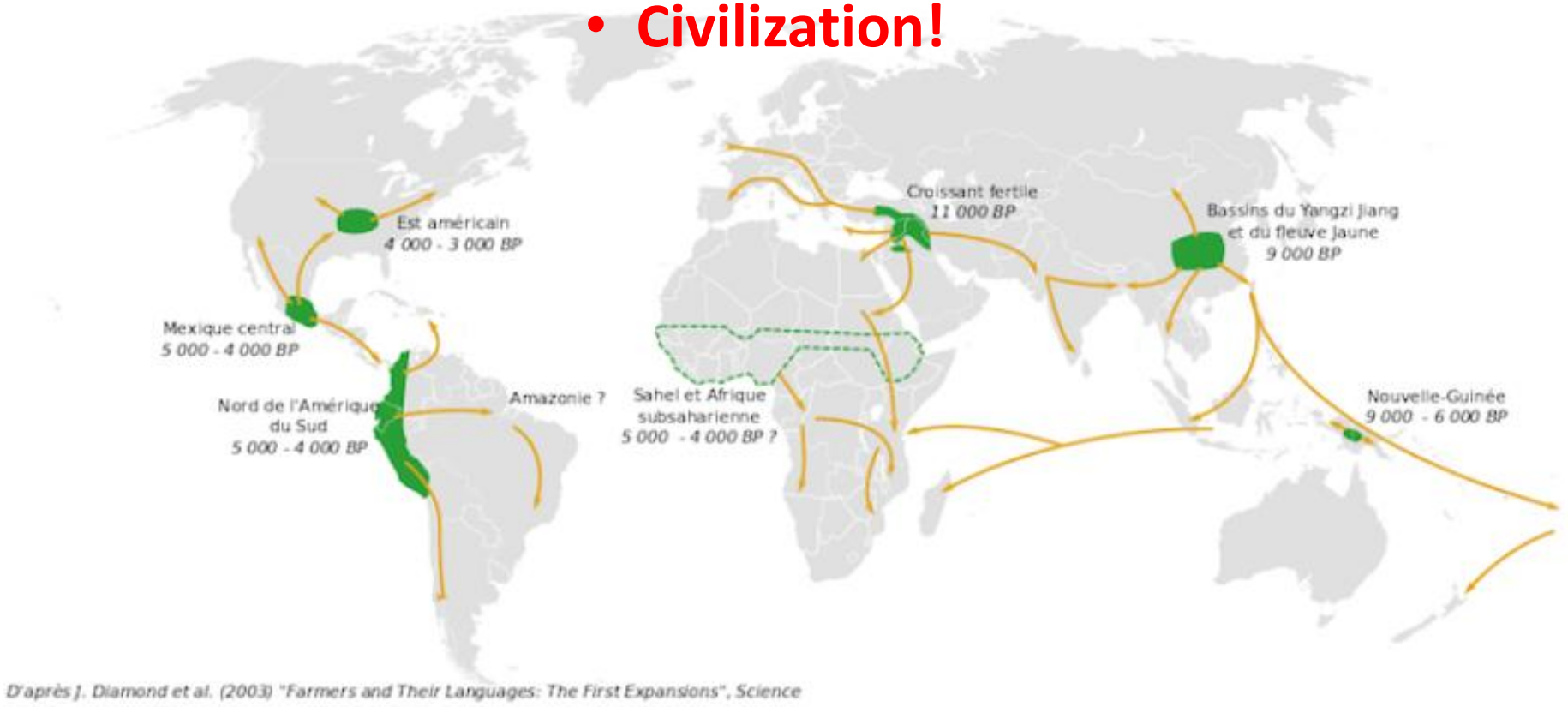
SEED PRODUCTION, BIOLOGY AND QUALITY

Dr Vladimir Miklič

Beginning of agriculture

- Plant cultivation began when there were shortfalls of easily accessible wild grass harvests.
- About 11,000 years ago, a thousand-year drought settled over the Middle East. So, people began to plant seeds to improve natural stands and to do selection.
- Genetic changes in the plants that made harvesting more controllable followed.
  - **How to keep selected genotypes and genetic changes?**
  - **With the help of seeds!!!**
  - **What was the consequence of all this?**
  - **Civilization!**

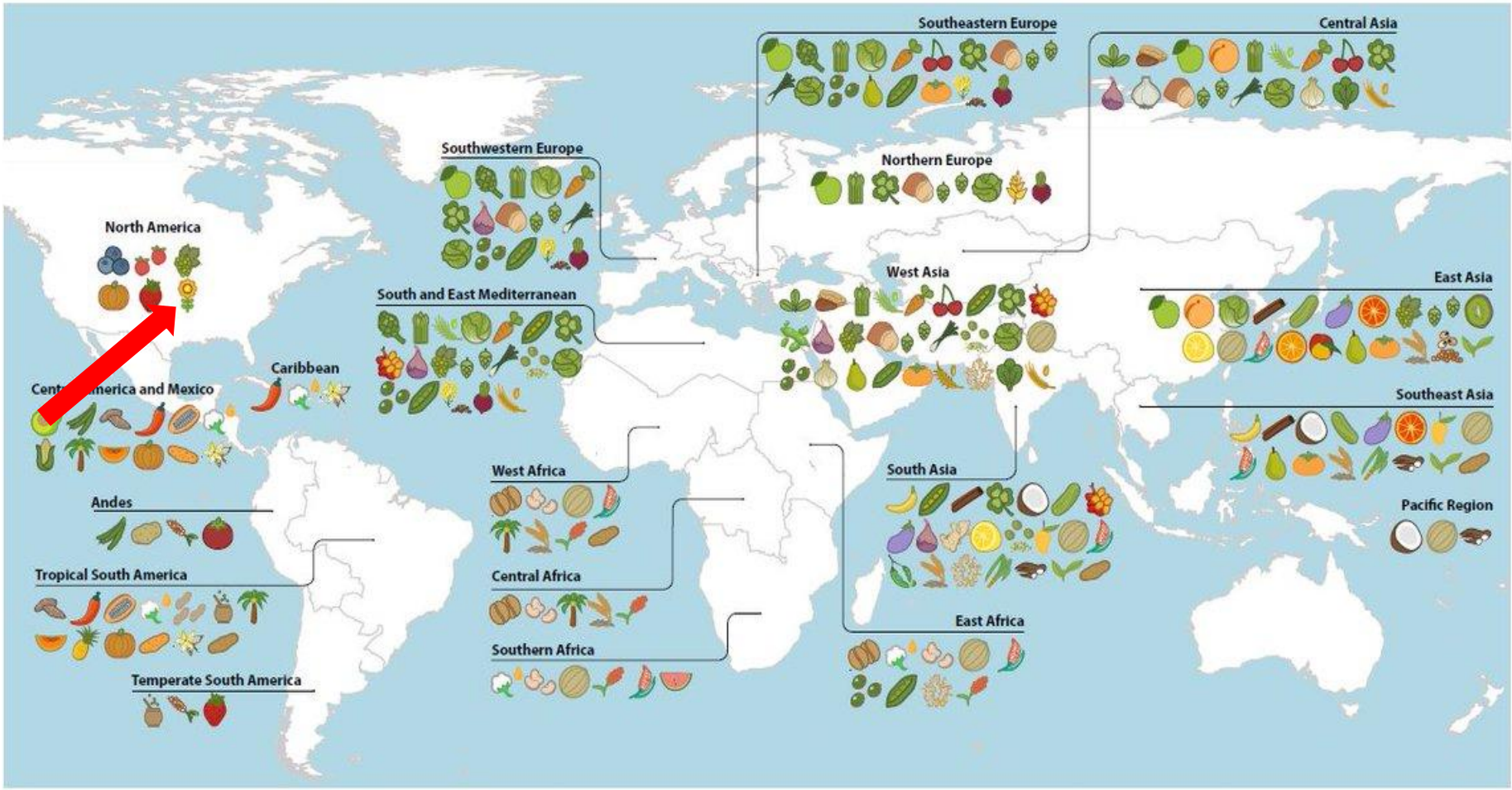


Centres of origin and spread of agriculture.

ORIGINS AND PRIMARY REGIONS OF DIVERSITY OF AGRICULTURAL CROPS

Khoury CK, Achicanoy HA, Bjorkman AD, Navarro-Racines C, Guarino L, Flores-Palacios X, Engels JMM, Wiersema JH, Dempewolf H, Sotelo S, Ramírez-Villegas J, Castañeda-Álvarez NP, Fowler C, Jarvis A, Rieseberg LH, and Struik PC (2016). Origins of food crops connect countries worldwide. Proc. R. Soc. B 283: 20160792. DOI: 10.1098/rspb.2016.0792.

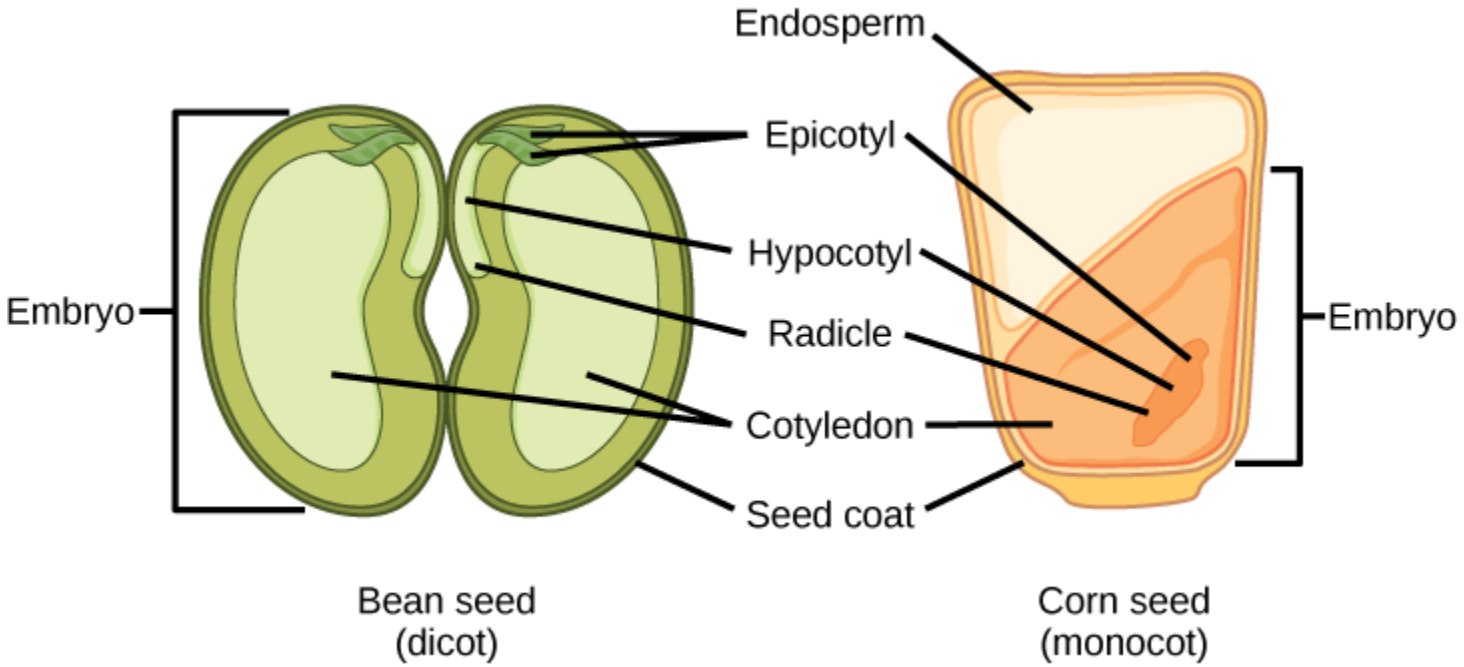
CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change



