</td>
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<tr>
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<td>112</td>
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<td>912</td>
<td>34</td>
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</tr>
<tr>
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<td>31,8</td>
<td>873</td>
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</tr>
<tr>
<td>A-90</td>
<td>104</td>
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<td>863</td>
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</tr>
<tr>
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<td>5%</td>
</tr>
<tr>
<td>NK Rocky</td>
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</tr>
<tr>
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<td>122</td>
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<td>30,6</td>
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<td>108</td>
<td>14</td>
<td>31,4</td>
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<td>Ясон</td>
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<td>831</td>
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## Productivity and oil content of sunflower hybrids, 2008
(sorted by oil output per hectare at Stepnoye)

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<th>Variety, hybrid</th>
<th>Company, country</th>
<th>Oil content, %</th>
<th>Yield, '00 kg/ha</th>
<th>Oil, kg/ha</th>
<th>Yield, '00 kg/ha</th>
<th>Oil, kg/ha</th>
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<td>6.5</td>
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<td>456</td>
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<td>279</td>
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<tr>
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<td>-</td>
<td>-</td>
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<td>6.1</td>
<td>-</td>
<td>-</td>
<td>8.4</td>
<td>-</td>
</tr>
</tbody>
</table>
ANNEX 3: SHORT DESCRIPTION OF CERTAIN SUNFLOWER HYBRIDS TESTED IN THE DEMONSTRATION TRIALS IN 2008 (in Russian only as reported by seed companies)

Краткая характеристика некоторых гибридов подсолнечника, протестированных в демонстрационных опытах в 2008 г (по данным компаний).

Институт растениеводства им. В.Я. Юрьева УААН
http://www.yuriev.com.ua

ГИБРИД ПОДСОЛНЕЧНИКА «АНТ®»
Простой межлинейный гибрид масличного направления.
Скороспелый, длительности вегетационного периода до 100 сут.
Высота растений 130-140 см.
Устойчивый к ложной мучнистой росе, волчку, стойкий к серой и белой гнили
Потенциальная урожайность 3,82 т/га.
Содержание масла в семенах 50,0-52,5 %.

ГИБРИД ПОДСОЛНЕЧНИКА «ОСКИЛ®»
Простой межлинейный гибрид масличного направления.
Скороспелый, длительности вегетационного периода до 105 сут.
Высота растений 160-165 см.
Имеет высокий уровень устойчивости к засухе, полеганию, основным болезням.
Потенциальная урожайность 4,09 т/га.
Содержание масла в семенах 49,1-49,6 %.
В производственных условиях 2007 года в Украине этот гибрид обеспечил урожайность до 2,7 т/га.

ГИБРИД ПОДСОЛНЕЧНИКА «ХАРЬКОВСКИЙ 49»
Простой межлинейный гибрид масличного направления.
Скороспелый, длительности вегетационного периода до 95 дн.
Высота растений 90-120 см.
Устойчивый к ложной мучнистой росе, волчку, стойкий к фомопсису и гнилям.
Потенциальная урожайность 3,90 т/га.
Содержание масла в семенах 50,5-52,6 %
<table>
<thead>
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<th>Гибрид Подсолнечника</th>
<th>Описания</th>
</tr>
</thead>
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<td>Трехлинейный гибрид масличного направления. Скороспелый, длительности вегетационного периода до 105-106 сут. Высота растений 165-170 см. Потенциальная урожайность 4,00 т/га. Содержание масла в семенах 49,8-50,2 %.</td>
</tr>
<tr>
<td><strong>ГИБРИД ПОДСОЛНЕЧНИКА «СВИТОЧ»</strong></td>
<td>Простой межлинейный гибрид масличного направления. Скороспелый, длительности вегетационного периода до 105 сут. Высота растений 130-150 см. Устойчивый к ложной мучнистой росе, волчку, стойкий к серой и белой гнили, фомопсису. Потенциальная урожайность 4,50 т/га. Содержание масла в семенах 50,5-52,6 %.</td>
</tr>
<tr>
<td><strong>ГИБРИД ПОДСОЛНЕЧНИКА «КОВЧЕГ®»</strong></td>
<td>Простой межлинейный гибрид масличного направления. Скороспелый, длительности вегетационного периода до 105 сут. Высота растений 160-170 см. Устойчивый к ложной мучнистой росе, волчку, стойкий к серой и белой гнили. Потенциальная урожайность 3,55 т/га. Содержание масла в семенах 51,2-52,6 %. Рекомендован к выращиванию в Луганской области (характеризующейся особо засушливыми погодными условиями Степной зоны Украины).</td>
</tr>
<tr>
<td><strong>ГИБРИД ПОДСОЛНЕЧНИКА «ПОГЛЯД»</strong></td>
<td>Простой межлинейный гибрид масличного направления. Скороспелый, длительности вегетационного периода до 105-108 сут. Высота растений. Имеет высокий уровень устойчивости к полеганию и основных болезнях. Потенциальная урожайность 4,20 т/га. Содержание масла в семенах 50,0-51,5 %.</td>
</tr>
</tbody>
</table>
ГИБРИД ПОДСОЛНЕЧНИКА «ЯСОН®»
Трехлинейный гибрид масличного направления
Скороспелый, длительности вегетационного периода до 108 сут.
Высота растений 175-180 см.
Имеет генетически обусловленную устойчивость к волчку и ложной мучнистой росе.
Потенциальная урожайность 4,16 т/га. В производственных условиях 2007 г гибрид обеспечил урожайность до 3,51 т/га.
Содержание масла в семенах 49,7-50,1 %.

ГИБРИД ПОДСОЛНЕЧНИКА «ДАРИЙ®»
Трехлинейный гибрид масличного направления, олеинового типа.
Средне-ранний с продолжительностью вегетационного периода 107-110 сут.
Высота растений 175-180 см.
Имеет генетически обусловленную устойчивость к волчку и ложной мучнистой росе, устойчивый к белой гнили.
Потенциальная урожайность 4,21 т/га.
Содержание масла в семенах 50,9 %.
Содержание олеиновой кислоты в масле 76,0 %.
В производственных условиях 2006-2007 г гибрид обеспечил урожайность до 3,2 т/га на значительных площадях.

ГИБРИД СОНЯШНИКУ «ЭТЮД»
Простой межлинейный гибрид масличного направления
Скороспелый, длительности вегетационного периода до 100 сут.
Высота растений 120-140 см.
Потенциальная урожайность 4,84 т/га.
Содержание масла в семенах 48,2-52,3 %.
Арена ПР

Стабильность из года в год

● Среднезерный гибрид.
● Хороший потенциал урожайности и высокая пластичность.
● Гибрид умеренно интенсивного типа, хорошо отзывается на плодородные почвы.
● Устойчив к заразихе рас A, B, C, D, E.
● Устойчивый к ложной мучнистой росе.
● Имеет отличную толерантность к фомозу, корзиночной и стеблевой форме белой и серой гнилей.
● Рекомендуется сеять в оптимальные сроки с использованием классической технологии обработки почвы.
● Не рекомендуется использовать высокие дозы азотных удобрений.
● Густота к моменту уборки 42-48 тыс./га.

Санлука

Раннеспелость прежде всего

● Раннеспелый гибрид.
● Гибрид с хорошими темпами роста на начальных этапах органогенеза.
● Хороший потенциал урожайности и хорошая засухоустойчивость.
● Адаптирован к зонам возделывания подсолнечника с коротким вегетационным периодом.
● Устойчив к заразихе рас A, B, C, D, E.
● Благодаря ранним срокам созревания, может быть хорошим предшественником для озимых зерновых.
● Пластичный, высокостабильный гибрид.
● Возделывать при «минимальной» и «нулевой» обработке почвы.
● Густота к моменту уборки 45-50 тыс./га.

НК Роки

Чемпион среди ранних

● Раннеспелый гибрид.
● Отличный потенциал урожайности, высокая масличность.
● Пластичный к срокам посева.
● Хорошая устойчивость к засухе.
● Средняя толерантность к белой и серой гнилям.
● Устойчив к заразихе рас A, B, C, D, E.
● Рекомендуемая густота к моменту уборки 45-50 тыс./га.
Принтасол
Простой скороспелый гибрид. Зарегистрирован в России с 1999 года по Западно-Сибирскому и Уральскому регионам.

Морфологические характеристики:

Стебель и листья:
- стебель средней длины (160-165 см)
- светло-зеленые листья

Корзинка:
- среднего размера
- диаметр 14 – 18 см
- тонкая, слабовыпуклая
- быстро высыхает при созревании

Семена:
- у длиненно-округлой формы
- черного цвета
- потенциал урожайности в производстве 29-32 ц/га

Период вегетации (от посева до физиологической спелости зерна) 95 – 98 дней

**РЕКОМЕНДАЦИИ:**

<table>
<thead>
<tr>
<th>Густота к уборке:</th>
<th>ПРЕИМУЩЕСТВА:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50000-55000 шт/га (засушливые условия)</td>
<td>1. Высокая скороспелость</td>
</tr>
<tr>
<td>55000-60000 шт/га (достаточное увлажнение)</td>
<td>2. Хорошая урожайность в зонах с укороченным периодом роста</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Элементы урожая:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Выполн. корзинки (%):</td>
<td>92 - 94</td>
</tr>
<tr>
<td>Содержание масла (%):</td>
<td>49 - 50</td>
</tr>
<tr>
<td>Масса 1000 зерен (г):</td>
<td>60 - 75</td>
</tr>
</tbody>
</table>
LEILIA

Очень ранний
Устойчивый к заразихе

Новый чемпион урожайности в областях, подверженных заразихе!

