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INTENSIVE SUNFLOWER CULTIVATION FROM IMMATURE SEEDS

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SUMMARY

Experiments were laid out to investigate the germination ability of immature sunflower seeds. Seeds of different age after fertilization were planted directly into bags filled with soil mixture. The experiments, conducted in the period 1984-1986, proved the possibility of sunflower cultivation with immature seeds directly in soil, without artificial nutritive media. Seeds are removed from a head 10 or 12 days after fertilization and immediately planted (do not permit them to dry) into bags with soil mixture. Our method is simple and easy. It does not demand special equipment, tools and specially prepared nutritive media and allows getting six vegetative cycles per year. It permits to obtain different line analogues in a single year instead of 6 or 7 years.

Key words: seed dormancy, germination, sunflower

INTRODUCTION

Intensive breeding of sunflower hybrids involves the question of urgency. It depends completely on intensive formation of valuable inbred lines with high combining ability and their CMS and Rf analogues. In this connection the obtaining of maximum generation cycles in a year is of utmost importance.

It is well-known that with greenhouses and climatic chambers one can obtain three plant generations per year, using mature seeds which have gone through the stage of post-harvesting maturation. The length of this stage may be reduced by different methods, stratification, scarification, treatment with physiological active substances, warming at 30±2°C during 10 or 14 days, *etc*. In addition, six generations per year can be obtained with *in vitro* culture. However, the former methods do not allow obtaining more than three generations per year. The last method demands first of all maintaining aseptics conditions, compound nutritive media and also much labor and heavy expenses. It does not allow to develop lines and their analogues in large amounts as it requires considerable time and effort.

Observing seeds from late flowering to early maturation under high air humidity, we found well-developed green cotyledons. These observations moved us to study possibilities of sunflower cultivation from immature seeds.

MATERIALS AND METHODS

Experiments were established to investigate the germination ability of immature sunflower seeds. Seeds of different age after fertilization were planted directly into bags filled with soil mixture. The experiments, which lasted for several years (1984-1986), proved the possibility of sunflower cultivation from immature seeds directly in soil, without artificial nutritive media (Table 1).

Table 1: Germination ability of immature sunflower seeds from 10 to 12 days of age after fertilization

Line, hybrid	Germination ability of immature sunflower seeds (%)
VK 373	74
VK 369	91
VK 366	59
VK 66	66
K 562 A x GR 457	34
VK 373 A x VK 369	90
VK 373 A x SL 3372	93
W 501 A x SL 3372	73

RESULTS

The Table 1 shows that the germination ability of different sunflower lines and hybrids ranged from 34 to 93%. It provided the necessary potential to continue breeding. This sunflower cultivation technique is applied in the following way. Seeds are removed from a head 10 or 12 days after fertilization and immediately planted (in order not to permit them to dry) into bags filled with soil mixture. The bags are placed in climatic chamber, which maintain the following conditions: temperature – from 28 to 30°C, illumination – 18000 luxes, air humidity – from 70 to 75%, soil moisture – about 70% of full soil moisture.

Plantlets appear in 6 to 8 days. After formation of two or three pairs of leaves they are replanted into the soil (in a greenhouse or in a field). Sunflower plants are cultivated under 16 h photoperiod. After flowering season and fertilization of new plants, the cycle recurs. One cycle lasts from 50 to 60 days in phytotron, from 60 to 70 days in field. If to obtain more generations (7 or 8), plants may be grown directly in bags till flowering, without planting into the soil. Such plants have small heads but the number of seeds is sufficient to continue the cycles.

This method is simple and easy. It does not demand special equipment, tools and specially prepared nutritive media and allows getting six vegetative cycles per year. It permits to obtain different line analogues in a single year instead of 6 or 7 years.

A comparison of experimental and theoretical data showed no contradictions, is spite of a widely accepted assumption that sunflower seeds cannot germinate prior to undergoing the dormancy stage.