- Alfalfa
- Almonds
- Apples
- Apricots
- Artichokes
- Asparagus
- Avocados
- Bananas & plantains
- Barley
- Beans
- Blueberries
- Cabbages
- Carrots
- Cassava
- Cherries
- Chickpeas
- Chillies & peppers
- Cinnamon
- Clover
- Cocoa beans
- Coconuts
- Coffee
- Cottonseed oil
- Cowpeas
- Cranberries
- Cucumbers
- Dates
- Eggplants
- Faba beans
- Figs
- Garlic
- Ginger
- Grapefruit
- Grapes
- Groundnut
- Hazelnuts
- Hops
- Kiwi
- Leeks
- Lemons & limes
- Lentils
- Lettuce
- Maize
- Mangoes
- Mate
- Melons
- Millets
- Oats
- Olives
- Onions
- Oranges
- Palm oil
- Papayas
- Peaches & nectarines
- Pears
- Peas
- Pigeonpeas
- Pineapples
- Plums
- Potatoes
- Pumpkins
- Quinoa
- Rape & mustard seed
- Rice
- Rye
- Sesame
- Sorghum
- Soybean
- Spinach
- Strawberries
- Sugar beet
- Sugarcane
- Sunflower
- Sweet potatoes
- Taro
- Tea
- Tomatoes
- Vanilla
- Watermelons
- Wheat
- Yams

SEED

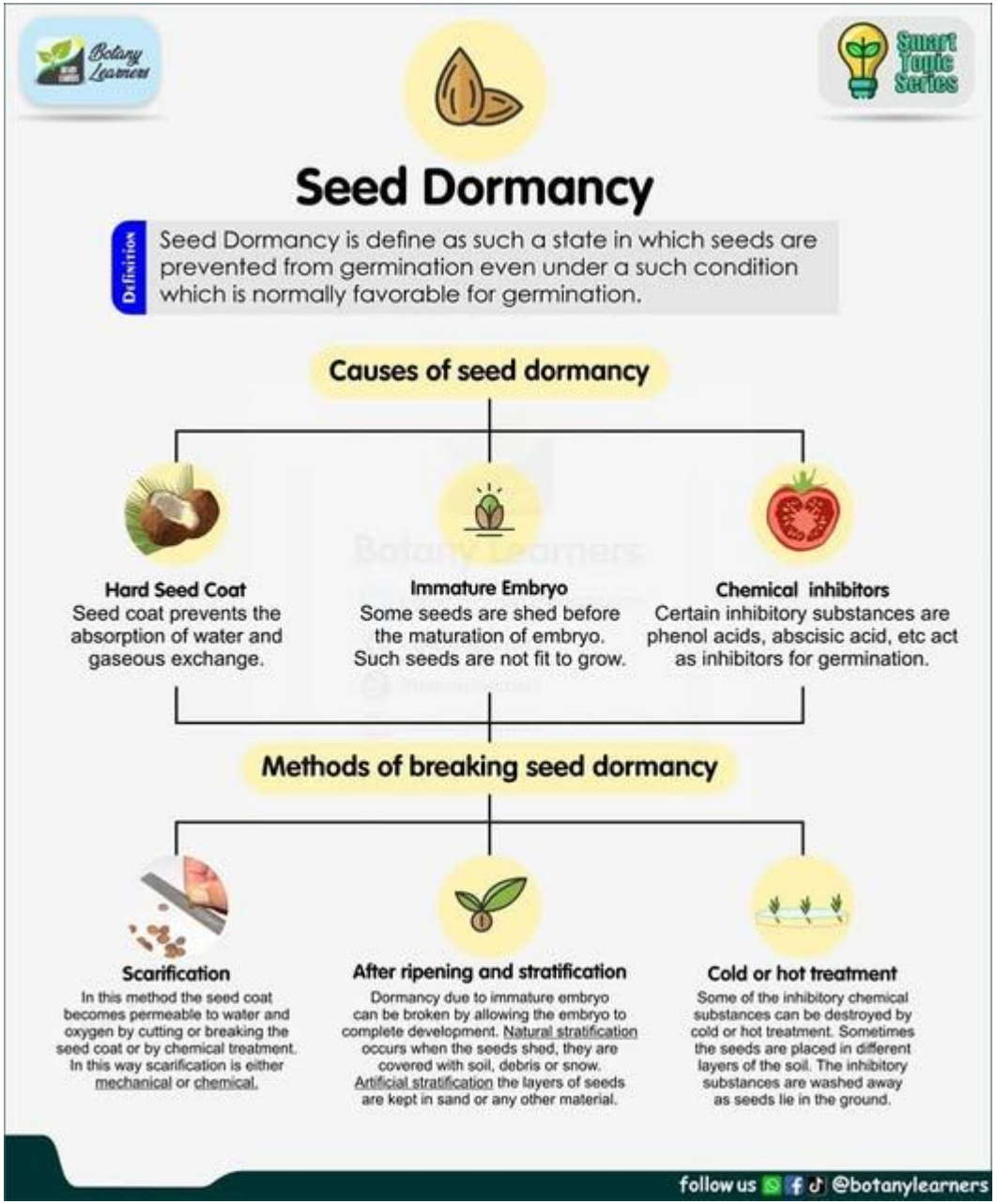
- A seed is a reproductive plant organ that arises after fertilization from a seed embryo and contains an embryo (germ of a new plant), reserve nutrients and a protective seed coat.
- Its basic function is plant reproduction, i.e. survival in unfavorable conditions and germination of a new plant when conditions become favorable.



SEED DORMANCY

- Seed dormancy is the inability of a viable seed to germinate under favorable conditions, serving as a crucial survival mechanism that allows plants to delay germination until environmental conditions are optimal for seedling survival and growth.

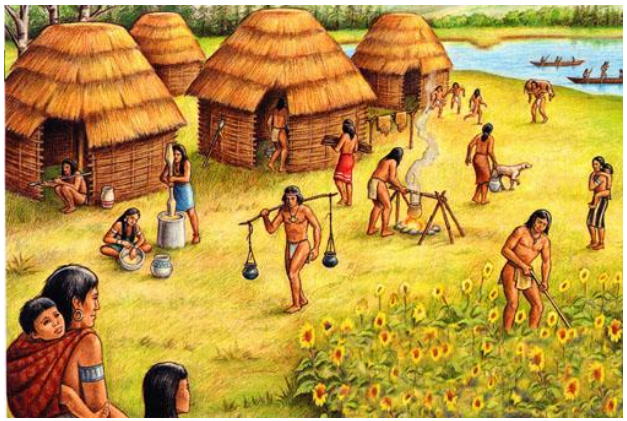
- Dormancy is a genetically controlled trait, influenced by environmental factors and plant hormones like abscisic acid (ABA) and gibberellins (GA), and it ensures plants can distribute their offspring across time, increasing their chances of success in unpredictable environments.



SEED PRODUCTION

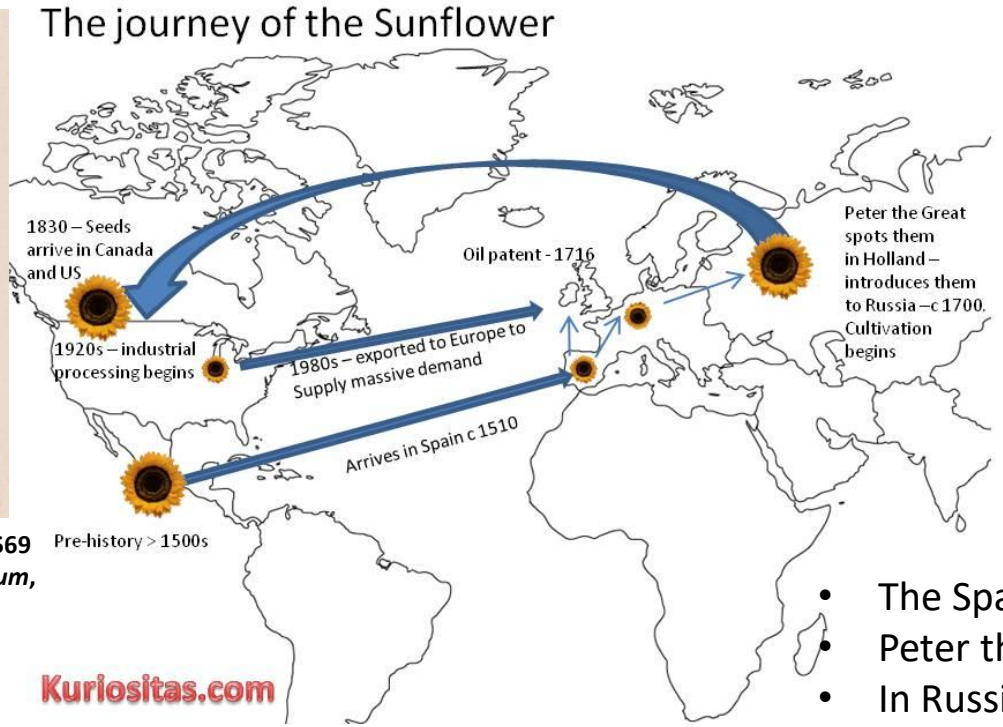
- Seed production is the systematic process of cultivating and harvesting seeds from selected plant varieties to ensure a supply of high-quality, genetically pure, and viable seeds for future planting.
- It involves selecting superior parent plants, multiplying the seeds through various stages, and ensuring quality through testing, processing, and certification before they reach farmers and gardeners.
- This process is fundamental to agriculture, providing the essential starting material for crop growth and maintaining genetic diversity within agricultural systems.

HISTORY OF SUNFLOWER CULTIVATION



The first evidence of sunflower cultivation dates back to 2600 BC.

Rembert Dodoens, 1569
Florum, et coronariarum,



Anthony van Dyck – self portrait with sunflower.1632.

- The Spanish brought it from America in 1510.
- Peter the Great brought it to Russia in 1700.
- In Russia as an oil plant since 1818.
- The first varieties created in Russia in 1912.

SUNFLOWER SPECIFICITIES OF IMPORTANCE FOR SEED PRODUCTION

- Open polinated plant
- An entomophilous plant
- Honey producing plant
- Flowers are bisexual
- Flowering in rings 5-10 days
- Susceptible to diseases
- Existence of husk and problems in harvesting and processing of seeds

Breeding field
Novi Sad Institute

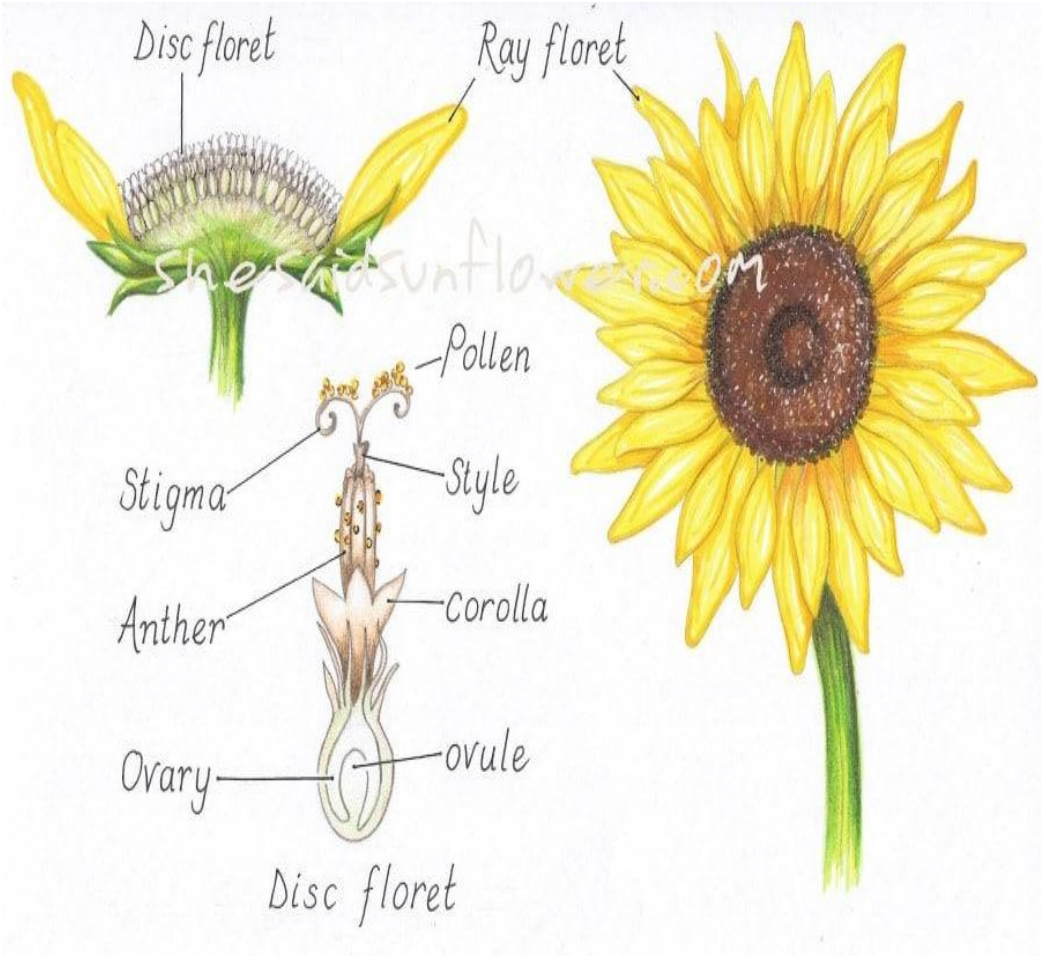
BASIC GOALS IN SUNFLOWER SEED PRODUCTION, WHAT KIND OF SEEDS SHOULD BE PRODUCED?