Идентификация

Тип гибрида: трехлинейный
Количество дней всхожесть-цветение: 70 дней
Количество дней всхожесть-уборка: 106 дней

Структура урожайности

178 см
22 см
Вес 1000 зерен: 62 гр
Наклон шляпки: вниз

Потенциал урожайности

40-45 ц/га

Содержание масла

Масличность: 51%

Агрономические характеристики

Энергия при всходе 7
Стрессоустойчивость 8
Устойчивость к полеганию 7
Устойчивость к фомопсису 6
Устойчивость к склеротиниозу 8
Устойчивость к Rhoma 6
Устойчивость к заразихе от A до E
0=низкая
10=высокая
ЕС ИЗАБЕЛЛА

Очень ранний
Устойчивый к заразихе

Превосходная устойчивость к заразихе, терпимость к новым расам и высокий потенциал урожайности

Идентификация

Тип гибрида: трехлинейный
Количество дней всхожесть-цветение: 70 дней
Количество дней всхожесть-уборка: 109 дней

Структура урожайности

180 см
22 см
Вес 1000 зерен: 65 гр
Наклон шляпки: вниз

Потенциал урожайности
43-48 ц/га

Содержание масла
Масличность: 50%

Агрономические характеристики

Энергия при всходе 7
Стрессустойчивость 7
Устойчивость к полеганию 6
Устойчивость к фомопсису 6
Устойчивость к склеротиниозу 7
Устойчивость к Rhoma 6
Устойчивость к заразихе -
от А до Е толерантный к расе F
0=низкая
10=высокая

Рекомендуемая плотность посева

Лесостепь: 65 000 - 70 000 зерен/га
Степь: 55 000 - 60 000 зерен/га
ПОМАР
ранний

Ранний гибрид с устойчивым стеблем, резистентный к фомопсису

Идентификация

Тип гибрида: простой
Количество дней всхожесть-цветение: 71 дней
Количество дней всхожесть-уборка: 104 дней

Структура урожайности

175 см
20 см
Вес 1000 зерен: 58 гр
Наклон шляпки: вниз

Потенциал урожайности

40-45 ц/га

Содержание масла
Масличность: 49%

Агрономические характеристики

Энергия при всходе 7
Стрессоустойчивость 8
Устойчивость к полеганию 10
Устойчивость к фомопсису 10
Устойчивость к склеротиниозу 8
Устойчивость к Rhoma 7

0=низкая
10=высокая

Рекомендуемая плотность посева

Лесостепь: 65 000 - 70 000 зерен/га
Степь: 60 000 - 65 000 зерен/га
ANNEX 4: PRESENTATIONS AND MATERIALS

Presentations and training materials (English and Russian)

Presentations (indoor training session, Uralsk, 29 February–1 March 2008)

(i) Aspects of sunflower crop physiology (English) ................................................................. 43
    Aspects of sunflower crop physiology (Russian) ............................................................... 91
(ii) Sunflower crop (English) .................................................................................................... 139
    Sunflower crop (Russian) .................................................................................................. 166
(iii) Sunflower diseases (English) ............................................................................................ 193
     Sunflower diseases (Russian) ............................................................................................ 218

Posters (field day, Stepnoye, Aktobe Oblast, 25 September 2008)

(i) Sunflower harvesting (English) ............................................................................................. 243
    Sunflower harvesting (Russian) ........................................................................................ 244
(ii) Sunflower planting (English) .............................................................................................. 245
    Sunflower planting (Russian) ............................................................................................ 246
(iii) Sunflower tilling (English) ................................................................................................. 247
     Sunflower tilling (Russian) ............................................................................................... 248
Aspects of sunflower crop physiology (English)
The plant

Cycle: 120 to 150 days according to earliness

Temperature requirements: 1570 to 1700 °C (base 6)
According to earliness of the variety
(3 classifications in France)

Flowering takes place 65 to 70 days after emergence

Cycle: 5 Key-periods could be identified:
1- From sowing to emergence
2- From emergence to 5 leaves stages
3- From 5 leaves stages to begin. of flow.
4- Flowering time
5- Seed filling period

Scales for Sunflower GDD requirements

<table>
<thead>
<tr>
<th>Earliness group</th>
<th>Sowing to emergence (°C)</th>
<th>Beginning of flowering (°C)</th>
<th>End of flowering (°C)</th>
<th>Maturity (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>90</td>
<td>790</td>
<td>990</td>
<td>1570</td>
</tr>
<tr>
<td>Mid - early</td>
<td>90</td>
<td>840</td>
<td>1040</td>
<td>1640</td>
</tr>
<tr>
<td>Mid - late</td>
<td>90</td>
<td>900</td>
<td>1100</td>
<td>1700</td>
</tr>
</tbody>
</table>

GDD: Growing degrees days in °C base 6
Cumulative values required to reach the stage
Description of the main growth stages for sunflower (CETIOM scales)

Maturity

1- Sowing to emergence

Duration: 7 to 20 days according to soil humidity and T° (mini 4°C and optimum 8°C)

The success ratio for germination is established at that time

There is an inverse relationship between the daylength of this period and the potential yield: plant density, damages from pests.
2- From Emergence to «10 leaves stage»

Zero for growth: 6°C to 7°C

Sensitivity to low temperatures:
- Cotyledons stage: -5 to -7°C
- «one leaf stage»: Temperatures below 0°C will lead to necrosis

Sensitivity to high temperatures:
- Over 27°C: max for photosynthetic activity, but transpiration still increases
- Depressive effect on oil (mainly through the leaf area senescence)
- Modification in the Fatty acids composition

Important stage for the plant density and for the LAI (leaf area index)

Establishment of the root system (A1 to B8)

- Duration = 30 days
- Very sensitive to soil structure accidents
- The quality of the root system will determine the later quality of Water/Nitrogen supplies

Establishment of the leaves primordia

- 18 to 20°C days are requested for the differentiation of one leaf (elastochron)
- After 8 leaves, changes in phyllotaxy appears (from opposite to alternate)
- Initiation of 20 to 30 leaves (effect mainly of genetics and water shortage)
2- From Emergence to « 10 leaves stage »

From « 8 leaves to 10 » (B8 to B10)

- Duration from 20 to 25 days (until bud stage E2 = 15 mm diem)
- Effect of low temperatures: mainly on the quality of initiation

It's a key stage: the vegetative bud moves to reproductive one: Floral initiation
Star stage: floral bud reaches around 15 mm

3- From «10 leaves stages to Beginning of flowering)

- High requirements in nutrients
- High crop growth rate: 200 kg/ha/day
- Duration: 40-50 days
- High expansion rate for leaf area => establishment of the LAI
  LAI = Leaf area per plant X plant density

The water and nitrogen availabilities will control the leaf area establishment but also duration

A moderation in leaf area will be looked for:
Optimum value at E2 = 1.7
Optimum value at F1 = 2.5
4- Flowering (F1 to F4)

- Duration: 9 days max at the plant level
  15 - 20 days at the field level
- End of the root Growth: most of the assimilates will move to the bud instead of the roots. The bud becomes the main sink for C and N
- Leaf area reaches a pick at flowering
- Flowering = the stage most sensitive to water shortages
- Sensitive stage to Sclerotinia Scl. head attacks

Assimilates allocation during flowering (F1) for sunflower (using C\textsuperscript{14}O\textsubscript{2})
The florets are male first and then female.

Up to now, self-pollination reaches 80% for the more recent hybrids.
5- Seed filling period (F4-M3)

- Redistribution of assimilates: 65% of the proteins contained in the seed at harvest come from the leaves and stem redistribution.

- Oil biosynthesis (mainly from late assimilation) consequences = leaf area duration will maintain C flux to the seed for oil synthesis (high level of Energy required).

- Total Dry Matter (DM) produced: 10-15 t/ha (on the basis of 30 q/ha of yield).

Plant stages (1)

- Sowing: 10-20 days
  - Emergence and cotyledons growth

- 30 days
  - 5 pairs of leaves

- 40 days
  - Beginning of floral initiation

- 50 days
  - Star bud stage

- 60 days
  - End of floral initiation
  - Bud appears among the leaves (diameter 5 to 8 cm)
Plant stages (2)

70-80 days
- Beginning of flowering
- The head starts to bend
- Ligule flowers appear

90-100 days
- End of flowering
- Ligule flowers fall
- Back of the head still green

140-150 days
- The head back turns to brown color
- Physiological maturity

Biomass production and « captors »
Root & Leaf area
KAZAKHSTAN: Technical Assistance to the Sunflower Seed Sector

---

**Figure 13:** Seed dry matter accumulation in sunflower after anthesis

- **Whole seed**
- **Kernel**
- **Hull**

**Figure 14:** Allocation of assimilates by nature over time in sunflower

- **Glucose-equivalent (g/ha)**
  - Total
  - Carbo-hydrates
  - Oil
  - Nitrogen compounds

**Energetic costs for 1 g of final products:**
- Carbo hydrates = 1.2 g of Glucose
- Nitrogen compounds = 2.5 to 2.7 g of Glucose
- Oil = 3 g of Glucose
Variation in leaf area according to the rank on the stem

Photosynthetic level (mg of CO2/cm²/s)

<table>
<thead>
<tr>
<th>Rank on the stem</th>
<th>Leaf area per leaf (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.15</td>
<td>150</td>
</tr>
<tr>
<td>1.12</td>
<td>200</td>
</tr>
<tr>
<td>0.97</td>
<td>250</td>
</tr>
<tr>
<td>0.77</td>
<td>300</td>
</tr>
</tbody>
</table>

Relative importance of leaf area according to the canopy level

<table>
<thead>
<tr>
<th>Leaves maintained (numbered from bottom to top)</th>
<th>% of leaf area maintained</th>
<th>Weight of seeds harvest (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All leaves (1 to 25)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Leaves 1 to 18</td>
<td>88 (-22 %)</td>
<td>55 (-45 %)</td>
</tr>
<tr>
<td>Leaves 1 to 13</td>
<td>59 (-41 %)</td>
<td>25 (-75 %)</td>
</tr>
<tr>
<td>Leaves 1 to 8</td>
<td>23 (-77 %)</td>
<td>2 (-93 %)</td>
</tr>
</tbody>
</table>

Leaves ablation occurs at flowering
A simple method for checking leaf area on sunflower

L = length
I = Width

Leaf area = 0.747 \times L \times I
A simple method for checking leaf area on sunflower

Leaf area = surface of the triangle
= 0.5 \times n \times h
= 0.5 \times n \times \text{Leaf area of the biggest leaf}
= 0.5 \times n \times (0.747 \times L \times l)

Leaf area: moderation in growth, improvement in duration

Leaf area index

Sunflower

Corn

2.5 to 3

1.5 to 1.7

Initiation

Flowering

Nb of seeds

1000 seed Weight

Rad 15 mm
Leaf area duration (LAD)

Leaf area duration = \int_{0}^{LAI_{max}} LAI(t) \, dt (m^2 \cdot day)

Sunflower and water relationships
In most of the cropping sunflower area in the world, water is the main limiting factor for sunflower crops.