DISCUSSION

The main factors blocking seed germination are:

1. water resistance of seed coat determined by the layer of thick-walled cells and the cuticle (a waterproof wax coat);
2. substances in the pericarp, inhibiting germination;
3. incomplete development of the germ;
4. physiological mechanism of germination inhibition.

Normal seed germination ability depends on temperature, water and oxygen. Water consumption in a necessary condition for the beginning of seed germination. In addition, water resistance of the hull and water consumption characteristics of sunflower seeds are equal importance. As a result of water absorption, the activity of many enzymes increases. These enzymes transform seed compound substances into simple ones, which form the plantlet. Water penetrates sunflower seed mainly through parenchymal layers located in the pericarp sclerenchyma. Water consumption intensity of immature seeds is considerably higher than that of mature ones, in spite of the fact that water content in the latter is two times higher.

Sunflower seeds germinate after absorbing 56.5% (Goffman, 1975), 48.8% (Gaberlandt, 1975) or 132.6% of water in the ratio to air dry weight for confection sunflower and 161.9% for oil seed sunflower (Bogdanov, 1975). According to Gaberlandt (1975), the minimum germination temperature is 8 to 9°C, optimum 28°C, and maximum 35°C. During seed swelling, the volume of oxygen consumed during respiration is larger than the volume of carbon dioxide released. Respiratory coefficients range from 0.44 to 0.98 regardless of changes in absolute volume of oxygen consumed and carbon dioxide released (Fenelonova, 1975).

During sunflower seed development, from ovule fertilization to full seed maturation, a number of qualitative changes of physiological and biological processes occurs. First of all, we distinguish periods of seed growth, when oil storage tissue is formed, and also the period of seed filling, when oil, protein and other storage substances are accumulated in the tissue (Ivanov, 1975; Morozov, 1975). Seed growth lasts from 14 to 16 days after ovule fertilization, then oil and other storage substances accumulate for 20 or 25 days (Iliena, 1975). Though oil is accumulated mainly after completion of all growing periods, the seed growing period is the most important stage of sunflower vegetation. At this time the number of full developed seeds in a head is determined (Morozov, 1975).

The first stage of seed development is characterized as first by intensive seed growth and rapid endosperm development compared with slow germ development, and then by rapid germ development, when substances accumulated in endosperm are consumed (Iliena, 1975). Endosperm remains can be found only in a micropylar part of germ "bag", but they are destroyed on the 12^{th} to 14^{th} day. This period corresponds to complete germ formation, which occupies the whole hull cavity. Thick tissues of ovule coat turn to a very thin seed coat. The latter becomes a part of thin endosperm, which covers the seed on the outside.

Determination of the beginning of seed filling is an important point. The beginning of seed filling may be determined on the basis of phytin accumulation, which is a typical storage substances containing a large amount of phosphorus. According to Sobolev (1975), 12 days after flowering sunflower seeds contain a considerable amount of phytin. In addition, he found that the beginning of phytin accumulation coincides with the beginning of accumulation of main seed storage substances.

During the final stage of seed growth and the beginning of water release, the average oil increment per day increases rather quickly. The beginning of absolute water loss in seeds is observed on the 12^{th} or 13^{th} day after ovule fertilization. So, in this period the seed filling processes (accumulation of storage substances in cells) begin to prevail over seed growing processes (increase in cell number and size). Prokofiev and Kholodova (1975) found that the absolute maximum water content in seeds occurs on the 13^{th} day of their development. In addition, they demonstrated that change of seed water content at that time does not depend on air humidity.

The beginning of growth inhibitor accumulation accounts for growth inhibition during this period.

The beginning of accumulation and deposition of nutrients is at the same time the beginning of seed dormancy. Artificial interruption of seed dormancy in that period (from 10^{th} to 14^{th} day) or, to be more exact, not allowing its beginning, provides cessation of deposition of oil and seed growth inhibitors. In addition, the thickness of the newly formed hull is quite small. This fact together with intensive water consumption (water consumption of immature seeds is considerably higher than that of mature ones) and seed swelling leads to quick hull cracking and washing away of accumulated growth inhibitors during watering. In addition, if there is a valuable breeding material (very few seeds), it is better to separate the hull from the kernel by hand.