- Genetically and physically pure seed
- Physiologically mature seed
- High germination seeds
- Stress tolerant seeds
- Healthy seeds
- Seeds clean from weeds and other seeds

Sunflower seed crop

BIOLOGY OF SUNFLOWER FLOWERING

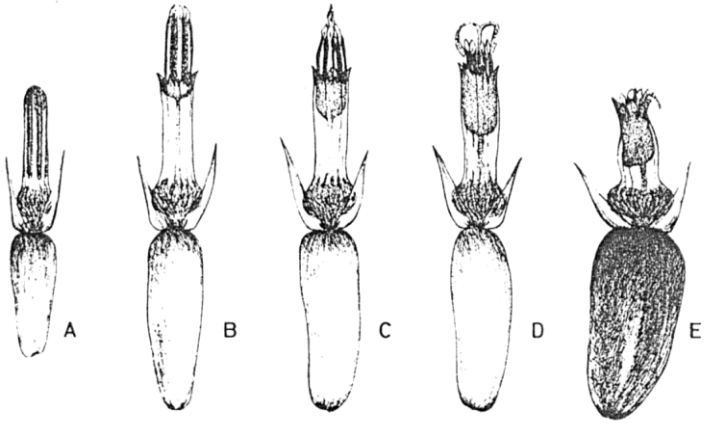
- Flowers collected in an inflorescence - head
- Ray floret around the rim (infertile, metamorphic), disc floret in the middle (fertile)
- Number of disc florets 600-1200, sometimes up to 4000
- Inflorescence formation begins at the stage of 5-7 pairs of leaves
- Flowering takes place in zones, usually lasting 5-7 days per head and 10-12 days in the plot



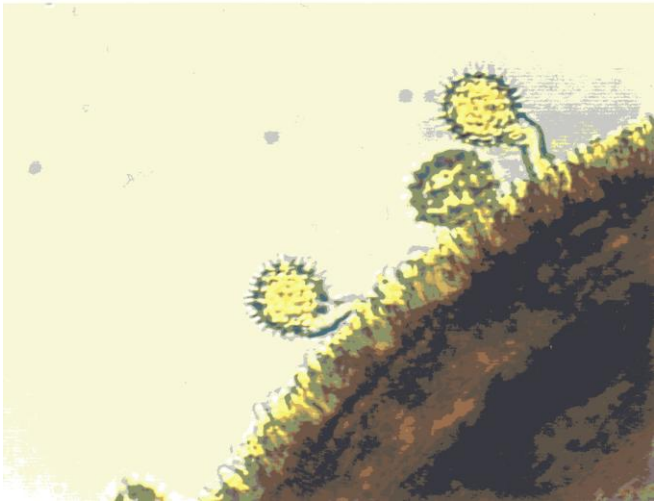
BIOLOGY OF SUNFLOWER FLOWERING- 2

The life cycle of a disc floret lasts 1 to 1.5 davs

- 1. The initial stage of button opening in the early morning hours (3-4) ž
- 2. Anther emergence between 4 and 6 o'clock in the morning;
- 3. Opening of anthers and shedding of pollen grains between 6 and 8 in the morning (temperature):
- 4. Occurance of the stigma in the evening between 5 and 7 o'clock;
- 5. Opening of the stigma (ball halves) between 7 and 9 in the evening;
- 6. Flowering and withdrawal of the stigma in the first half of the next day (if fertilization has occurred).



Disc floret flowering



Pollen germination on stigma

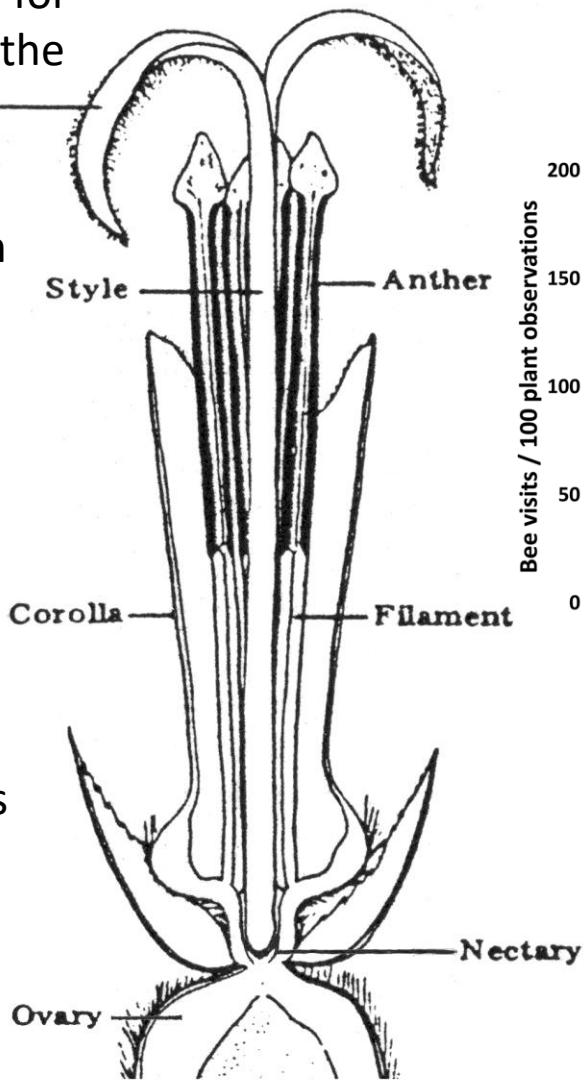
COROLLA LENGTH

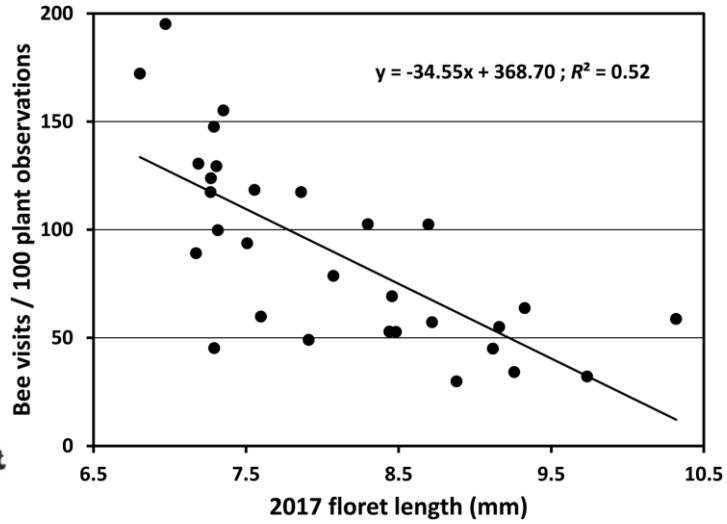
Inbred lines had larger variablity for corolla length 7.9-11.1mm than the hybrids 8.6-9.6mm

There was significant corellation between corolla length and honeybee visitation

The mean functional length of the honey bee proboscis is approximately 7 mm (Waddington 1987).

Floret lengths shorter than 10 mm should not restrict access as depth is at 70% of floret length





Miklič et al. 2003. Effects of genotype and growing conditions on several parameters of sunflower attractiveness to bees.

Portlas et al. 2018. Variation in floret size explains differences in **wild** bee visitation to cultivated sunflowers. Plant Genetic Resources: Characterization and Utilization, 16(6), 498-503.

WORK ON THE CREATION OF SUNFLOWER HYBRIDS

- The first sunflower hybrids created on the basis of nuclear male sterility were created in France (1969) and Romania (1971 – first hybrids in the world produced at commercial scale)
- 1969 - discovery of the source of cytoplasmic male sterility (cms) PET1 (*Leclercq*) and of gen responsible for restoring ferility (*Kinman*, 1970)
- First commercial hybrids based on cms in Romania 1974, and in Yugoslavia 1978

Patrice Leclercq

Hybrid sunflower seed production based on cms

OPEN-POLLINATED VARIETIES OR HYBRIDS?

Advantages of open-pollinated varieties over hybrids:

- **Larger ecological plasticity..**
- **Simpler and less expensive breeding procedures, shorter development cycle.**
- **Larger disease resistance spectrum.**
- **Better economic efficiency of seed production.**
- **Cheaper seed for planting.**

Advantages of hybrids over open-pollinated varieties:

- **More intense heterosis for yield and other important traits**
- **Uniformity (maturity, height, resistance (to diseases, herbicide..) seed qualities).**
- **More modern and efficient breeding: - trait incorporation.**
- **More efficient biotech transformation.**
- **Sunflower product diversification.**

Stoenescu, F. (2002) https://www.isasunflower.org/fileadmin/documents/Symposia/2nd_Symposium_Sunflower_2002/Stoenescu.pdf

The biggest advantage for seed companies:
farmers can't use their own seeds for new planting
But we are also facing with more difficult seed production

SEED PRODUCTION OF VARIETIES

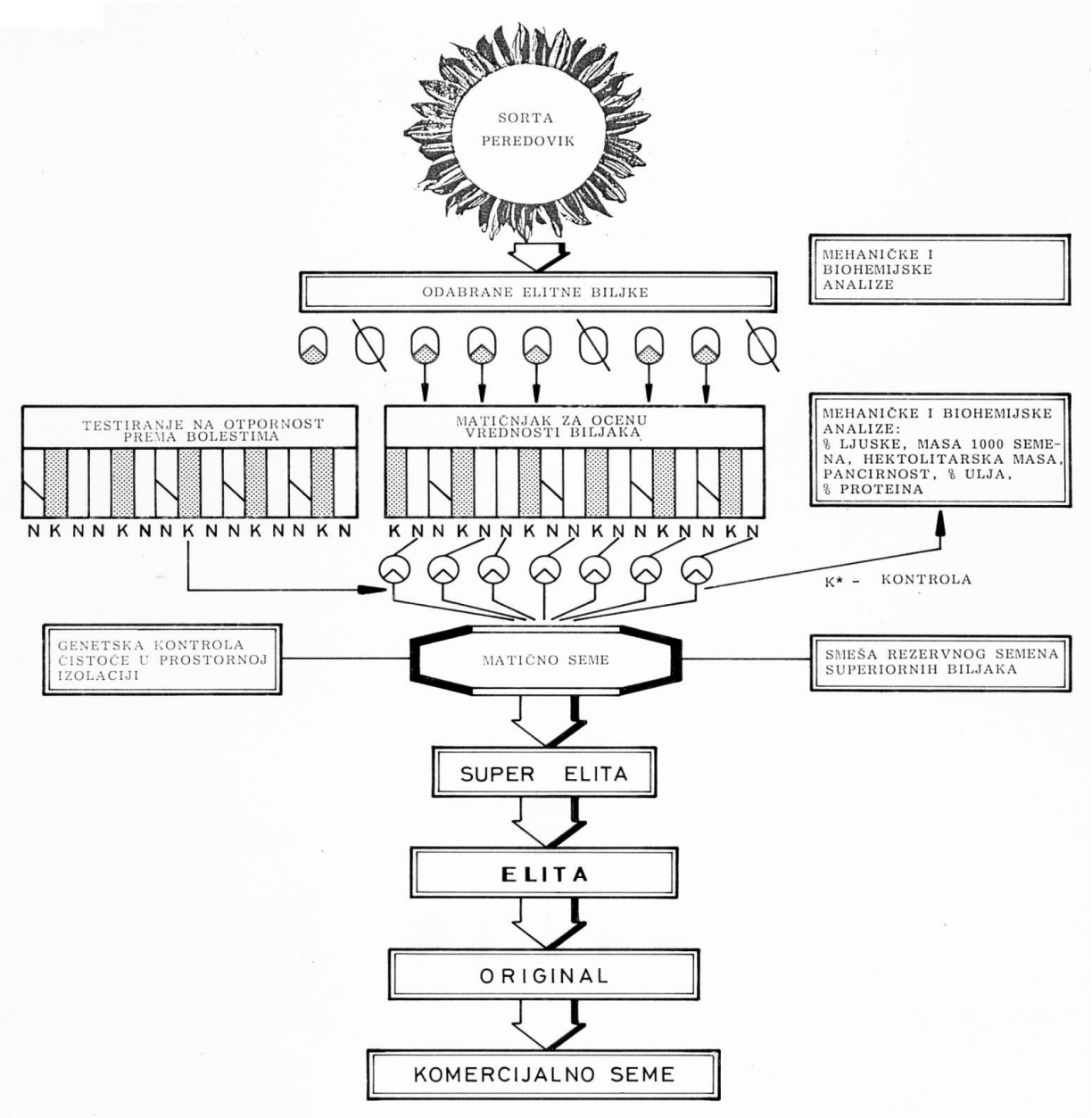
In Serbia we dont grow sunflower varieties