Nevertheless, the water behaviour is paradoxical:

- If shortage, yield is mainly reduced by the number of seeds and the 1000 seeds weight
- If excess, leaf area will increase leading to water wastage and poor water use efficiency

Water consumption for different crops without any limiting factors

<table>
<thead>
<tr>
<th>Crops</th>
<th>Full water consumption</th>
<th>Optimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>520 mm</td>
<td>95 %</td>
</tr>
<tr>
<td>Sunflower</td>
<td>550 mm</td>
<td>75 %</td>
</tr>
<tr>
<td>Sorghum</td>
<td>450 mm</td>
<td>90 %</td>
</tr>
<tr>
<td>Soybean</td>
<td>480 mm</td>
<td>90 %</td>
</tr>
</tbody>
</table>
Most sensitive periods to drought for Sunflower compared to corn

Water response curve for sunflower
**Water use efficiency (WUE)**

Definition: Quantity of water required for biomass production (g/L)

\[
\text{WUE for dry matter} = \frac{\text{Dry matter produced}}{\text{Water consumption}}
\]

\[
\text{WUE for seeds} = \frac{\text{Seeds dry matter produced}}{\text{Water consumption}}
\]

**How to improve WUE for seeds?**

\[
\text{WUE for seeds} = \frac{\text{Seeds dry matter produced}}{\text{Total dry matter produced}} \times \frac{\text{Total dry matter produced}}{\text{Water consumption}}
\]

\[
\text{WUE for seeds} = \text{Harvest index} \times \text{WUE for dry matter}
\]
**KAZAKHSTAN: Technical Assistance to the Sunflower Seed Sector**

---

**Gas exchanges according to different water treatments**

<table>
<thead>
<tr>
<th>Water treatment</th>
<th>Max ET</th>
<th>0.5 MET after progressive adaptation</th>
<th>Max ET stress during flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water consumption (mm)</td>
<td>405</td>
<td>225</td>
<td>290</td>
</tr>
<tr>
<td>Total dry matter (g/plant)</td>
<td>111</td>
<td>120</td>
<td>96</td>
</tr>
<tr>
<td>Leaf area (dm²/plant)</td>
<td>55.0</td>
<td>36.6</td>
<td>21.9</td>
</tr>
<tr>
<td>Water potential (Mpa)</td>
<td>0.3</td>
<td>1.0</td>
<td>0.3</td>
</tr>
<tr>
<td>soil</td>
<td>0.7</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>leaves</td>
<td>93.1</td>
<td>85.4</td>
<td>88.0</td>
</tr>
<tr>
<td>Relative water content (% max)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomatal resistance (°C/cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper face</td>
<td>0.50</td>
<td>0.42</td>
<td>0.43</td>
</tr>
<tr>
<td>Lower face</td>
<td>1.15</td>
<td>0.72</td>
<td>0.82</td>
</tr>
<tr>
<td>Transpiration (g/dm²/h)</td>
<td>12.8 b</td>
<td>14.6 b</td>
<td>16.2 b</td>
</tr>
<tr>
<td>Net photosynthesis (mg CO₂/dm²)</td>
<td>24.0 bc</td>
<td>45.1 a</td>
<td>30.3 b</td>
</tr>
<tr>
<td>Photosynthesis/transpiration (×10⁻⁴)</td>
<td>1.9</td>
<td>3.1</td>
<td>1.9</td>
</tr>
</tbody>
</table>

---

**Sunflower adaptation to water shortage: Experimental treatments**

![Graph showing sunflower adaptation to water shortage](image)
### Sunflower adaptation to water shortage

<table>
<thead>
<tr>
<th>Water treatment</th>
<th>Water consumption (l/plt)</th>
<th>Dry matter produce (g/plt)</th>
<th>Seed dry matter (g/plt)</th>
<th>Effic. for DM (g/l)</th>
<th>Effic. for seed (g/l)</th>
<th>Seed harvest index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full requirements</td>
<td>75.8</td>
<td>161</td>
<td>56.8</td>
<td>2.1</td>
<td>0.7</td>
<td>0.35</td>
</tr>
<tr>
<td>Full requires until F1 than progressive stress</td>
<td>32.5</td>
<td>104.2</td>
<td>33.9</td>
<td>3.2</td>
<td>1</td>
<td>0.32</td>
</tr>
<tr>
<td>50 % of the full requires until F1 than 30%</td>
<td>16.1</td>
<td>67.4</td>
<td>23.3</td>
<td>4.2</td>
<td>1.4</td>
<td>0.35</td>
</tr>
</tbody>
</table>

*Efficiency = quantity of matter (seed or total) produced per litre of water used*

*Harvest Index = Seed dry matter / total dry matter produced*
Kinetics of photosynthesis and transpiration over time, according to different water supplies

Foliar structures of different species (1)

<table>
<thead>
<tr>
<th>Species</th>
<th>Stomata nb. upper face</th>
<th>Stomata nb. lower face</th>
<th>Average size (L x L) (micron)</th>
<th>Average distance on the epiderm between 2 stomas (micron)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower</td>
<td>85</td>
<td>156</td>
<td>38 x 7</td>
<td>91</td>
</tr>
<tr>
<td>Corn</td>
<td>53</td>
<td>168</td>
<td>19 x 5</td>
<td>137</td>
</tr>
<tr>
<td>Wheat</td>
<td>33</td>
<td>14</td>
<td>18 x 7</td>
<td>302</td>
</tr>
<tr>
<td>Soybean</td>
<td>7</td>
<td>17</td>
<td>16 x 4</td>
<td>250</td>
</tr>
</tbody>
</table>
**Foliar structures of different species (2)**

<table>
<thead>
<tr>
<th>Species</th>
<th>Stomatal resistance (t/m)</th>
<th>Transpiration (l/d/dm²)</th>
<th>Leaf water potential (bars)</th>
<th>WUE for Dry matter (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower</td>
<td>60 - 100</td>
<td>4</td>
<td>-8</td>
<td>2.5</td>
</tr>
<tr>
<td>Corn</td>
<td>200 - 300</td>
<td>3</td>
<td>-3</td>
<td>-</td>
</tr>
<tr>
<td>Wheat</td>
<td>200</td>
<td>3</td>
<td>-4</td>
<td>-</td>
</tr>
<tr>
<td>Soybean</td>
<td>80 - 120</td>
<td>3.8</td>
<td>-4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Sunflower adaptation to water shortage**

[Diagram showing water consumption and leaf area over time]
**Variation of WUE and HI according to different levels of water shortages**

<table>
<thead>
<tr>
<th>Water consumption (l/pl)</th>
<th>Ratio</th>
<th>Dry matter (g/pl)</th>
<th>Seed dry matter (g/pl)</th>
<th>WUE / TDM (g/l)</th>
<th>WUE / seed DM (g/l)</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>1</td>
<td>161</td>
<td>57</td>
<td>2.1</td>
<td>0.7</td>
<td>0.35</td>
</tr>
<tr>
<td>32</td>
<td>0.42</td>
<td>104</td>
<td>34</td>
<td>3.2</td>
<td>1.1</td>
<td>0.33</td>
</tr>
<tr>
<td>29</td>
<td>0.40</td>
<td>80</td>
<td>24</td>
<td>2.7</td>
<td>0.8</td>
<td>0.30</td>
</tr>
<tr>
<td>28</td>
<td>0.37</td>
<td>76.5</td>
<td>30</td>
<td>3.5</td>
<td>1.1</td>
<td>0.31</td>
</tr>
<tr>
<td>22</td>
<td>0.30</td>
<td>74</td>
<td>27</td>
<td>3.4</td>
<td>1.2</td>
<td>0.36</td>
</tr>
<tr>
<td>16</td>
<td>0.2</td>
<td>67</td>
<td>23</td>
<td>4.1</td>
<td>1.5</td>
<td>0.34</td>
</tr>
<tr>
<td>12</td>
<td>0.16</td>
<td>52</td>
<td>19</td>
<td>4.3</td>
<td>1.6</td>
<td>0.36</td>
</tr>
</tbody>
</table>

*Results obtained from sunflower plants grown in pots (7 l) under controlled conditions*

**Yield elaboration and components**
Yield elaboration

Yield = number of heads/m² \times number of seeds per head \times average weight of the seed

Yield = number of seeds/m² \times average weight of the seeds

Yield elaboration

Number of plants

- Optimal values between 5 and 8 plants/m²
- No compensation for one plant loss
- Seeds germination will be improved if soil \( T^\circ > 8^\circ C \)
**Effect of Plant density on characteristics of the capitulum**

<table>
<thead>
<tr>
<th>Plant density (plant/ sqm)</th>
<th>Head diameter (cm)</th>
<th>Stem diameter (cm)</th>
<th>Number of parastics</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 3</td>
<td>&gt; 30</td>
<td>-</td>
<td>144</td>
</tr>
<tr>
<td>4 to 7</td>
<td>21 to 27</td>
<td>2.5 to 3.5</td>
<td>89</td>
</tr>
<tr>
<td>7 to 10</td>
<td>11 to 21</td>
<td>1.8 to 2.5</td>
<td>55</td>
</tr>
<tr>
<td>10 to 12</td>
<td>6 to 11</td>
<td>1.1 to 1.8</td>
<td>34</td>
</tr>
</tbody>
</table>

Un = Un-1 + Un-2

**Effect of the sowing speed on yield:**

**Effect of plant distribution heterogeneity**

<table>
<thead>
<tr>
<th>Speed of the driller (km/h)</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
</tr>
</tbody>
</table>
# Impact of plant settlement heterogeneity on the final production