Engel (1975) gives interesting results of a study of storage substances mobilization during sunflower seed germination. According to Engel (1975), carbohydrates are first to mobilize, while the hydrolysis of storage protein begins almost simultaneously. Oil is utilized considerably later. Oligocarbohydrates are utilized first among carbohydrates. There is only sucrose in cotyledons. Monocarbohydrate is not found. In the hypocotyledon together with the growing point there are also mono-, di- and oligocarbohydrates. Therefore, except moisture, temperature $28 \pm 2°C$ and sufficient aeration, all substances necessary for germination are present in the seeds 10 to 12 days of age. These substances provide normal germination without nutritive media and root reserves, which, when put in function, stimulate further plantlet development.

Thus, artificial interference in the successive chain of physiological and biological processes which occur in sunflower seeds from the end of seed growth processes to the beginning of seed filling process leads to uninterrupted growth, avoiding seed dormancy. Utilization of “elder” seeds does not give such results, since the accumulation and deposition of storage nutrients, growth inhibitors, hull “getting hard” and less intensive water consumption lead to reduction in growth processes and to seed dormancy.

It is worth mentioning that mature seeds and seeds which have gone through the post-harvesting maturation germinate in two days under optimum conditions (Sevastianova, 1975). According to genetic characteristics, for example oil content in initial phenotypes, germination ability of immature seeds is observed from 2 or 3 to 10 or 12 days. In addition, if a seed has started growing, all the following growing processes proceed normally, although natural weakness of plantlets can be observed. Such plantlets are as good as plantlets germinated from seeds after dormancy.

CONCLUSIONS

The proposed method is simple and effective. It is of great importance for sunflower breeding. It was widely used at the All-Russian Institute for Oil Crops for development of CMS and Rf analogues, different isogenic lines and for quick obtaining of constant material. We believe that this method may find wide application at other research institutes and breeding companies and ensure further advances in sunflower hybrid breeding.

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CULTIVO INTENSO DEL GIRASOL A PARTIR DE SEMILLAS NO COMPLETAMENTE MADURAS

RESUMEN

Los experimentos fueron hechos para determinar la habilidad de germinacion de semillas del girasol no completamente maduras. Las semillas de varia edad eran sembradas, despues de fecundacion, directamente en las vasijas con mezcla de tierra. Los experimentos, realizados en el periodo entre 1984 y 1986, confirmaron la posibilidad de cultivo del girasol por las semillas no completamente maduras directamente en el suelo, sin medios nutritivos artificiales. Las semillas se toman de la cabeza durante 10 a 12 dias despues de la fecundacion y estan sembradas inmediatamente (para impedir su desecacion) en las vasijas con mezcla de tierra. Este metodo es simple y facil. Ese no exige l equipo especial, herramientas y un medio preparado particularmente, y posibilita de llegar a seis ciclos vegetativos por año. Es posible por este metodo de producir las lineas analogas en un unico año en vez de seis a siete años.

CULTURE INTENSIVE DE TOURNESOL À PARTIR DE GRAINES IMMATURES

RÉSUMÉ

Des expériences ont été faites pour étudier l’aptitude à la germination des graines de tournesol immatures. Après fertilisation, des graines d’âge différent ont été plantées directement dans des sacs remplis d’un mélange de terre. Les expériences, effectuées entre 1984 et 1986 ont démontré qu’il était possible de cultiver du tournesol à graines immatures directement dans le sol, sans substance nutritive artificielle. Il faut retirer les graines de la tête 10 ou 12 jours après la fertilisation et les planter immédiatement (en évitant de les laisser sécher) dans des sacs remplis d’un mélange de terre. Notre méthode est simple et facile. Aucun équipement particulier, ni outils, ni substance nutritive spécialement préparée ne sont nécessaires. Six cycles végétatifs sont possibles par année et de plus, cette méthode permet d’obtenir plusieurs lignes analogues en une seule année plutôt qu’en six ou sept ans.