The cycle lasts 6 years

1. Establishment of lines, selection of 1-2000 elite plants with shell % below 25%, oil content above 50%, high weight of 1000 seeds, tick husk graphite layer...
2. The broodstock for progeny evaluation is sown in 300-600 selected heads, usually with the control rows, in parallel the broodstock for checking disease resistance is sown on the infected board. At the end, the yield is measured and mechanical and chemical analyzes are performed.
3. Production of parent seed mixture of reserve seed of selected plants is sown in isolation 1500 m with strict observance of crop rotation. Atypical and diseased plants are removed three times.
4. Production of superelite mother seed is multiplied according to the same principles
5. The production of elite super elite seeds is multiplied according to the same principles as the previous multiplication
6. The production of the original elite seed is multiplied according to the same principles as the previous multiplication

New seed categories: pre-basic seed, basic seed and C1

Schematic diagram seed production cycle in varietal populations



BREEDING OF HYBRIDS BASED ON CYTOPLASMIC MALE STERILITY

- Made possible by the discovery of a source of CMS in wild sunflower (Leclercq, 1969)
- The phenomenon of heterosis (hybrid vigor of the F1 generation) is used for practical purposes
- It started in Romania and Yugoslavia for the first time in the world
- The female line must have built-in CMS and the male line must have restorer gen

B analogue A analogue

Fertile and sterile analogue

TYPES OF SUNFLOWER HYBRIDS

- Depending on the number of inbred lines participating in one hybrid, there are the following types of hybrids:
- 1. Two-line (SC) hybrids: (A h Rf)
- 2. Three-line (TWC) hybrids ((A x B1) x Rf)
- Four-line (DC) hybrids are not produced in sunflower, because the seed production process is very complicated and not economically justified. In addition, in four-line hybrids, the effect of heterosis is reduced and, as a rule, they are less productive than two-line and three-line hybrids.
- In two-line hybrids, for the production of hybrid seeds, the cytoplasmic male-sterile form A- of the female line and the male line-restorer are used in a certain row ratio.
- For the production of three-line hybrids, three lines are used: first, the A-sterile form of one line is crossed with the B1-fertile form of the other line and a sterile hybrid is obtained. This sterile hybrid is crossed with the corresponding restorer line and thus the hybrid seed of the three-line hybrid is obtained.
- In our country, exclusively two-line sunflower hybrids are grown

MAINTENANCE AND PRODUCTION OF FEMALE LINES (A X B)

- Based on the evaluation of general and special combining abilities, the best inbred lines were selected for translation into cytoplasmic male sterile (CMS) form or A-form. An inbred line into which CMS is to be introduced is crossed with the CMS donor inbred line. In the next generation, the resulting hybrid plant, which is sterile, is backcrossed with the recipient inbred line. Further backcrosses are made in the following years. Individual crossings are made in each generation, and plants that are typical for the respective recipient line are selected for the crossings. After the completion of backcrosses (BC6-8) the inbred line has two forms:
- cytoplasmic male sterile
- fertile form
- These two forms of one inbred line are absolutely identical in terms of their morphological and genetic characteristics except for the CMS property.
- Then, individual typical plants of A and B analogues are selected and placed in the seed multiplication process. The obtained 50 plants of the B analogue and 200 plants of the sterile analogue are isolated with isolators before flowering, and then a cross is made with a mixture of pollen from the B plants. Crossings are done manually

MAINTENANCE AND PRODUCTION OF FEMALE LINES (A x B)-2

4. The following year, in a spatial isolation of at least 3 km, 4-10 rows of A form and 2-4 rows of B form are sown alternately. This is how the female line pre-basic seed is obtained
5. The next year, it is multiplied again according to the same principle and the basic seed of the female line is produced. The A form will serve as a mother in the production of hybrids and the B form for the repeated cycle of basic seed production

Sterile analogue flower

MAINTENANCE AND PRODUCTION OF RF LINES

- For the practical use of CMS-based heterosis in the past, inbred lines with good general and special combination abilities were also translated into the Rf-form, i.e. the form that possesses the gene for fertility restoration. However, in modern sunflower breeding, breeders started creating restorer populations that already have this gene in a homozygous state. The main reason for this is that it turned out to be extremely important that these lines, in addition to desirable good agronomic characteristics and good combining abilities, are also recessive branched. Namely, recessive branching allows us to obtain unbranched hybrid plants, and the flowering period of the male line is extended to 3-4 weeks.
- After selecting a suitable restorer line as a component of the hybrid, a single typical plant is selected and placed in the seed multiplication process. The obtained 250 plants of the restorer line are isolated with isolators before flowering and subjected to self-fertilization.
- Parent (breeder's) seed is sown the following year in spatial isolation in order to obtain pre-basic seed
- The pre-basic seed is sown the following year in spatial isolation

SEED PRODUCTION TECHNOLOGY OF PARENTAL LINES AND HYBRID SUNFLOWER

Features of the production area

1. - fertile lands
2. - sufficient amount and good distribution of precipitation
3. - moderate climate without extreme temperatures in vegetation
4. - avoid areas at risk due to disease
5. - avoid concentration of production due to risk (!!!)

Choice of producers

1. - choose the best manufacturers
2. - equipped with machinery
3. - the manufacturer must be registered to perform seed production

PROVISION OF SPATIAL ISOLATION

- Sunflower – an open pollinated entomophilous plant
- Spatial isolation enables controlled fertilization
- The problem of small plots and wild sunflowers
- The number of pollen grains per plant can exceed 100 million
- Ineffectiveness of herbicides on wild sunflower
- The size of the required isolation is also influenced by the structure of the pollinators present
- In Serbia, the minimum isolation is 1.5 km for C1, and 2 km for production of basic seed (lines)

THE MOST IMPORTANT SUNFLOWER POLLINATORS

If spatial isolation is not followed, uncontrolled fertilization occurs, which is observed in the following season.

PLOT SELECTION

- Favorable water-air regime
- Flat plots without depressions
- Plots close to hard roads
- Avoid heavy, cold and acidic soils
- Avoid weedy and infected soils
- Choose a plot where sunflowers have not been grown for at least 6 years and soybeans and rapeseed for at least 3 years
- Pay attention to herbicides applied to the pre-crop (atrazine on corn...)
- Small grain the best previous crop (with soil pest control)

Characteristics of parental lines that should be known in order to determine the method of sowing, row ratio, sowing time, sowing rate, required number of hives, etc.

- The influence of sowing time and latitude on the length of vegetation
- Number of days from emergence to flowering
- Flowering length of female and male lines
- Compatibility of parent components
- Attractiveness to pollinators
- Germination and germination energy
- 1000 seeds weight
- Percentage of atypical plants in male and female lines
- Percentage of fertile plants in female line

FERTILIZATION AND SOIL CULTIVATION

- Basic and pre-sowing soil cultivation, as in mercantile production
- For a yield of 1000 kg/ha of sunflower, it is 40-50 kg N, 15-20 kg P2O5, and 80-100 kg K2O. At the same time, through crop residues, sunflower returns 40-50% N, 30-40% P2O5, and 80-90% K2O to the soil. (Crnobarac et al., 1999)
- P and K are introduced in the fall and N before sowing, part of it can also be fed in the phase of 3-6 pairs of leaves.
- Caution with nitrogen due to excessive growth
- If necessary, add trace elements (Boron)

Plowing or...

direct sowing?

The direction of the rows is north - south

PROTECTION AGAINST PESTS IN SOWING

- Special danger with two-phase sowing
- If there are more than 2 wireworms per hectare, treatment is mandatory
- It can be treated over the entire surface, in strips or seed treatment
- Prevention of bird attacks:

repellents (Mesurol) or hiring hunters

Wireworms damage(*Elateridae*) on sunflower seedlings

Weed protection in sowing
weeds problem in vegetation due to competition, weed seeds must not be present in the seed

- Application of appropriate herbicides in incorporation or before emergence
- Due to the sensitivity of the lines, reduce the doses by 20%
- Application of herbicides in vegetation is mostly only for narrow-leaved weeds
- Clearfield technology Pulsar 40 in the IMI crop
- Often necessary hoeing
- Resistance to tribenuron metyl (Express/SUMO)

Weedy sunflower crop

SOWING

- Time of sowing - when the temperature of the soil at the depth of the sowing layer has reached 8-10 degrees Celsius
- Sow as fast as possible (2-4 days)
- The ratio of female and male lines in the production of hybrid seeds is from 8:2 to 14:2, depending on the branching of the male and the attractiveness of the lines to pollinators. Plan the sowing time so that the male line starts flowering 3 days before the female line
- The ratio of female and male rows in the production of basic seed from 4:2 to 8:2, sowing both analogues simultaneously to be sown
- The direction of the rows is preferably north-south
- Sowing depth 4-5 cm depending on seed size, sowing time and quality of soil preparation
- Row spacing 70 cm (Argentina 50 cm), between male rows if necessary more - for easier destruction after flowering
- Optimum crop density generally 55-60000 plants/ha

THE FIGHT AGAINST WEEDS

Narrow-leaved weeds are no longer a problem

Broadleaf weeds are still a big problem

HERBICIDE RECOMMENDATION THEN

ili
Frontier super 1-1,4 L/ha
ili
Dual Gold 960EC 1,4-1,5 L/ha
+
Racer 25-EC 1,5-2 L/ha
ili
~~Afalon tečni 1,5-2 L/ha~~
ili
~~Prometrin SC 2-2,5 L/ha~~
ili
~~Raft 1-1,25 L/ha~~

Gardoprim plus gold 500 SC 3-3,5 l/ha

AND NOW
+
Vibala

For conventional hybrids!