<table>
<thead>
<tr>
<th>% of soil cover</th>
<th>Yield (% of the standard)</th>
<th>Plant distribution in the settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>110</td>
<td>Uniform distribution</td>
</tr>
<tr>
<td>75</td>
<td>11.3</td>
<td>Uniform distribution, but leaf area overlap 2 by 2</td>
</tr>
<tr>
<td>62</td>
<td>17.8</td>
<td>Non-uniform distribution, some leaf areas overlap</td>
</tr>
<tr>
<td>60</td>
<td>71.1</td>
<td>High heterogeneity and bad distribution of the plant on the row</td>
</tr>
<tr>
<td>51</td>
<td>76</td>
<td>Non-uniform distribution and isolated plants on the row</td>
</tr>
</tbody>
</table>

---

# Yield elaboration

**Number of seeds**

- Crop vigour (leaf area, DM) at the initiation stage (B8 to B12)
- Crop growth before flowering (max observed for Sunflower varieties = 2000 seeds per plant)
- Water availability at beginning of flowering
- Leaf area duration during 30 days after flowering To prevent from empty seeds
Effect of water stress at different periods on the seed number

Yield elaboration

Thousand-seed weight (40 to 60g)

Leaf area duration from flowering to maturity
Optimum values = 90 m².days (i.e.: leaf area Index of 2 during 45 days)

For a same level of LAI, if the number of seeds increases, the 1000-seeds weight decreases

No excess in LAI at flowering (optimum 2.5 to 3)

No water shortages during the seed filling period
Kinetics for 1000 seed weight through to maturity

1000 seed weight (g)

CV = Albena

DAA (days after anthesis)

Low Temperatures  High Temperatures

1000 seed Weight according to location of the seeds on the capitulum (in g)

<table>
<thead>
<tr>
<th>Rank on the parastic</th>
<th>1 (Outside)</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
<th>12 (Inside)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varieties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albena</td>
<td>67</td>
<td>63</td>
<td>56</td>
<td>48</td>
<td>55</td>
<td>54</td>
</tr>
<tr>
<td>Eury floer</td>
<td>49</td>
<td>53</td>
<td>51</td>
<td>50</td>
<td>49</td>
<td>48</td>
</tr>
<tr>
<td>Viki</td>
<td>50</td>
<td>46</td>
<td>44</td>
<td>45</td>
<td>45</td>
<td>41</td>
</tr>
</tbody>
</table>
Genetic variation for 1000 seed weight

Oscar
Pardisol
Vidoc
Frankazol
Albena
IBH 166
Euroflor
Phaon
Flamme
Viki
Mirazol

70 - 80 g

30 - 40 g

Effect of different levels of water deficit applied at different stages on the 1000 seed weight

\[
\begin{array}{|c|c|c|c|c|c|c|}
\hline
\text{RET/MET ratio} & 0.3 & 0.4 & 0.5 & 0.6 & 0.7 & 0.8 \\
\hline
\text{Phase 1} & \text{nc} & \text{nc} & -20\% & -10\% & - & - \\
(F1) & & & & & & \\
\text{Phase 2} & \text{nc} & & -22\% & -15\% & .5\% & - \\
(F1-F4) & & & & & & \\
\text{Phase 3} & & & -50\% & -46\% & -28\% & -20\% & -10\% & -5\% \\
(-F4) & & & & & & \\
\hline
\end{array}
\]

\text{NC = no data} \quad \text{MET = full requirements} \quad \text{RET = relative requirements}
### Some seed characteristics according to location on the capitulum

<table>
<thead>
<tr>
<th>Location of the kernel</th>
<th>Weight of the seed (mg)</th>
<th>Proteins (%)</th>
<th>Oil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside</td>
<td>56.4</td>
<td>17.4</td>
<td>45.0</td>
</tr>
<tr>
<td>Middle</td>
<td>50.5</td>
<td>19.6</td>
<td>39.0</td>
</tr>
<tr>
<td>Center</td>
<td>44.8</td>
<td>21.8</td>
<td>35.7</td>
</tr>
</tbody>
</table>
Hull/kernel ratio: A stable character for sunflower

<table>
<thead>
<tr>
<th>Variety</th>
<th>23.5</th>
<th>24.2</th>
<th>25.9</th>
<th>28.9</th>
<th>27.6</th>
<th>24.5</th>
</tr>
</thead>
</table>

Yield components values:

High genetic effect:

Varieties with high 1000-seed weight and lower seeds number/m²

- 5 à 7000 seed/m²
- 1000-Seed weight: 55 à 65 g

Varieties with low 1000-seed weight and high seeds number/m²

- 7 à 9000 seeds/m²
- 1000-Seed weight: 40 à 45 g
Successive contribution of yield components to the final production

Potential yield: 45 to 55 t/ha

- Nb of kernels/2 9 to 12,000
- 1000-seed weight

Nb of capitulum: 0.5 to 1 m²

- Nb of kernels/capitulum

Nb of plants: 5.5 to 7 per m²

- Potential nb of kernels/capitulum
- % of seedation: 80 to 90%

Nb of seeds sown

The optimum pathway for sunflower yield elaboration

Sunflower yield is strongly influenced by leaf area behaviour after flowering

Leaf area index

End of flowering

Nb of days after end of flowering
An optimum value for dry matter produced at flowering

Yield (g/ha)

Dry matter at F1 (g/m²)

An optimum value for LAI at flowering

Yield (g/ha)

LAI at F1

To reach 2.5 at F1, no more than 1.7 at E1
KAZAKHSTAN: Technical Assistance to the Sunflower Seed Sector

Leaf area: The key for sunflower behaviour
Moderation in leaf area followed by leaf area duration

Leaf area index at F1:
2.5 is enough

Leaf area duration from F2 until physiological maturity
90 m².d

Kinetics of oil accumulation from anthesis to maturity

Oil (%)

DAA (days after anthesis)

CV: albena

Low Temperatures

High Temperatures
Relation between Leaf area duration (LAD) and oil content

Oil content (%)

Total leaf area duration (m².d)

Relationship between leaf area duration after flowering and yield

LAI: Leaf Area Index; LAD: Leaf Area Duration
**Kinetic of oil accumulation from anthesis to maturity**

<table>
<thead>
<tr>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0</td>
</tr>
<tr>
<td>M1</td>
</tr>
<tr>
<td>M3</td>
</tr>
<tr>
<td>F4</td>
</tr>
</tbody>
</table>

**Effect of irrigation on the oil content at harvest**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Oil (%)</th>
<th>Stage for watering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not irrigated</td>
<td>45.5</td>
<td>bc</td>
</tr>
<tr>
<td>1 irrigation</td>
<td>42.5</td>
<td>c</td>
</tr>
<tr>
<td>2 irrigations</td>
<td>53.1</td>
<td>a</td>
</tr>
<tr>
<td>3 irrigations</td>
<td>47.4</td>
<td>b</td>
</tr>
<tr>
<td>Optimum Irrigation</td>
<td>52.6</td>
<td>a</td>
</tr>
</tbody>
</table>

*a,b,c : Test NK at 5%*
KAZAKHSTAN: Technical Assistance to the Sunflower Seed Sector

Strategy for irrigation according to the level of LAI expected at flowering

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Strategy for irrigation according to the level of LAI expected at flowering

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88
A strategy for irrigation based on the leaf area

Examples of yield benefits

+ 5 to 10 q/ha from irrigation are possible
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Water response (irrigation) can be high if LAI is moderated

2000: 2.7 q/ha for 100 mm (High LAI at F1)
2001: 13.7 q/ha for 100 mm (LAI moderated, as climatic requirements
2003: 13.7 q/ha for 100 mm (LAI moderated, but high climatic demand)

Quality for sunflower grown in France: A survey over 5 years

Impurities (%)

Proteins (% in the meal)

Water content (%)

% of acidity

Oil content (%)

Formal & commercialization
Aspects of sunflower crop physiology (Russian)
Растение

Цикл: 120-150 дней в зависимости от скороспелости

Температурные требования: 1570-1700 °C (база 6)
В зависимости от скороспелости культуры
(3 классификации во Франции)

Цветение начинается на 65-70 день после появления всходов

Цикл: 5 ключевых периодов:
1- С посева до появления всходов
2- С появления всходов до стадии 5 листьев
3- Со стадии 5 листьев до начала цветения.
4- Цветение
5- Период наполнения семян

Градация требований к ГДР подсолнечника

<table>
<thead>
<tr>
<th>Группа скороспелости</th>
<th>Стадия</th>
<th>Посев - появление всходов</th>
<th>Начало цветения</th>
<th>Завершение цветения</th>
<th>Зрелость</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ранняя</td>
<td>90</td>
<td>790</td>
<td>990</td>
<td>1570</td>
<td></td>
</tr>
<tr>
<td>Среднепоздняя</td>
<td>90</td>
<td>900</td>
<td>1100</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td>Среднепоздняя</td>
<td>90</td>
<td>900</td>
<td>1100</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td>Среднедо-ранняя</td>
<td>90</td>
<td>840</td>
<td>1040</td>
<td>1640</td>
<td></td>
</tr>
</tbody>
</table>

ГДР: Градусо-дни роста в °C (база 6)
Кумулятивные значения для достижения следующей стадии
Описание основных стадий роста для подсолнечника (CETIOM)

1- Посев - появление всходов

Длительность: 7-20 дней в зависимости от влажности и температуры (мин. 4°C и оптим. 8°C)

В это время устанавливается коэффициент успешности прорастания

Существует обратная связь между продолжительностью дня в этот период и потенциалом урожая: плотность растений, ущерб от паразитов.
2- Появление всходов - «Стадия 10 листьев»

Ноль для роста: 6°C-7°C
- Чувствительность к низким температурам:
  - Стадия семя-доли: - 5 до -7°C
  - «стадия 1 листа»: Температура ниже 0°C приводит к омертвению

Чувствительность к высоким температурам:
- Выше 27°C: максимальная температура для фотосинтеза при увеличивающемся испарении влаги растением
- Угнетающее влияние на содержание масла (в основном из-за увлажнения листовой поверхности)
- Изменение состава жирных кислот

Важная стадия для плотности растений и ИЛП (индекс листовой поверхности)

2- Появление всходов - «Стадия 10 листьев»

Установление корневой системы (A1 до B8)
- Длительность ~ 30 дней
- Очень высокая чувствительность к изменениям состава грунта
- Качество корневой системы определяет будущее качество обеспеченности водой и азотом

Установление зачатков листа
- Для дифференциации листа необходимы дни с температурой 18-20°C
- После стадии 8 листьев возникают изменения листорасположения (из противоположного в чередующееся)
- Появление 20-30 листьев
  (в основном это влияют генетические аспекты и нехватка воды)
Максимальное иссушение почвы корневой системой разных культур на стадии уборки урожая

2- Появление всходов - «Стадия 10 листьев»
От «8 листьев до 10» (V8 до V10)

Продолжительность от 20 до 25 дней
(пока не наступит стадия бутонизации, E2 = 15 мм в диам.)

Влияние низких температур - в основном на качество начальных стадий

Ключевая стадия: вегетативный бутон, переходящий на репродуктивную стадию:
Инициация соцветья
Звездообразная стадия: цветочный бутон достигает 15 мм в окружности

3- Со стадии «10 листьев» до стадии начала цветения

- Высокая потребность в питательных веществах
- Высокая степень роста культуры: 200 кг/га/день
- Продолжительность: 40-50 дней
- Высокий темп роста листовой поверхности

Установление ИЛП
ИЛП = Листовая поверхность 1 растения * плотность растений

Обеспеченность водой и азотом регулирует установление листовой поверхности, а также продолжительность стадии
Необходимо найти умеренную степень развития листовой поверхности для получения:
Оптимального значения на стадии E2 = 1,7
Оптимального значения на стадии F1 = 2,5
4- Цветение (F1 до F4)

- Продолжительность: 9 дней максимально на уровне растения и 15-20 дней на уровне поля
- Окончание роста корней: большинство ассимилаторов преобразуется в бутон, вместо корней. Бутон становится основным местом поглощения азота и углерода
- При цветении листовая поверхность достигает пика
- Цветение = наиболее чувствительная к нехватке воды стадия
- Стадия чувствительна к атакам головки со стороны грибка Sclerotinia Scel.

Размещение ассимилаторов на стадии цветения (F1) подсолнечника (используя C14O2)
<table>
<thead>
<tr>
<th>Орган Время (д)</th>
<th>La</th>
<th>Pa</th>
<th>Л2</th>
<th>Р2</th>
<th>Т2</th>
<th>Л5</th>
<th>Р5</th>
<th>Т5</th>
<th>Брр.</th>
<th>Cap</th>
<th>Flор</th>
<th>Семя</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>92</td>
<td>6</td>
<td>Т</td>
<td>Т</td>
<td>0.4</td>
<td>Т</td>
<td>Т</td>
<td>0.3</td>
<td>Т</td>
<td>0.7</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>73</td>
<td>5</td>
<td>0.4</td>
<td>Т</td>
<td>2.4</td>
<td>1.8</td>
<td>Т</td>
<td>13</td>
<td>Т</td>
<td>1.4</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>54</td>
<td>3</td>
<td>Т</td>
<td>Т</td>
<td>2.4</td>
<td>Т</td>
<td>Т</td>
<td>16</td>
<td>Т</td>
<td>10</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>37</td>
<td>3</td>
<td>0.4</td>
<td>Т</td>
<td>4.6</td>
<td>0.4</td>
<td>Т</td>
<td>14</td>
<td>1</td>
<td>0.5</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>5</td>
<td>Т</td>
<td>Т</td>
<td>3.6</td>
<td>0.3</td>
<td>Т</td>
<td>15</td>
<td>Т</td>
<td>4</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>
Вначале цветки являются "самцами",
а затем становятся "самками"

До настоящего времени самоопыление свежих гибридов достигало 80%
5- период наполнения семян (F4-M3)

- Перераспределение ассимилянтов: 65% белков, содержащихся в семенах при сборке урожая, приходят в результате перераспределения листьев и стебля

- Биосинтез масла (в основном на стадии поздней ассимиляции)

Последствия листовая поверхность будет поддерживать выделение углерода в семенах для образования масла (требуется высокий уровень энергии)

- Общая произведенная сухая масса (СМ): 10-15 т/га

(на основе урожая 30 ц/га)

Стадии развития растения (1)

Посев - 10-20 дни
Появление всходов и рост семядолей

30 дни
5 пар листьев

40 дни
Начало инициации развития соцветия

50 дни
Стадия «звездообразных» бутона

60 дни
Завершение инициации развития соцветия
Среди листьев появляются бутоны
(диаметр 5 - 8 см)
Стадии развития растения (2)

70-80 дней

- Начало цветения
- Корзинка начинает изгибаться
- Появляются цветы Ligule

90-100 дней

- Завершение цветения
- Опад цветов Ligule
- Задняя часть корзинки все еще зеленая

140-150 дней

- Задняя часть корзинки становится коричневой
- Физиологическая зрелость

Производство биомассы
Корневая и листовая поверхность
Изменение листовой поверхности в зависимости от высоты стебля

Уровень фотосинтеза
(мг СO2/см2/с)
1.15
1.12
0.97
0.77

Площадь листовой поверхности на 1 листе (см2)

Относительная значимость листовой поверхности в зависимости от уровня растительного покрова

<table>
<thead>
<tr>
<th>Листья (количество с основания до верхушки)</th>
<th>% листовой поверхности</th>
<th>Вес урожая семян (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Все листья (1-25)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Листья 1-18</td>
<td>88 (-22%)</td>
<td>55 (-45%)</td>
</tr>
<tr>
<td>Листья 1-13</td>
<td>59 (-41%)</td>
<td>25 (-75%)</td>
</tr>
<tr>
<td>Листья 1-8</td>
<td>23 (-77%)</td>
<td>2 (-93%)</td>
</tr>
</tbody>
</table>

При цветении наблюдается разрушение листьев.
Оптимальное значение индекса листовой поверхности (ИЛП)

Простой метод проверки листовой поверхности на подсолнечнике

$L = \text{Длина}$
$I = \text{Ширина}$

Листовая поверхность $= 0,747 \times L \times I$
Казахстан: техническое содействие сельскохозяйственной отрасли подсолнечника.

1. Метод проверки площади листовой поверхности подсолнечника.
   Листовая поверхность = площадь треугольника
   = 0,5 * n * h
   = 0,5 * n * листовая поверхность наибольшего листа
   = 0,5 * n * (0,747 * L * l)

2. Листовая поверхность: регулирование роста.
   Улучшение вегетационного периода.
   Индекс листовой поверхности (ЛИП)

   Подсолнечник
   Кукуруза

   Бутен 15мм
   Цветение
   Инициация
   Кол-во семян
   Вес 100 семян

   2,5 до 3
   1,5 до 1,7
Площадь листовой поверхности (ПЛПП)

Листовая поверхность (м²)

Ф1
Макс. ПЛПП
Уменьшение листовой поверхности
Увеличение листовой поверхности
Время

Площадь листовой поверхности = ∫ ПЛПП (t) dt  (м²/день)

Требования подсолнечника к влагообеспеченности
Низкий уровень увлажнения почвы является основным ограничивающим фактором развития культур подсолнечника, т.к. в большинстве регионов мира, где выращивают подсолнечник, наблюдаются очень засушливые погодные условия.

Тем не менее, ответ подсолнечника на влагообеспеченность парадоксален:

- При ее дефиците, урожай снижается в расчете на количество семян и вес 1000 семян
- При избытке листовая поверхность увеличивается, что приводит к потерям воды и низкой эффективности водопользования

Водопотребление для различных культур без каких-либо ограничивающих факторов

<table>
<thead>
<tr>
<th>Культуры</th>
<th>Общее водопотребление</th>
<th>Оптимальное</th>
</tr>
</thead>
<tbody>
<tr>
<td>Кукуруза</td>
<td>520 мм</td>
<td>95 %</td>
</tr>
<tr>
<td>Подсолнечник</td>
<td>550 мм</td>
<td>75 %</td>
</tr>
<tr>
<td>Сорго</td>
<td>450 мм</td>
<td>90 %</td>
</tr>
<tr>
<td>Соя</td>
<td>480 мм</td>
<td>90 %</td>
</tr>
</tbody>
</table>
Периоды развития подсолнечника, наиболее чувствительные к засухе, по сравнению с кукурузой

Кривая зависимости урожайности подсолнечника от водообеспеченностии
Урожай R.ET / Урожай M.ET
Коэффициент потребления воды (КВ)

Определение: Количество воды, необходимое для производства биомассы (г/л)

\[ \text{КВ для сухой массы} = \frac{\text{Произведенная сухая масса}}{\text{Водопотребление}} \]

\[ \text{КВ для семян} = \frac{\text{Произведенная сухая масса семян}}{\text{Водопотребление}} \]

Как повысить КВ для семян?

\[ \text{КВ для семян} = \frac{\text{Произведенная сухая масса семян}}{\text{Общая произведенная сухая масса}} \times \frac{\text{Общая произведенная сухая масса}}{\text{Водопотребление}} \]

\[ \text{КВ для семян} = \text{Индекс урожайности (ИУ)} \times \text{КВ для сухой массы} \]
### Газообмен в зависимости от внесения влаги