~~Roundap~~

~~Treflan EC 2 l/ha ili Stomp 330-E 5 l/ha~~

+

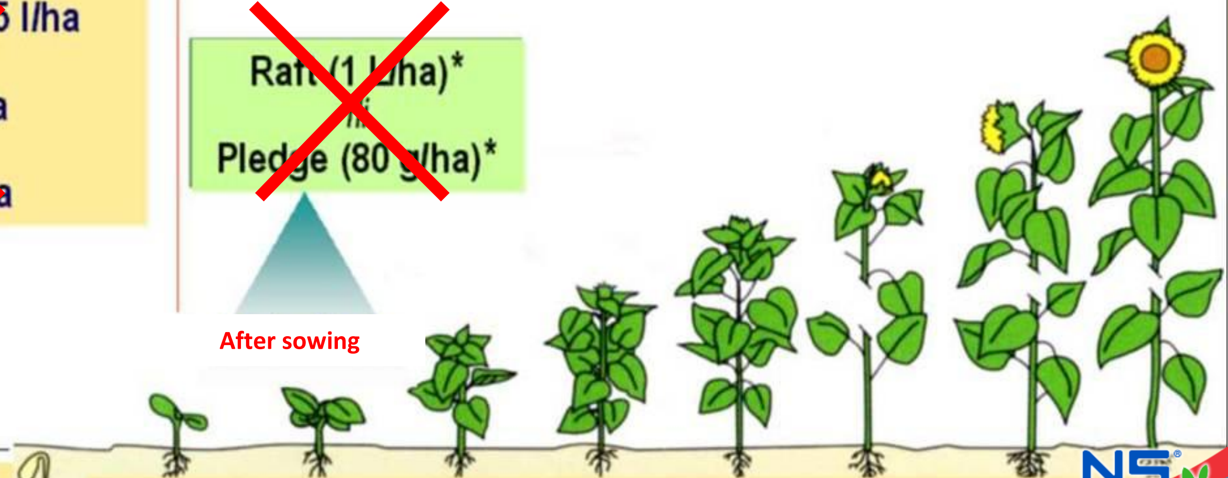
Racer 25-EC 1,5-2 l/ha
ili
~~Afalon tečni 2 l/ha~~
~~ili~~
~~Prometrin SC 2-2,5 l/ha~~
~~ili~~
~~Goal 0,5-1 l/ha~~
~~ili~~
~~Raft 1-1,25 l/ha~~

~~Raft (1 L/ha)*~~
~~ili~~
~~Pledge (80 g/ha)*~~

Incorporation before sowing

after sowing before emergence

After sowing



HYBRIDS TOLERANT TO HERBICIDES

IMAZAMOX
(Pulsar® 40 and Passat®)
(PulsarPlus®)

TRIBENURON-METIL
(Express® 50 SX)

Clearfield® Production System

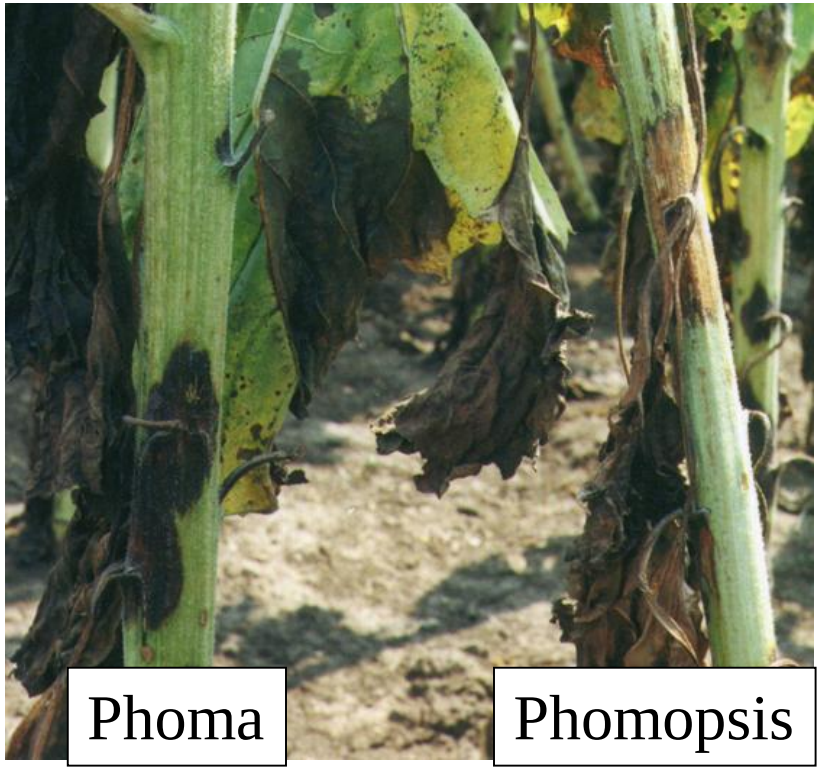
Clearfield® Plus Production System

SUMO

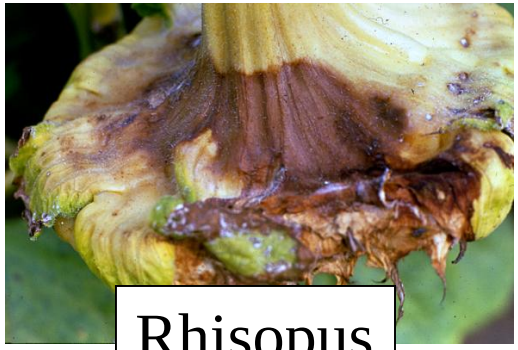
SUNFLOWER DISEASES

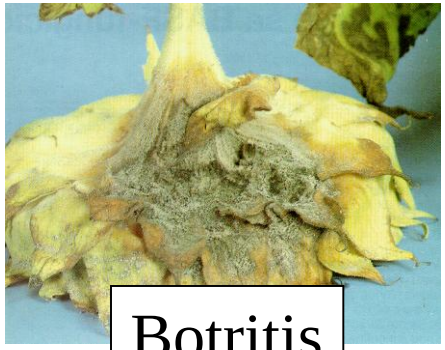

Sclerotinia

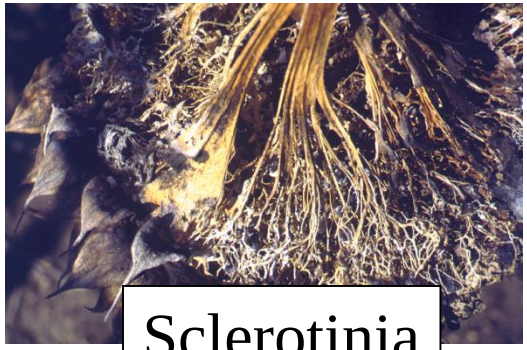

Sclerotinia


Phoma

Phomopsis


Rhisopus


Botritis


Sclerotinia

DISEASE CONTROL MEASURES

- The most important measure is crop rotation
- 2-3 treatments in vegetation, the first in the phase of 5-6 pairs of leaves, the second in budding, the third after flowering
- Best with tractor sprayers, it can also be done by plane
- Combinations of systemic and botricidea

Do not treat in flowering stage!!

OTHER CROP CARE MEASURES

- At least two inter-row cultivations, one at the stage of 3-4 pairs of leaves, the other at the stage of 6-7 pairs of leaves
- It is best to fight against broomrape by growing resistant hybrids or hybrids resistant to herbicides from the imidazolinone group (Clearfield system).
- Irrigation in the emergency phase (if necessary, due to the coincidence in flowering), in the bud phase (to get higher nectar production). Do not water too often in order to develop the deep roots and not to provoke the development of diseases
- Hand hoeing

POLLINATION AND FERTILIZATION

- Sunflower is an entomophilous plant
- Sunflower pollen is heavy - only 4% of wind fertilization
- Bees are the main pollinator in Europe
- Pollinators necessary for the transfer of pollen from male to female in both F1 and basic seed production
- Without pollinators, yields decrease by over 90%

SUNFLOWER POLLINATION

- Sunflower is an open pollinated entomophilous plant
- In the production of sunflowers without pollinators, the yield can be drastically reduced
- The NS Institute was the first in Serbia, more than 30 years ago, to provide pollinators with financial compensation
- Bees are brought no later than 2-3 days before flowering
- At least 2-3 (today even 4) hives/ha
- Bees should be protected, avoid all treatments during the flowering period!!

When there are no pollinators, fertilization is done manually - India 2006

The attractiveness of sunflowers to bees

The color of the flower

Aroma

sense of sight

attractiveness

sense of smell

Pollen

Nectar

Pollination - Higher yields

The color of the flower

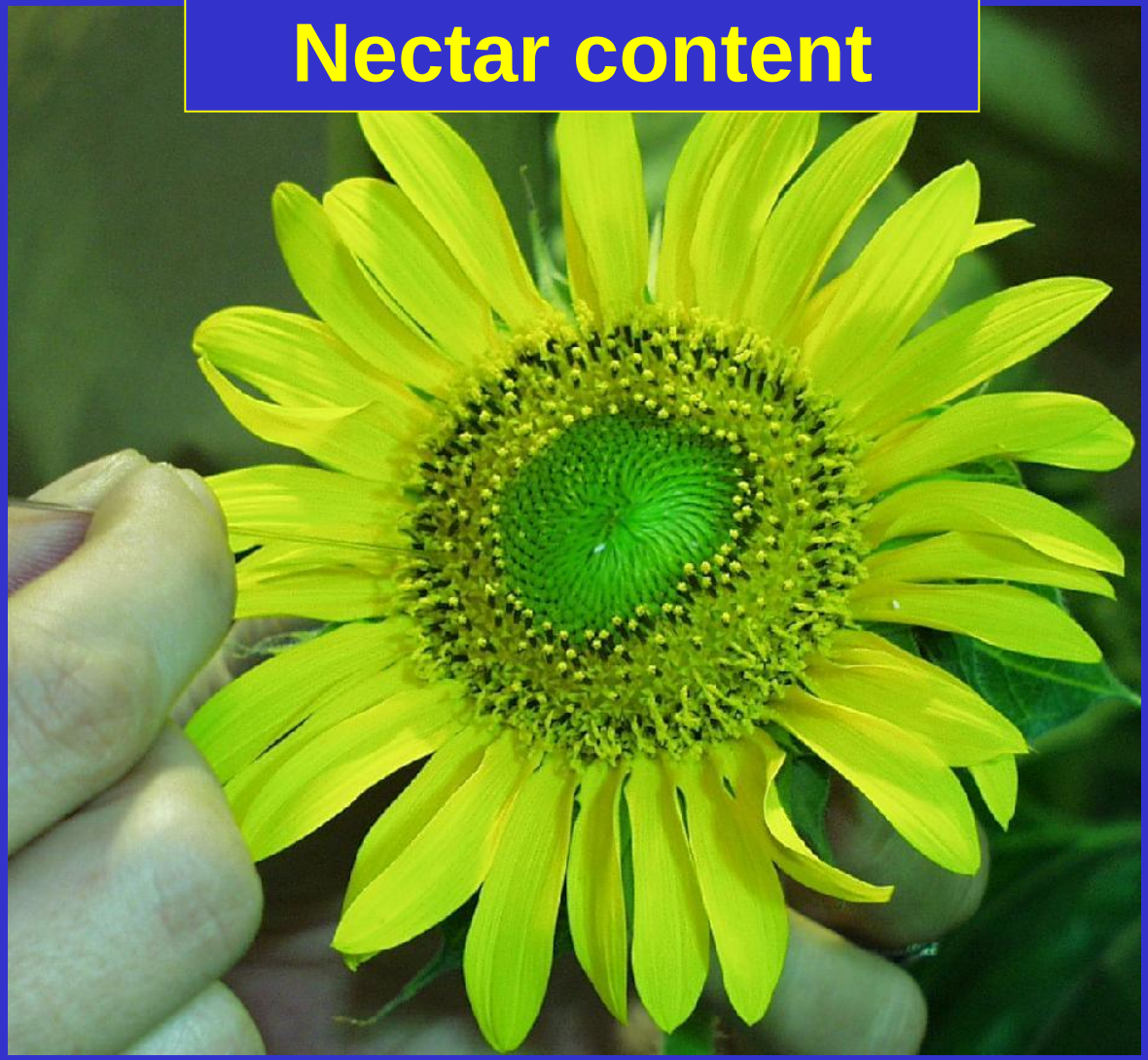
Aroma - terpenoids

SUNFLOWER PRODUCES ABOUT 80 KG OF POLLEN PER Ha.