<table>
<thead>
<tr>
<th>Внесение влаги:</th>
<th>Макс. ET</th>
<th>0,5 МЕТ чем прогрессивная адаптация</th>
<th>Макс ET Дефицит во время цветения</th>
</tr>
</thead>
<tbody>
<tr>
<td>Потребление воды (мм)</td>
<td>405</td>
<td>225</td>
<td>290</td>
</tr>
<tr>
<td>Общая сухая масса (г/растение)</td>
<td>111</td>
<td>120</td>
<td>96</td>
</tr>
<tr>
<td>Листовая поверхность (дм²/растение)</td>
<td>55,0</td>
<td>36,6</td>
<td>21,9</td>
</tr>
<tr>
<td>Водный потенциал (Мпг):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>почва</td>
<td>-0,3</td>
<td>-1,0</td>
<td>-0,3</td>
</tr>
<tr>
<td>листья</td>
<td>-0,7</td>
<td>-1,1</td>
<td>-1,1</td>
</tr>
<tr>
<td>Относительное содержание воды (% макс.)</td>
<td>93,1</td>
<td>85,4</td>
<td>88,0</td>
</tr>
<tr>
<td>Устойчивое сопротивление (с/см):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>верхняя сторона</td>
<td>0,50</td>
<td>0,42</td>
<td>0,43</td>
</tr>
<tr>
<td>нижняя сторона</td>
<td>1,15</td>
<td>0,72</td>
<td>0,82</td>
</tr>
<tr>
<td>Испарение (г/дм³/ч)</td>
<td>12,5 b</td>
<td>14,6 b</td>
<td>16,2 b</td>
</tr>
<tr>
<td>24,0 bc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Наблюденный фотосинтез (мг CO₂/дм²/ч)</td>
<td>1,9</td>
<td>3,1</td>
<td>1,9</td>
</tr>
<tr>
<td>Фотосинтез/испарение (х10³)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Адаптация подсолнечника к дефициту воды:

в экспериментальных условиях

![Graph showing adaptation of sunflower to water deficit under experimental conditions](image-url)
Адаптация подсолнечника к дефициту влаги

<table>
<thead>
<tr>
<th>Доступность влаги</th>
<th>Водное требление (л/пас)</th>
<th>Пр-во сухой массы (т/пас)</th>
<th>Сухая масса семян (т/пас)</th>
<th>Эфф-т для сухой массы (т/л)</th>
<th>Эфф-т для семян (т/пас)</th>
<th>Индекс урожайности семян</th>
</tr>
</thead>
<tbody>
<tr>
<td>Полная необходимая (оптимальная)</td>
<td>75,8</td>
<td>161</td>
<td>56,8</td>
<td>2,1</td>
<td>0,7</td>
<td>0,35</td>
</tr>
<tr>
<td>Полная до стадии F1, затем прогрессирующая млеватка</td>
<td>32,5</td>
<td>104,2</td>
<td>33,8</td>
<td>3,2</td>
<td>1</td>
<td>0,32</td>
</tr>
<tr>
<td>50 % от полной до стадии F1, а затем 50% от нее</td>
<td>16,1</td>
<td>67,4</td>
<td>23,3</td>
<td>4,2</td>
<td>1,4</td>
<td>0,35</td>
</tr>
</tbody>
</table>

Эффективность = количество массы (общей или семян), произведенного на литр используемой воды.
Индекс урожайности = отношение массы урожая к полной массе растений.

Повышение эффективности можно выразить через отношение «Фотосинтез / испарение»

![Graph showing the relationship between temperature and photosynthesis vs. evaporation](image-url)
Динамика фотосинтеза и испарения во времени в зависимости от доступа к влаге

Листевенная структура различных культур (1)

<table>
<thead>
<tr>
<th>Вид</th>
<th>Количество устьев на верхней стороне</th>
<th>Количество устьев на нижней стороне</th>
<th>Средний размер (L x l) (микрон)</th>
<th>Среднее расстояние на эпидермисе между 2 устьями (микрон)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Подсолнечник</td>
<td>65</td>
<td>156</td>
<td>38 x 7</td>
<td>91</td>
</tr>
<tr>
<td>Кукуруза</td>
<td>53</td>
<td>168</td>
<td>19 x 5</td>
<td>137</td>
</tr>
<tr>
<td>Пшеница</td>
<td>33</td>
<td>14</td>
<td>18 x 7</td>
<td>302</td>
</tr>
<tr>
<td>Соя</td>
<td>7</td>
<td>17</td>
<td>16 x 4</td>
<td>250</td>
</tr>
</tbody>
</table>
### Листевая структура различных культур (2)

<table>
<thead>
<tr>
<th>Вид</th>
<th>Устойчивость сопротивление (с/м)</th>
<th>Испарение (л/л/м2)</th>
<th>Водный потенциал листа (бар)</th>
<th>КВ для сухой массы (г/л)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Подсолнечник</td>
<td>60 - 100</td>
<td>4</td>
<td>-8</td>
<td>2,5</td>
</tr>
<tr>
<td>Кукуруза</td>
<td>200 - 300</td>
<td>3</td>
<td>-3</td>
<td>-</td>
</tr>
<tr>
<td>Пшеница</td>
<td>200</td>
<td>3</td>
<td>-4</td>
<td>-</td>
</tr>
<tr>
<td>Соя</td>
<td>80 - 120</td>
<td>3,8</td>
<td>-4</td>
<td>4</td>
</tr>
</tbody>
</table>

### Адаптация подсолнечника к дефициту влаги

- Перераспределение
- Позднее усвоение (ассимиляция)
- Листовая поверхность
- Водопотребление в конце периода цветения (л/растение)
### Изменение КВ и ИУ в зависимости от различных уровней дефицита влаги

<table>
<thead>
<tr>
<th>Водопотребление (л/расс)</th>
<th>Отношение</th>
<th>Сухая масса (г/расс)</th>
<th>Сухая масса семян (г/расс)</th>
<th>ВК / ОСМ (г/л)</th>
<th>ВК / СМС (г/л)</th>
<th>ИУ</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>1</td>
<td>161</td>
<td>57</td>
<td>2,1</td>
<td>0,7</td>
<td>0,35</td>
</tr>
<tr>
<td>32</td>
<td>0,42</td>
<td>104</td>
<td>34</td>
<td>3,2</td>
<td>1,1</td>
<td>0,33</td>
</tr>
<tr>
<td>29</td>
<td>0,40</td>
<td>80</td>
<td>24</td>
<td>2,7</td>
<td>0,8</td>
<td>0,30</td>
</tr>
<tr>
<td>28</td>
<td>0,37</td>
<td>96,5</td>
<td>30</td>
<td>3,5</td>
<td>1,1</td>
<td>0,31</td>
</tr>
<tr>
<td>22</td>
<td>0,30</td>
<td>74</td>
<td>27</td>
<td>3,3</td>
<td>1,2</td>
<td>0,36</td>
</tr>
<tr>
<td>16</td>
<td>0,2</td>
<td>67</td>
<td>23</td>
<td>4,1</td>
<td>1,5</td>
<td>0,34</td>
</tr>
<tr>
<td>12</td>
<td>0,16</td>
<td>52</td>
<td>19</td>
<td>4,3</td>
<td>1,6</td>
<td>0,36</td>
</tr>
</tbody>
</table>

Результаты получены с растений подсолнечника, выращенных в горшках (7л) в регулируемых условиях.

### Формирование основных компонентов урожая
Формирование урожая

Урожай = количество корзинок в 1м² x количество семян в одной корзинке x средний вес семян

Урожай = количество семян в 1м² x средний вес семян

Формирование урожая

Количество растений

⇒ Оптимальные величины между 5 и 8 растениями/м²

⇒ Потеря 1 растения не компенсируется

⇒ Прорастание семян будет более эффективным, если температура почвы > 8°C
Влияние плотности посева на характеристики головки

<table>
<thead>
<tr>
<th>Плотность посадки (растений/м²)</th>
<th>Диаметр корзинки (см)</th>
<th>Диаметр стебля (см)</th>
<th>Количество паразитов</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 3</td>
<td>&gt; 30</td>
<td>-</td>
<td>144</td>
</tr>
<tr>
<td>4 - 7</td>
<td>21 - 27</td>
<td>2,5 - 3,5</td>
<td>89</td>
</tr>
<tr>
<td>7 - 10</td>
<td>11 - 21</td>
<td>1,8 - 2,5</td>
<td>55</td>
</tr>
<tr>
<td>10 - 12</td>
<td>6 - 11</td>
<td>1,1 - 1,8</td>
<td>34</td>
</tr>
</tbody>
</table>

Un = Un-1 + Un-2

Влияние скорости сейки на урожайность и неравномерность распределения растений

<table>
<thead>
<tr>
<th>Скорость сейки (км/ч)</th>
<th>Урожай (ц/га)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
</tr>
</tbody>
</table>
Влияние неравномерного посева на урожай

<table>
<thead>
<tr>
<th>% посева</th>
<th>Урожай (процент от эталона)</th>
<th>Распределение растений в колонии</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>Равномерное распределение</td>
</tr>
<tr>
<td>95</td>
<td>91.8</td>
<td>Равномерное распределение, но с перекристаллизацией листовой поверхности 2 на 2</td>
</tr>
<tr>
<td>83</td>
<td>87.8</td>
<td>Неравномерное распределение с наклоном листовой поверхности</td>
</tr>
<tr>
<td>66</td>
<td>71.1</td>
<td>Важное наклонение и зерно распределение растений в ряду</td>
</tr>
<tr>
<td>50</td>
<td>70</td>
<td>Неравномерное распределение, в ряду изолированных растений</td>
</tr>
</tbody>
</table>

Формирование урожая

Количество семян

- Энергия культуры (листовая поверхность, сухая масса) на начальной стадии (B8 - B12)
- Рост культуры до цветения (максимально наблюдаемая для подсолнечника = 2000 семян на 1 растение)
- Водообеспеченность в начале цветения
- Площадь листовой поверхности в течение 30 дней после цветения для предотвращения появления пустых семян
Влияние нехватки воды на количество семян в различные периоды

Формирование урожая

Вес 1000 семян (40-60 г)

Площадь листовой поверхности с периода цветения до зрелости
Оптимальные величины = 90 м²/день (т.е.: индекс листовой поверхности 2 за 45 дней)

Для того же уровня ИЛП, если количество семян увеличивается, вес 100 семян снижается

ИЛП при цветении не превышает предел (оптимально 2,5-3)

Нет нехватки воды в период заполнения семян
Генетическое изменение веса 1000 семян

- Oscar
- Pordisol
- Vidoc
- Frankasol
- Albena
- IBH 166
- Euroflor
- Phaoran
- Flamme
- Viki
- Mirasol

70 - 80 г

30 - 40 г

Влияние различных уровней дефицита влаги на вес 1000 семян на разных стадиях

<table>
<thead>
<tr>
<th>Отношение ОП/Оп</th>
<th>0,3</th>
<th>0,4</th>
<th>0,5</th>
<th>0,6</th>
<th>0,7</th>
<th>0,8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Фаза 1 (F1)</td>
<td>НД</td>
<td>НД</td>
<td>-20%</td>
<td>-10%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Фаза 2 (F1-F4)</td>
<td>НД</td>
<td>-22%</td>
<td>-22%</td>
<td>-15%</td>
<td>-5%</td>
<td>-</td>
</tr>
<tr>
<td>Фаза 3 (F4)</td>
<td>-50%</td>
<td>-46%</td>
<td>-28%</td>
<td>-20%</td>
<td>-10%</td>
<td>-5%</td>
</tr>
</tbody>
</table>

НД = нет данных; ОП = Объемные потребности; ОП=Оп = относительные потребности.
Таблица 1: Характеристики некоторых семян в зависимости от их расположения на головке

<table>
<thead>
<tr>
<th>Расположение съедобных сердцевин</th>
<th>Вес семены (мг)</th>
<th>Белки (%)</th>
<th>Масло (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Снаружи</td>
<td>56,4</td>
<td>17,4</td>
<td>45,0</td>
</tr>
<tr>
<td>В середине</td>
<td>50,5</td>
<td>19,6</td>
<td>39,0</td>
</tr>
<tr>
<td>В центре</td>
<td>44,8</td>
<td>21,8</td>
<td>35,7</td>
</tr>
</tbody>
</table>

График 1: Урожай (т/га) в зависимости от веса на 1000 семян (г)

Уравнение линейной зависимости: $y = 0.27x$.
Отношение оболочки-сердцевины:
Стабильное свойство подсолнечника

<table>
<thead>
<tr>
<th>Сорт</th>
<th>Оболочка</th>
<th>Сердцевина</th>
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</thead>
<tbody>
<tr>
<td>Albéna</td>
<td>23,5</td>
<td>25,9</td>
</tr>
<tr>
<td>Euroflor</td>
<td>24,2</td>
<td>28,9</td>
</tr>
<tr>
<td>Flamme</td>
<td>28,9</td>
<td>27,6</td>
</tr>
<tr>
<td>Frankasol</td>
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<td>24,5</td>
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<td>IBH 166</td>
<td>27,6</td>
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<tr>
<td>Viki</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Значения компонентов урожая:

Сильный генетический эффект:

Сорта с большим весом 1000 семян и низким количеством семян на 1м²

- 5 - 7000 семян/м²
- Вес 1000 семян: 55 - 65 г

Сорта с небольшим весом 1000 семян и высоким количеством семян на 1м²

- 7 - 9000 семян/м²
- Вес 1000 семян: 40 - 45 г
Последовательное внесение компонентов урожая в конечный продукт

Потенциальный урожай
45 - 55 ц/га

Кол-во семян/м²
9 - 12 000

Вес 1000 семян

Кол-во головок
6,8 - 7/м²

Кол-во растений
6,5 - 7/м²

Кол-во посевных семян

% фертилизации (опыление)
(80 - 90)%

Потенциальное кол-во семян в головке
2 000

Урожай подсолнечника сильно зависит от поведения листовой поверхности после цветения

Индекс листовой поверхности

Оценка цветения

Кол-во дней после окончания цветения
Листовая поверхность: Ключевой аспект поведения подсолнечника
Регулирование листовой поверхности с последующим регулированием площади листовой поверхности

Индекс листовой поверхности на стадии F1:
Достаточно 2,5

Площадь листовой поверхности со стадии F2 до стадии физиологической зрелости
90 м².д

Связь между площадью листовой поверхности после цветения и урожаем
ИЛП: индекс листовой поверхности;
PЛП: площадь листовой поверхности
Динамика аккумуляции масла в период со стадии цветения до стадии зрелости

Влияние орошения на содержание масла

<table>
<thead>
<tr>
<th>Внесение воды</th>
<th>Масло (%)</th>
<th>Стадия для орошения</th>
</tr>
</thead>
<tbody>
<tr>
<td>Не орошается</td>
<td>45,5</td>
<td>bc</td>
</tr>
<tr>
<td>1 орошение</td>
<td>42,5</td>
<td>c</td>
</tr>
<tr>
<td>2 орошения</td>
<td>53,1</td>
<td>a</td>
</tr>
<tr>
<td>3 орошения</td>
<td>47,4</td>
<td>b</td>
</tr>
<tr>
<td>Оптимальное орошение</td>
<td>52,6</td>
<td>a</td>
</tr>
</tbody>
</table>

а.b.c. : Тест NK при 5%
Стратегия орошения в зависимости от уровня ИЛПП, ожидаемого на стадии цветения

Стадии:
1: полное всходы; 2: Бутон ~2 см; 3: F1; 4: F4; 5: физиологическая зрелость

Стратегия орошения в зависимости от уровня ИЛПП, ожидаемого на стадии цветения

Стадии:
1: полные всходы; 2: Бутон ~2 см; 3: F1; 4: F4; 5: физиологическая зрелость
Кривая зависимости от воды (орожения) может быть выше, если регулировать ИЛП

Урожай: шт/га
Неорожаемая — Орожаемая

2000: 2.7 шт/га для 100 мм (высокий ИЛП на стадии F1)
2001: 13.7 шт/га для 100 мм (регулируемый ИЛП, но зависит от климатических условий)
2003: 13.7 шт/га для 100 мм (регулируемый ИЛП, но с сильными требованиями к климатическим условиям)

Качество роста подсолнечника во Франции:
Пятилетнее исследование

Примеси (%)

Содержание воды (%)

Содержание масла (%)

Протеин (% в муке)

% кислотности
Sunflower crop (English)

**SUNFLOWER**

**The Plant**

- **CYCLE:** In France 120 to 150 days according to variety type and sowing dates
- **Total needs in cumulative temperature° (basis 6°C):** 1,500 to 1,700 °C according to genotype
- **Flowering starts 65 to 70 days after emergence (850 °C)
- **CYCLE:** 5 key periods:
  - Sowing to emergence
  - Emergence to 5 pairs of leaves
  - 5 pairs of leaves – beginning of flowering
  - Flowering
  - Seed filling
The plant

period from sowing to emergence

Length: 7 to 20 days according to soil moisture and temperature
(mini 4°C and optimum 8°C)

period from emergence to 5 pairs of leaves

Zero vegetation: 6°C
Sensitivity to low temperatures:
At cotyledon stage: sunflower resists −6 to −7°C
After 1 pair of leaves: temperatures below 0°C = necrosis

Capital period to establish a crop with a good potential

The plant

period from emergence to 5 pairs of leaves (continuation)

Rooting system implementation (A1 to B8)
- duration: around 30 days
- very sensitive to soil structure problems
- water and nutrients absorption depends on rooting system implementation

Foliar primordia implementation
- 18 to 20°C/day for one foliar primordia
- initiation of 20 to 30 leaves according to genotypes
- water stress induces foliar initiation variation

Flower primordia implementation (B8 to B12)
- duration: 20 to 25 days (→ immature bud above the nearest leaf)

KEY-PERIOD: VEGETATIVE BUD changes to REPRODUCTIVE STAGE: FLOWERING INITIATION
- disturbed by low T°C (giving head malformations).
**The plant**

- Period from 5 pairs of leaves to beginning of flowering
  - High requirements
  - Period of high biomass accumulation: 200 kg/ha/day
  - Duration: 40-50 days
  - Very high foliar expansion

  Water and nitrogen availability: essential factors controlling the foliar surface implementation and its persistency

- Flowering
  - Duration: 9 days/plant
  - 15-20 days at the field level
  - End of the rooting system development
  - Maximum foliar surface at beginning of flowering
  - Head = main absorbing well for assimilates
  - Plant sensitive to water stress during flowering
  - Plant sensitive to sclerotinia contamination on head

---

**The plant**

- Seeds filling (F4-M3)
  - Proteins redistribution from stem and leaves to the seeds
  - Oil synthesis
  - Total dry matter produced: 10-15 t/ha for yield of 3 t/ha
**KAZAKHSTAN: Technical Assistance to the Sunflower Seed Sector**

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**The plant**

(in French conditions)

- **Sowing - 10-20 days**
  - emergence and cotyledons appearance

- **30 days**
  - 5 pairs of leaves

- **40 days**
  - beginning of the floral initiation

- **50 days**
  - stage "Star-like"

- **60 days**
  - end of floral initiation
  - bud above the nearest leaf (diameter 5 to 8 cm)

---

**The plant**

(in French conditions)

- **70-80 days**
  - beginning of flowering
  - bending of the floral bud
  - ray flower appearance

- **90-100 days**
  - end of flowering
  - fall of ray flowers
  - back of the head still green

- **140-150 days**
  - physiological maturity
Yield components

Number of plants

- Optimum between 5 to 8 plants/m² with a homogeneous distribution.
- No compensation when plant missing at emergence
- Quick germination if soil $T^\circ > 8 \, ^\circ C$.

Yield components

Main component: number of seeds
determined by:

- Plant vigor during the formation of the floral primordia (B8 to B12).
- Plant growth before flowering (limit 2 000 seeds/plant).
- Water availability at the beginning of flowering: any stress induces seed abortion
- Good functioning of the foliar surface for the 30 days after flowering; this ensures the potential seed number.
Yield components

- Weight of 1000 seeds (40 to 65 g)

Permits only a partial compensation for an insufficient number of seeds

Depends on:

- Leaves functioning after flowering according to genotype
- For the same Fl (Foliar Index) decreases if the number of seeds increases.
- No excessive Fl at flowering stage (2.5 to 3 max)
- Water availability for the seed filling period.