(0,3-0,6 MG POLLENA/FLOWER)

POLLEN SOURCE OF PROTEINS, CONTENS 10% OF SUGAR TOO

Nectar content



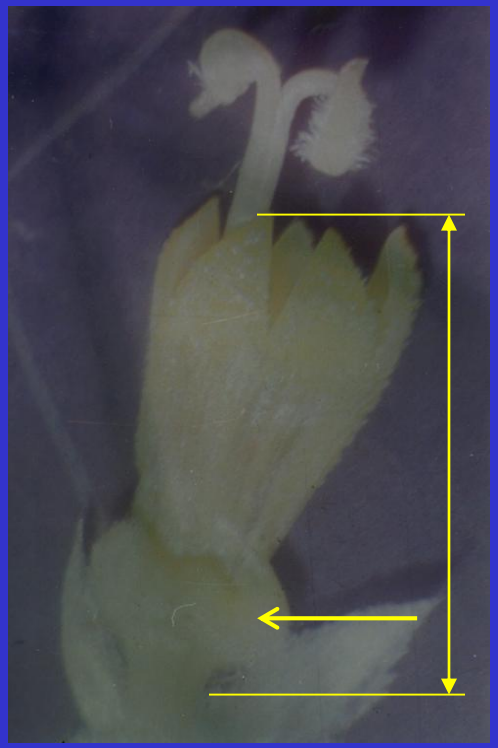
0.1-0.8 microliters/flower

45-75% dry matter

sugar content - amount of nectar

The length of the corola affects the availability of nectar and the visit of bees

The part of the oral apparatus used by the bee to take nectar is 6.46 mm long (Balana et al., 1992).

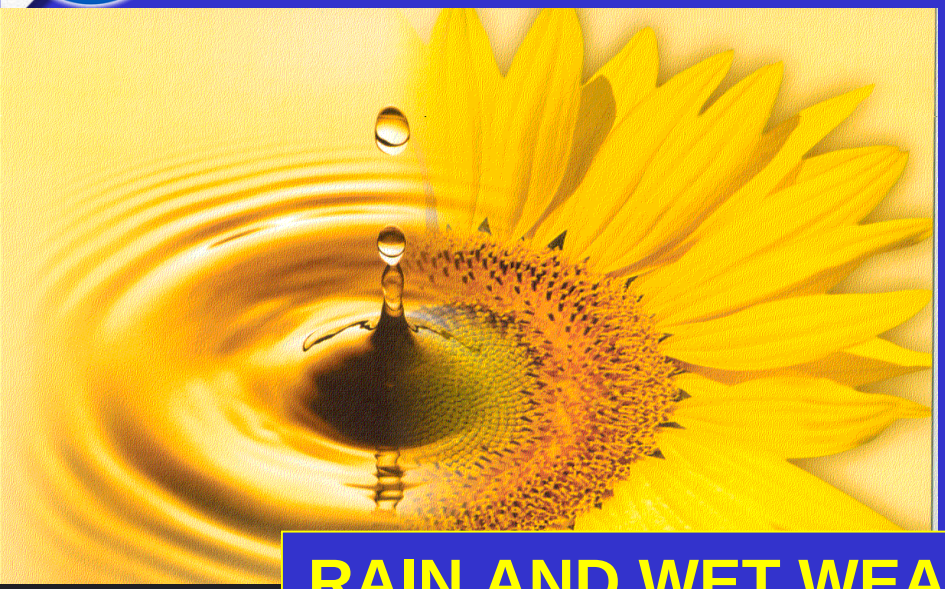


Average corolla lenght *(Atlagić et al.,1996)*:

A analogue	8,08 mm
B analogue	8,75 mm
Rf line	8,31 mm

Conditions for visiting bees and secreting nectar:

1. Air temperature
2. Air humidity
3. Soil moisture
4. Sunlight
5. Wind
6. Crop cultivation

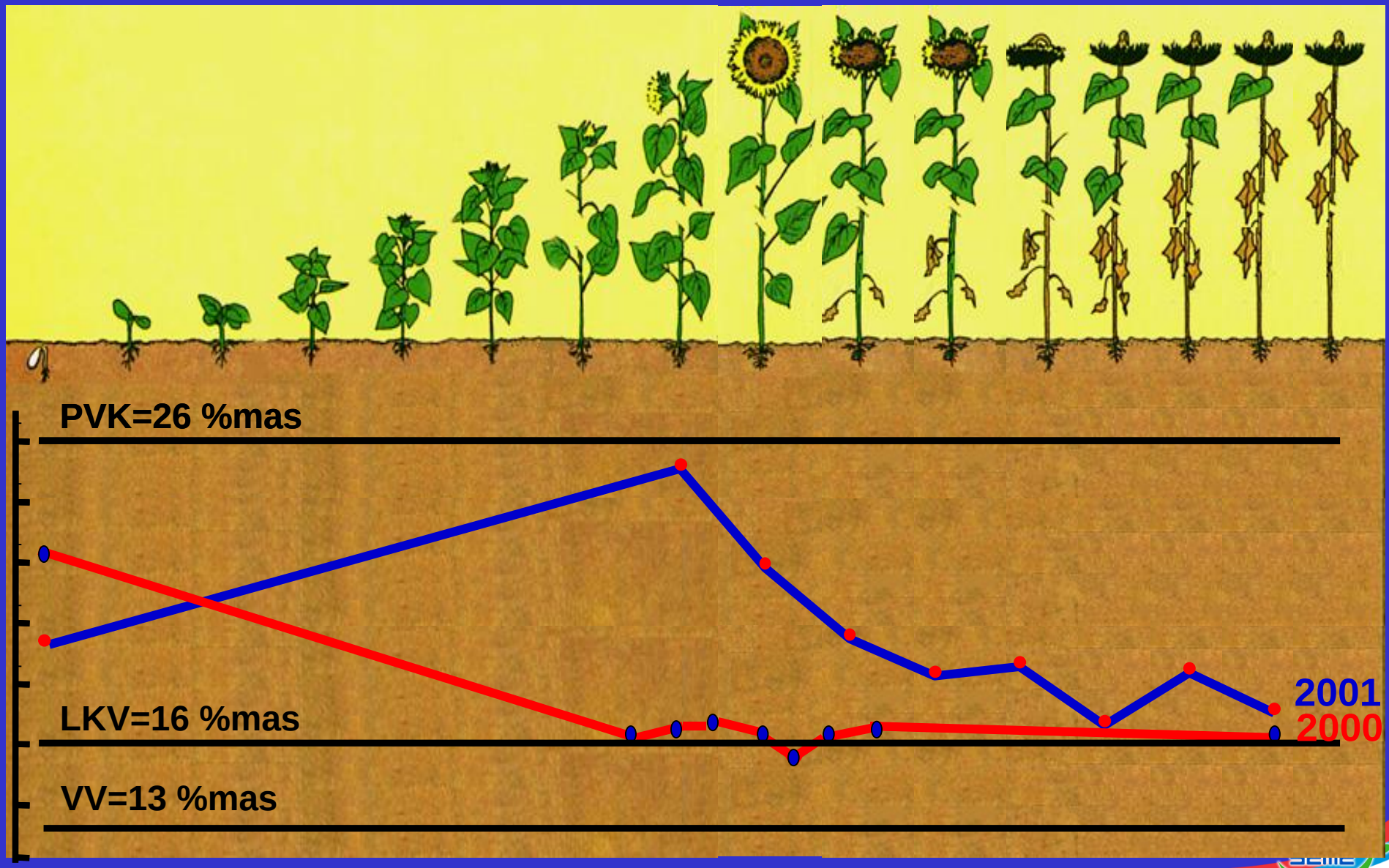


- less visit of bees
- deterioration of pollen due to humidity
- washing off the pollen from the stigma of the pistil

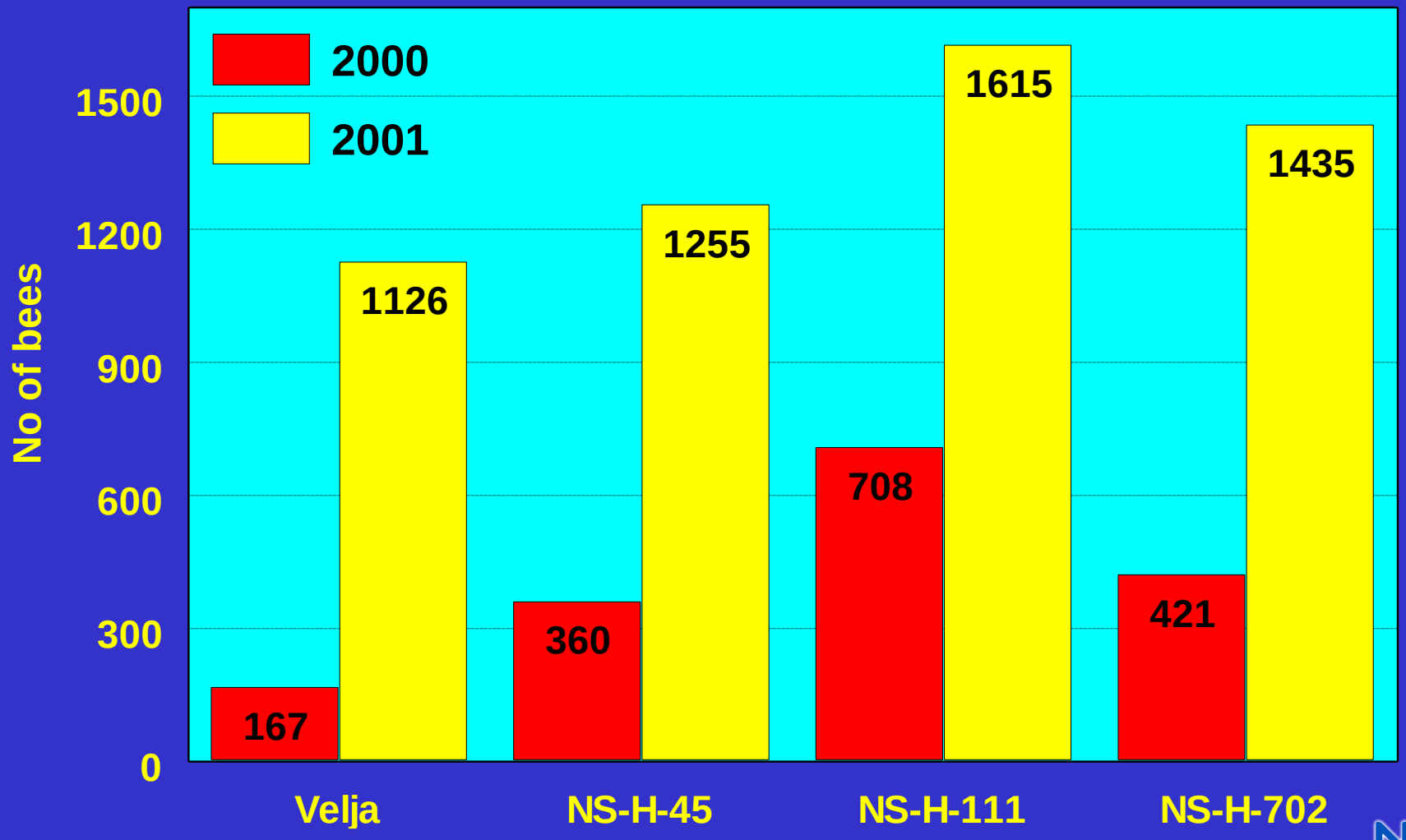
RAIN AND WET WEATHER IN FLOWERING

- washing of substances from the stigma necessary for pollen germination
- low fertilisation

Dynamics of soil moisture in sunflower hybrids



Total bee visit in different years



IFVCNS-Pollinator research center

Target plant species: sunflower, rapeseed, alfalfa…

Target pollinator species:
honeybee, bumblebee, Osmia species, Megachile…

Caged pollinators trial – wild and cultivated species

WORKS IN FLOWERING RELATED TO GENETIC PURITY

- Constant control and removal of selfsown sunflower plants in spatial isolation, before and during flowering
- Removal of atypical plants during the bud period
- · more strongly developed plants (in the hybrid type) usually taller, with thicker stems and wider leaves,
- · branch plants,
- · single-headed plants in the restorer line,
- · plants whose color and shape of leaves is not typical,
- · plants with uncharacteristic neck and head position
- · plants with an atypical stigma or anther color (with restorers).
- This cleaning should be repeated twice because the outcrosses differentiate successively.
- It is also necessary to remove diseased plants if they appear.
- The first and last 1-2% of flowering plants in the female line should be removed, because there is a possibility that they are atypical in terms of flowering time.

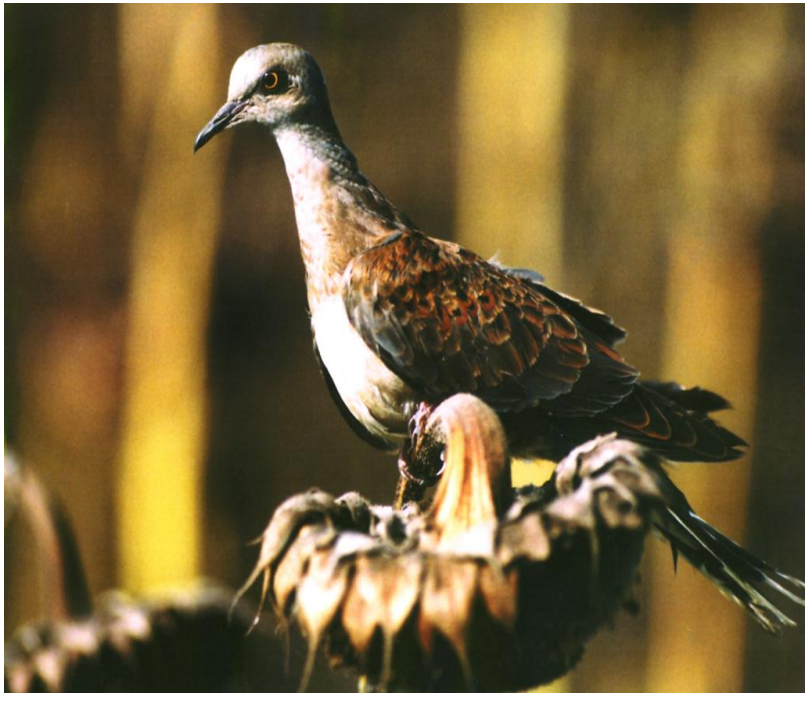
WORKS IN FLOWERING RELATED TO GENETIC PURITY -2

- With the appearance of disc florets, start the daily removal of fertile plants
- Perform this operation as early as possible due to the arrival of the bees
- Fertile heads are torn off and laid face down on the ground
- The stalks are pulled out so as not to interfere with the harvest
- 1 worker controls 2 rows
- Up to 1 worker per hectare is required

Fertile and sterile plant

REMAINING WORK UNTIL HARVEST

- Removing the male rows to prevent seed mixing, for aerating the crop and preventing seed loss
- Removal of diseased plants, especially white rot
- Weeding before harvest
- Protection of crops from birds, installation of nets on smaller plots



APPLICATION OF CHEMICAL DESICCATION

- Advantages of chemical desiccation: earlier harvest, reduction of damage from birds and diseases, prevention of lodging and dropping of seeds, increase of seed qualities
- The moment for treatment, when the grain moisture drops to 35-40%
- Preparations Reglone, Gramoxone, Basta, Harvade, Reglone is most often used in a dose of 2-3 l/ha with about 300 liters of water
- Treatment possible with tractor sprayers and airplane
- The harvest is accelerated in 7-10 days

HARVESTING

- Before starting, thoroughly clean combine harvesters and means of transport
- Harvest a part of the plot from the sade and use the harvested mass as mercantile goods
- Start the harvest when the grain moisture drops to 12-14%, moisture must not be allowed to drop below 9-10% due to peeling
- Reduce the number of revolutions of the drum to a maximum of 400/minute
- Release the drumstick as much as possible
- It is possible to use adapters for sunflower or corn with adjustments
- Means of transport must be closed
- Transport the seeds to the processing center the same day

PROCESSING OF SEEDS

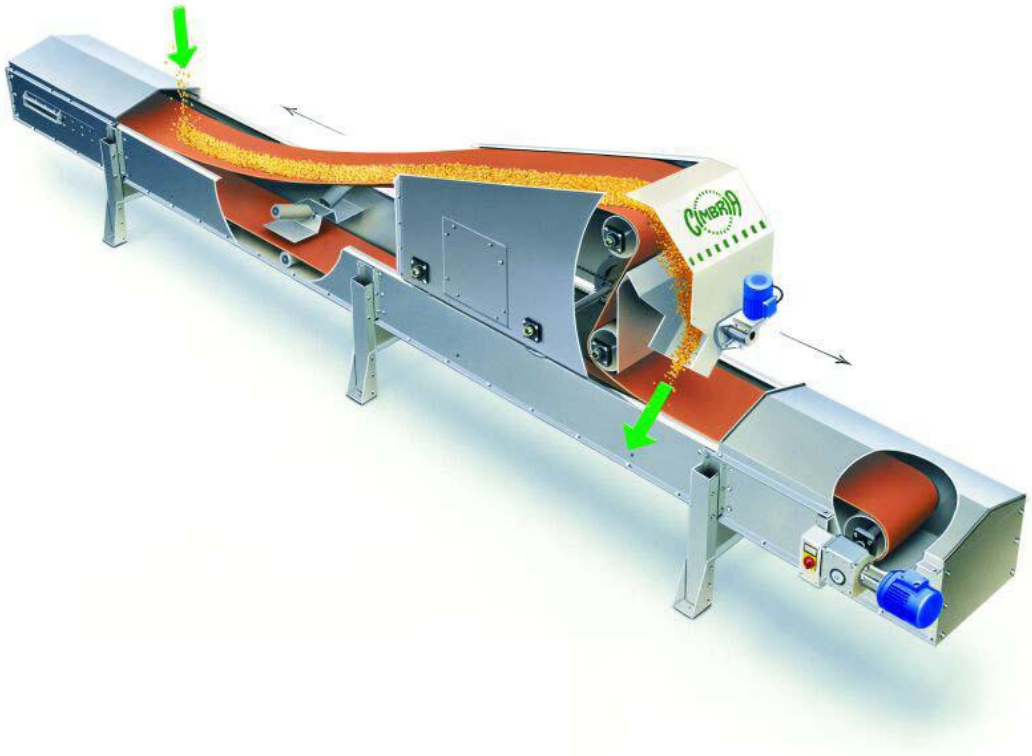
- Immediately after receiving the seeds, it should be passed through a cleaner with a sieve system and wind.
- The seeds are stored in bins with a central perforated cylinder and dried with cold or warm air (not over 40^{o}C).
- The seeds should be periodically elevated to the second bin until the moisture level reaches 9%, the seeds must not overdry
- Conveyors must be bucket-shaped due to the sensitivity of the shell
- The processing center should be designed in such a way that the machines are placed one above the other and thereby reduce the number of necessary conveyors
- The processing center and warehouses are kept clean of insects and rodents

SEED PROCESSING

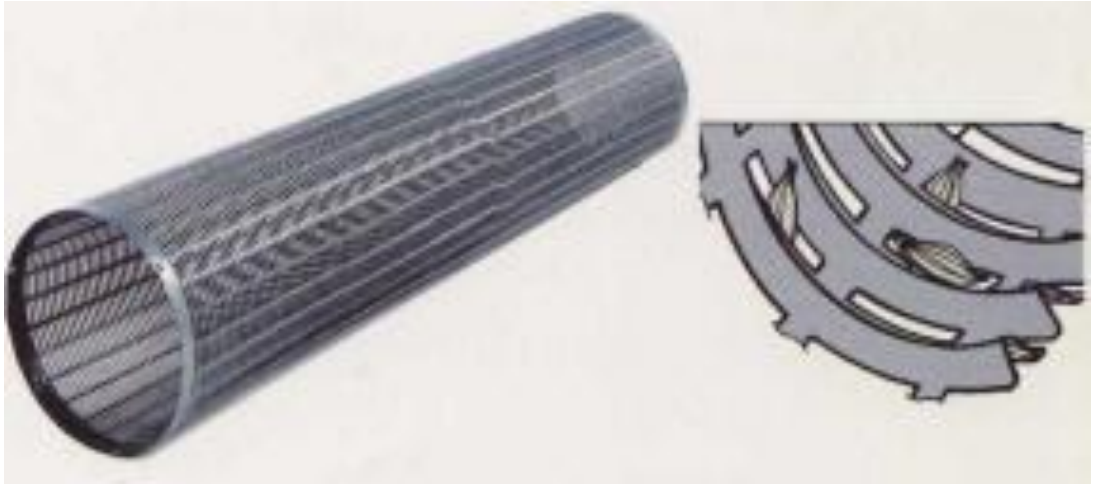
- An average seed processing line includes:
- 1. fine selector - physical and biological impurities, small and large seeds are removed by the sieve system and the wind
- 2. thresher - removes stumps, sclerotia and weeds
- 3. gravity table - removes sclerotia, weeds and peeled seeds
- 4. calibrator – fractions are formed by dimensions
- 5. duster with dryer - fungicides, insecticides, glues and paints are applied
- 6. scales and packers - seeds can be packed by weight (2.5, 5, 20 kg, for the morning, hectare or 4 hectares) or by the number of seeds (35000, 40000, 70000, 75000, 150000 grains)
- 7. aspirators for dust removal.

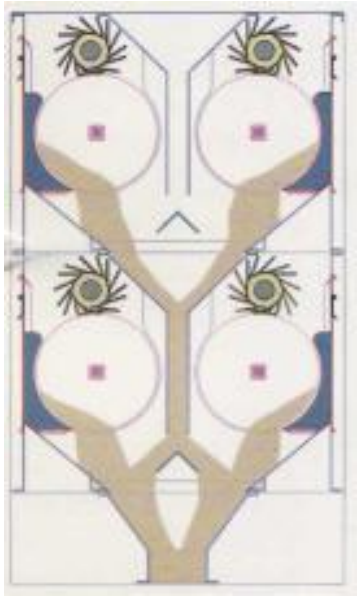
FINE AND COARSE CLEANERS

ELEVATORS AND CONVEYORS

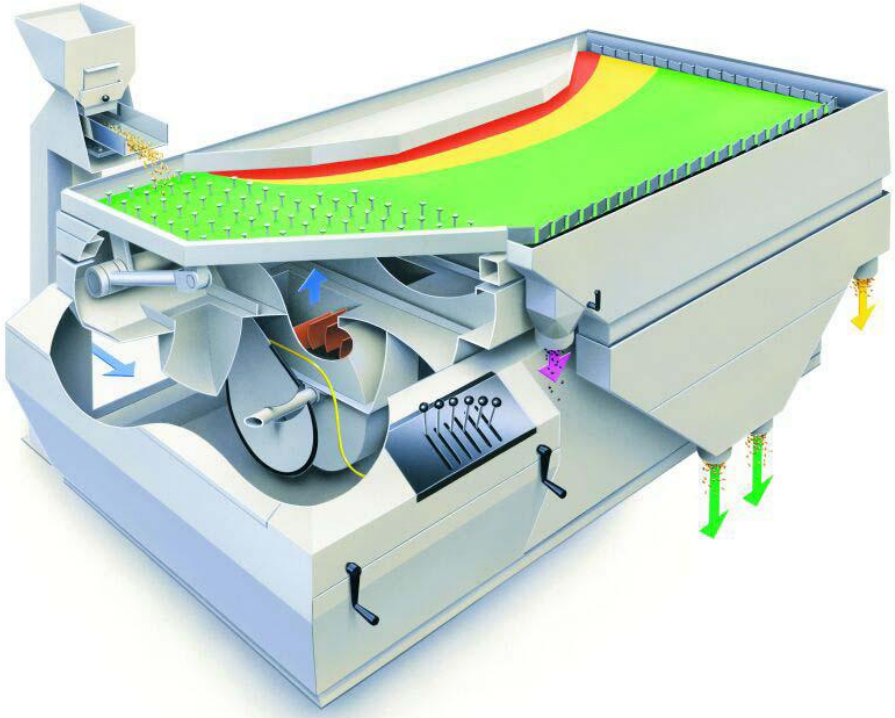


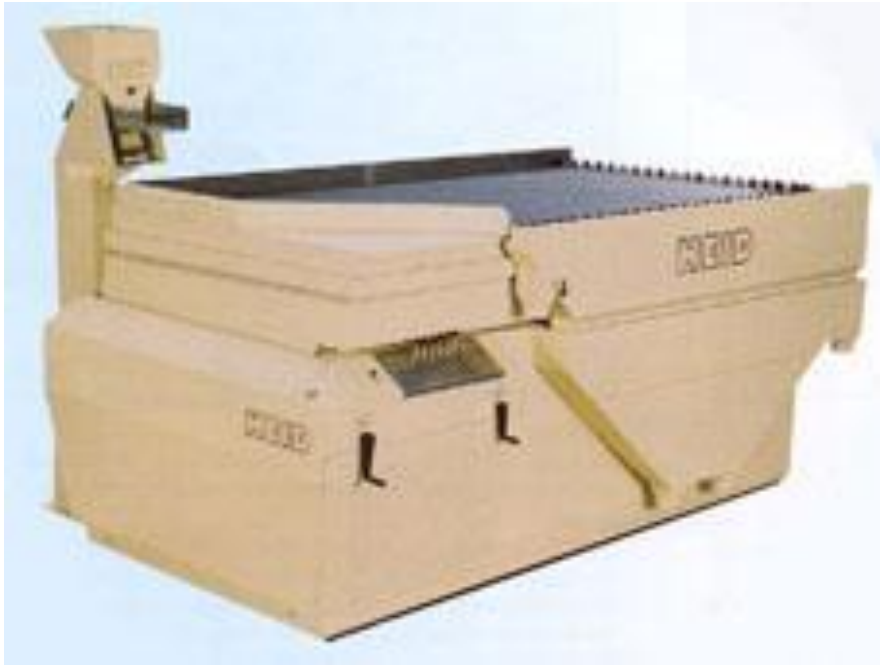
TRIERS AND CALIBRATORS





GRAVITY TABLES





COLOR SORTERS

Satake's ScanMaster
This unit uses high-speed color cameras that are set to accept or reject certain colors