Yield components

- Number and weight of seeds are different according to genotypes (varieties)
  - Variety with heavy weight of 1000 seeds and low number of seeds/m²
    - 5 to 7000 seeds/m²
    - weight of 1000 seeds: 55 à 65 gr
  - Variety with high number of seeds/m² and low weight of 1000 seeds
    - 8 to 10 000 gr/m²
    - weight of 1000 seeds: 40 à 45 gr
Yield components

- Number of plants
- Main component: number of seeds
- Weight of 1000 seeds

Soil preparation

The goal is:

To Obtain a deep and loose soil to maximize a deep root growth

1- Work when soil is well drained.
2- Reduce soil compaction by limiting the number of runs with tools.
3- Prefer tools with teeth: discs induce compaction areas especially in wet conditions.
Conventional tillage or minimum tillage?

1- Conventional tillage (Plowing)
   - Loose soil or beating soil, plow just before sowing.
   - Heavy soil, clay soil, plow during summer or autumn.

Plowing = Good mixing of the organic matter
Incorporated herbicides easy to use,
Needs high power tractors and working time

2- Minimum tillage

Possible in soils without compaction (In these situations, yields equivalent to conventional tillage method of cultivation).
More attention is requested (slugs, weeds)
Difficulties of incorporation of pre-sowing herbicides due to surface residues.

Weed control

Pre-emergence products are necessary

Association of a incorporated pre-sowing product (Triflurin) followed by a pre-emergence product remains the basis of the chemical weed control.
Weed control: Select the good product and the right application method

- Weed control starts before sowing:
  - During the rotation (Thistle, horsetail...)
  - During the soil preparation against weed regrowth after plowing using a non-selective herbicide (sowing without new soil preparation): False-sowing

- Pre-emergence products are necessary

- No solution against broadleaves after emergence, except with Challenge 600 (Aclonifen)

  Narrow-leaves: Several efficient products are available

Which weed control programme?

Sort in decreasing order the 4 to 5 main weeds and select the right herbicide against them

- Incorporated Treflan (Tritluralin) then pre-emergence herbicide such as:
  - Afalon (Linuron)
  - Other products: Racer (Fluochloridone)
  - Challenge 600 (Aclonifen)
  - Phare (Aclonifen + Oxdiazon)
  - Nickeyl (Aclonifen + Flurtamone)
Chemical weed control in one application

- Increasingly used method (saves time,...).
- Pre-emergence product with full dose application
- Association with Prowl and Duelor (Prowl 2.5 l + Racer 2 l...).
- Chemical weed control method more sensitive to climatic conditions (drought).

Hoeing: a complementary weed control method

Hoeing is efficient against annual broadleafes resistant to herbicides.

- Must be done at early stage
  Sunflower stage 1 to 2 leaves, weeds stage plantlet
- Permits to spray herbicide only on the row (band-applied)
  Saves up to 60% of the full dose of herbicide
- It breaks soils crust, aerates the soil stimulating the crop growth
  2 applications are necesssary: at cotyledons stage, then at stage 5-6 pairs of leaves.
**Variety selection**

To obtain the highest yield, stable from year to year, for the lower production cost

Hybrids replaced O.P. varieties because of their increased yield, pest resistance, uniformity, and self compatibility

The selection criteria

- Agronomical characteristics compatible with the environment.
  - Variety cycle duration adapted to types of soil and sowing dates.
    - Select very early or early maturing varieties

- Diseases tolerance:
  - Phomopsis stem canker
  - Sclerotinia diseases (head, bud, neck)
  - Downy mildew

Select a variety with low sensitivity to these diseases.

Only new varieties resistant to downy mildew must be planted

- Yield stability from year to year.
- Yield potential.
- Seed oil content.
KAZAKHSTAN: Technical Assistance to the Sunflower Seed Sector

Sunflower
Pneumatic precision planter

Planting

- Sow when the soil temperature reaches 8 to 10°C (In France from End of March to mid May according to region and type of soil).
- Planting depth: Between 2 and 3 cm. Must be adapted to type of soil: 4 to 5 cm in sandy soil.
- Reduce speed during sowing to ensure a good seed positioning.
- Plant population: plant a maximum of 75000 plants / ha. The goal is to obtain 55 to 60000 emerged plants well distributed.
- Row spacing: 50 to 60 cm.
- Protect against slugs immediately after sowing.
- Protect seedlings against soil insects (wireworm, Tipula, blanula, scutigerella) and diseases (downy mildew and botrytis).
Germinating seedling protection

The goal is to obtain a quick and vigorous emergence. The protection against slugs must be done all over the field at sowing time. Crop damages at beginning of emergence are never compensated.

The period sowing-emergence is sensitive to soil pest mainly slugs and wireworms

- Slugs:
  - Dangerous because of the low plant density: 6/m²
  - May affect seed in germination, cotyledons, hypocotyls of young plants, which are cut off.
  - Hypocotyl damages = wilted or dead plants

- Wireworms
  - Less damages than slugs because during the actual sunflower sensitivity period (germination to 1 to 2 pairs of leaves) larvae are not really active.
Control the slugs infestation before sowing

Avoid soil insufficiently compacted, cloddy, seedbed with high content surface crop residue.

- If a severe attack is expected: Apply molluscicide on the soil at sowing or immediately after, before rain and always before emergence.
- Keep watch on all fields during emergence especially if the soil is wet.
- Do not use pesticides if not necessary because some molluscicides have nocive effects on the soil fauna (night crawlers, ground beetles,...).

How to detect slugs?

- Using direct observation (early in the morning slugs are visible on soil or plants)
- Applying a molluscicide on a few m² and checking dead slugs
- Using a trap with few granules of molluscicide.
Control aphids and Wireworms at sowing

In risky situations (sowing after grassland for example):

- Seed dressing (Régent TS).
- Local treatment during sowing.
- Overall treatment with Schuss (expensive solution).

Diseases control

- Against downy mildew (Plasmopara halstedii):

  - If the variety is not genetically resistant to present Mildew races, seeds must be protected by a fungicide (Apron = Metalaxyl).
  - Fungicide treatment is efficient, but the active period could be too short.
  - Volunteers must be destroyed in all other crops to avoid secondary contaminations.
  - Variety genetically resistant to new Mildew races don’t need to be protected by a fungicide.
Against Botrytis (Botrytis cinerea)
grey mould on grain and plantlets

- Seed dressing with fungicide: Benlate, Konker, Ronilan, Silbos and Thirame.

- These treatments are not effective against Pythiums, rhyzoctonia and diseases on aerial vegetative parts.

Fertilisation

Sunflower fertilisation management must be done according to:

- Sunflower nutrients total needs (N) or exports (P2O5, K2O).

- Type of soil and level of nutrients available for the crop.

- Organic fertiliser applied.
Fertilisation: Good use of the soil nitrogen by the sunflower crop

0 to 80 units of nitrogen depending on type of soil and year

- Sunflower needs mainly nitrogen between stage 5 pairs of leaves and beginning of flowering (F1).
- Due to its strong rooting system, sunflower is able to use nitrogen from deep layers of soil.
- Maximum needs: 150 kg/ha for a yield of 30 q/ha. Average, 4.3 u/q of grains.
Fertilisation : Good use of the soil nitrogen by the sunflower crop

- The dose of nitrogen fertilisation must be the complement to the Nitrogen available in the soil.

- How to define the nitrogen dose:
  - Superficial soil and rainy winter: Low nitrogen remains in the soil → Apply a higher dose.
  - Winter with low rainfall: Higher remains in the soil → Reduce the dose.

Fertilisation : Good use of the soil nitrogen by the sunflower crop

- Nitrogen dose must be limited, any excess will:
  - Increase diseases problems: sclerotinia, phomopsis and botrytis.
  - Increase lodging
  - Delay physiological maturity.
  - Decrease oil content

- Superficial soil (40 to 60 u)
- Deep soil (0 to 40 u)

- After harvesting nitrogen remainder is low (high nitrogen content in exported seeds)
**Fertilisation: phosphate and potash**

- Low amount exported through the seeds:
  - About 44 units of P₂O₅ and 30 units of K₂O with a yield of 35 q/ha.
- Good ability to extract phosphate and potash from the soil:
  - Crop with moderate potash needs and low phosphate needs
- How to define the phosphate and the potash doses:
  - Soil test to estimate the quantity of nutrients available for the crop,
  - Take into consideration remainder from previous crop (Organic matter and fertilisation level)
- Average doses of fertilisers: 40 to 60 u from P₂O₅ and K₂O

**Fertilisation: boron**

- Total needs are similar to those of the sugarbeet: 400 g/ha
- Maximum requirements between 5 pairs of leaves and floral bud
  - Total needs: 400 g/ha
  - Exports: 80 g/ha
  - Restitutions: 320 g/ha

- Risk factors:
  - pH > 7
  - More than 10% of active limestone
  - Light and permeable soils; thin soil:
    - If pH (water) > 7, deficiency threshold = 0.5 ppm
  - Sandy soil:
    - If pH (water) < 7, deficiency threshold = 0.3 ppm
    - If pH (water) > 7, deficiency threshold = 0.6 ppm
Fertilisation: boron

Risk thresholds:
Calcareous soil (>10% active limestone).
- Deficiency threshold: 0.5 ppm
- Risk between 0.5 to 0.8 ppm
Non calcareous soil (total limestone < 5%)

Clay or loamy soils:
- If pH (water) < 7, deficiency threshold: 0.2 ppm
- If pH (water) > 7, deficiency threshold: 0.5 ppm

Sandy soils:
- If pH (water) < 7, deficiency threshold: 0.3 ppm

Inputs:
- to the soil before sowing: 1.2 to 1.5 kg/ha
- foliar application (B10 to bud stage): 0.5 kg/ha

Fertilisation: boron

Deficiency symptoms description:
- Deformed head or multi-flowering
- These symptoms may be also due to low temperature during floral primordia period (stage 10 – 12 leaves)
- Yellowing and/or dying of leaves
- Head fall
  - Below the head, cuts on stem, which can enlarge into open cracks.
- Bad seed setting
  - Smaller size of head or abnormal stand – Black (normal) and white (empty) seeds.
- Lodging and growth decreasing
  - Weak stem, reduction of the neck diameter.