SEED TREATMENT EQUIPMENT

SEED TREATMENT

extremely important topic in the production of basic and hybrid sunflower seeds

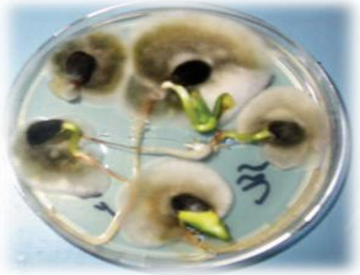
NS – Institute The most complete protection of sunflower seeds in Serbia.

Plenaris™

- for protection against Plasmopara

Maxim® 025FS

- in order to suppress white rot, black spot and gray rot on seeds and young plants



SEPIRET®

- Quality polymer for better grip of fungicides on seeds

But no insecticides!!!

New seed treatment agents against Downy Mildew
LUMISENA and PLENARIS

NEW!

ISC 2022
20th International Sunflower Conference, Novi Sad

Both fungicides introduced at ISC 2022 in Novi Sad!

INSECTICIDE RECOMMENDATION AGAINST SOIL PESTS AND FOR SEED TREATMENT 20 YEARS AGO

Aktivna materija	parat	Doza po ha	Doza na 100 kg semena
karbofuran	Fur	6 l	-
karbosulfan	P	l	-
bifentrin	Sem	-	0,20 l
imidakloprid	Gaucho	-	1,75 l
karbofuran	Furadan	-	2,00 l
tiametoksam	Cruise	-	1,00 l
fipronil	Co		0,25 l
metiokarb	M (repe ptice)		2,00 l

Lindan

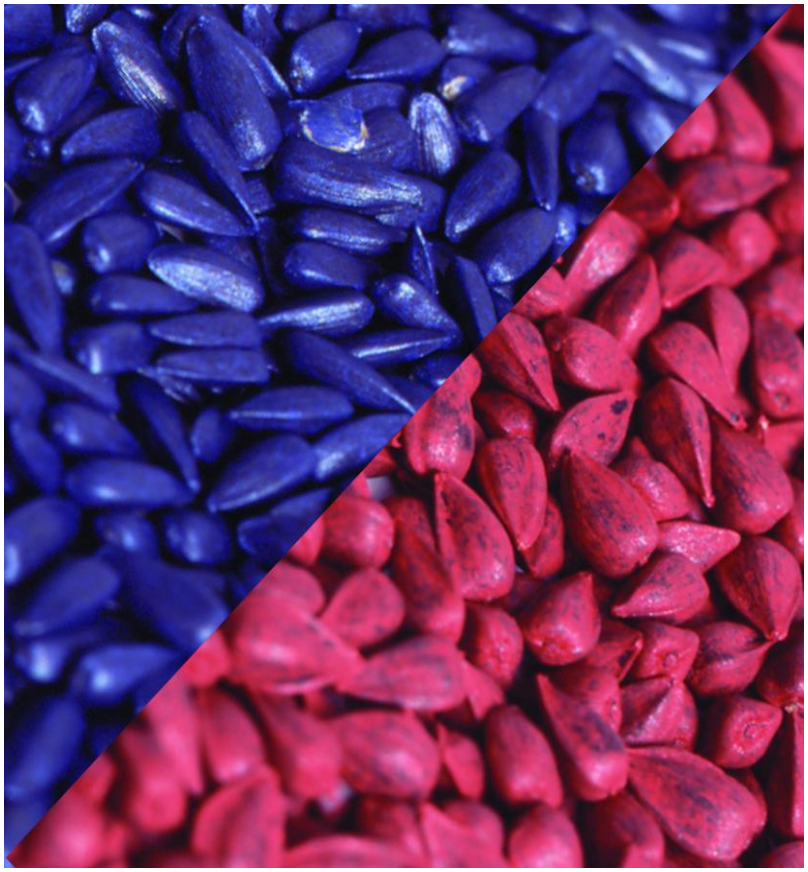
Force 1,5 G 5-8 kg/ha

Packing and palletizing

Seed storage

PACKAGING AND CERTIFICATION

- The seeds are packed in paper or polypropylene packaging
- A certificate issued by the Ministry of Agriculture is sewn or glued to the bags and contains:
- The name of the hybrid
- The year of production
- Serial number of the certificate
- Seed lot number
- Date of issue and expiration date
- Weight or number of grains
- Seed germination
- Pesticides applied



The seeds are dyed in various colors

The batch of seeds is reported to an authorized laboratory that samples the seeds, examines the qualities and issues a certificate on the seed qualities. Based on it, the producer issues a declaration and releases the seeds for sale

CONTROL OF THE SEED PRODUCTION PROCESS IN SERBIA

- The producer reports the production to the Ministry of Agriculture
- The Ministry authorizes a professional institution to control the production process
- 5 approbation inspections of crops are carried out:

1. In the stage of 3-4 pairs of leaves, control of spatial isolation, weediness and crop uniformity

2. In the bud phase, isolation control and removal of atypical plants

3, 4. In the flowering phase, control of removal of fertile and atypical plants, control of fertilization

5. Before harvest, control of uniformity, characteristics of seeds, presence of weeds and diseases.

- There are also 3 health examinations by a phytopathologist

APPROVAL OF SEED CROPS IN SERBIA

- A crop of hybrid sunflower seeds and parental components will not be recognized as seed if:
- a) the spatial isolation is less than prescribed;
- b) the crop was sown on a plot where sunflowers were represented in the crop rotation in the last five years, or soybeans and rapeseed were pre-crops;
- c) in the production of hybrid seed lines, atypical plants above 0.2% are not removed before flowering (at the time when 2% of the plants are ready for fertilization;
- d) during the production of CMS lines and hybrids based on this type of male sterility in the flowering phase, more than 0.5% of fertile plants are found in sterile form;
- e) in the production of parental components and hybrids in the phase of physiological maturity, more than 1% of plants with atypical seeds are found.
- f) if the crop is assessed as uneven
- g) weediness higher than grade 1
- h) the varietal purity of male was below 99.5% at the time when 5% of the female plants flowered
- i) varietal purity of female less than 99.0%, sterility less than 99.5%
- The sample has 100 plants, on 10 ha - 10 trials, then for every 10 ha one more

- If the crop meets all the regulations, the Ministry issues an approval certificate with which the producer can start processing and put the seeds on sale.
- In domestic trade, the seeds are accompanied by a dispatch note, declaration and approval certificate, for export an OECD certificate, Orange certificate and phytocertificate are required, as well as an invoice

OECD CERTIFICATION

- International certification schemes developed by the Organisation for Economic Co-operation and Development (OECD) for agricultural products, primarily seeds and forest reproductive material.
- These schemes harmonize standards and procedures to facilitate international trade by ensuring quality and providing international recognition for certified products, such as OECD certified seed and OECD certified forest reproductive material.

ADVANTAGES OF USING CERTIFIED SEED

1. Higher quality seed material for agricultural producers as a prerequisite for achieving higher yields and profits. Some studies show that this increase can be as much as 10-30%;

2. Preventing the spread of weeds through seeds, and reducing the number of herbicide treatments, while reducing costs;

3. Preventing the spread of diseases transmitted through seeds;

4. Greater protection of seed users and the environment through controlled treatment in professional processing centers, with the important point being the complete disposal of packaging waste in cooperation with professional processing centers;

5. Increasing the "return" of money to breeders - innovations in plant breeding are the main way to find new traits, values and tolerance of varieties, which alone can respond to the increased pressure for yield, more efficient and more stable production

Source: Seed Association of Serbia

DAMAGE CAUSED BY THE USE OF NONCERTIFIED SEEDS

- Financial losses to the Republic of Serbia due to the use of undeclared seeds, mostly due to reduced yields (SAS estimate)
- - 80 million EUR for wheat seeds
- - 50 million EUR for soybean seeds,
- Damage from the spread of weeds and diseases, as well as from health problems that may occur in humans and animals, are enormous and difficult to estimate.

Claviceps purpurea

Peronospora manshurica

Avena fatua

GLOBAL WARMING

THE EXAMPLE OF SERBIA – Novi Sad

AVERAGE MONTHLY TEMPERATURES

- Long-term average (l.a.)
- below l.a.
- below l.a. >1°C
- above l.a.
- above l.a. >1°C

Mesec	1964-2015	1964-1975	1976-1985	1986-1995	1996-2005	2006-2015	2016-2021
April	11,7	11,3	10,6	11,7	11,7	13,1	13,7
May	17,0	16,7	16,5	16,5	17,7	17,5	17,2
June	20,0	19,7	19,3	19,6	20,8	20,9	22,1
July	21,7	21,1	20,6	22,2	21,7	23,1	23,1
August	21,2	20,4	20,0	21,8	21,7	22,5	23,7
September	16,9	16,8	16,7	17,3	16,3	17,5	18,4
all year round	11,4	10,9	10,8	11,3	11,6	12,3	13,0
in the growing season	18,1	17,7	17,3	18,2	18,3	19,1	19,7

Source: Đukić, 2022

SEED QUALITTY CONTROL

- **dormancy breaking methods** - *dry storage, preheating, pre-cooling, light, KNO, gibberellic acid...*
- **seed germination, energy of germination test** (*according to ISTA rules, on filter paper, in sand, compost...*)
- **seed vigor tests** (*assess a seed's ability to perform under unfavorable conditions, predicting its emergence and growth in the field, Cold Test, which simulates early spring conditions; the Accelerated Aging (AA) Test, which stresses seeds with high heat and humidity; Hiltner test, also known as the brick gravel test or brick stone method, Tetrazolium (TZ) test - quick biochemical test used to determine seed viability by showing which seeds are alive and which are dead*)
- **Control of seed health** *(visual examination, incubation tests, and molecular techniques like PCR and ELISA to identify pathogens)*
- **Physical purity test, moisture content, 1000 seed weight**
- **GMO test** (*PCR methods*)

SEED QUALITTY CONTROL

- **Control of genetic purity**:

- **Presence of atypical plants, sterile of fertile plants, branching plants…** (*In the field or with molecular markers (new!*)

- **Presence of traits that cannot be detected in the field:**

- **Plasmopara resistance** (*molecular markers or whole seedling emmergion method (in the lab), inoculation in the field*)
- **Orobanche resistance** (by races) (*molecular markers, biotest in the greenhouse)*
- **High oleic traits (oil qualities)** (*chemical analyses – NMR*)
- **Herbicide resistance (Clearfield, Clearfield Plus, Express, Air…)** (*molecular markers or biotest for herbicide resistance in the greenhouse)*

WINTER NURSERIES

1. Acceleration of the breeding process
2. Multiplication of lines and hybrids
3. Post-control tests of all categories of seeds produced in the previous season

Chile

Argentina

India

Thanks for your attention!!