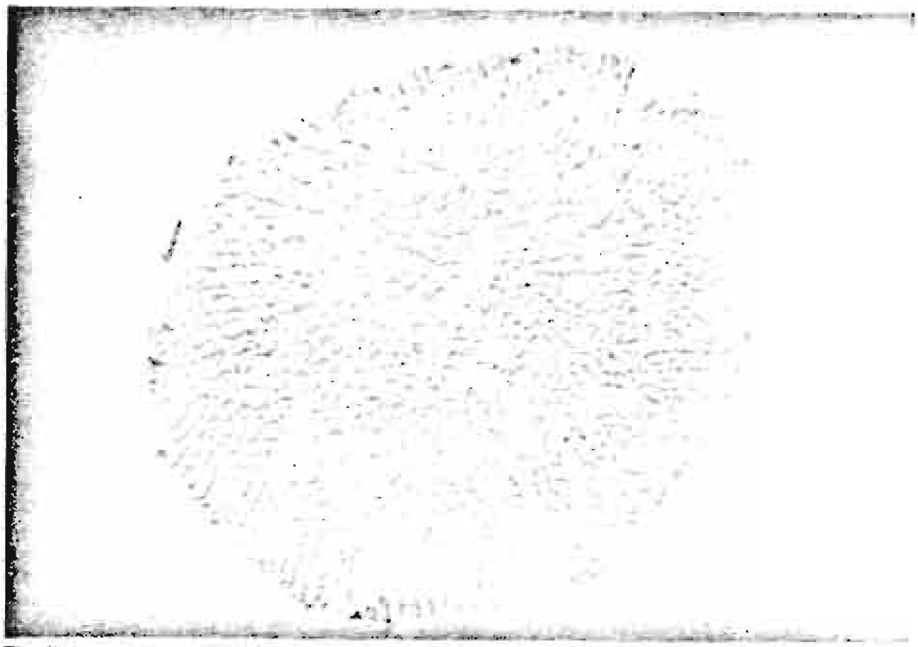
SEED SET IN SUNFLOWER

By Donald Smith, Gerhardt Fick, Freeman Johnson and Paul Knowles[1]



The light grey areas in this sunflower head are unfilled seed. *Photo: Donald Smith.*

Harvest is the high point of the season for a farmer. Sunflower harvest is no exception, even though a great sense of pleasure usually comes from seeing a field in full flower. There are always some frustrations, though, that are a part of the harvest. Blank or unfilled seed is one such cause of frustration. The unfilled seed create a special challenge. The challenge to the farmer is in adjustments of the combine so that the filled seed is saved while discharging the unfilled along with the plant residue. This adjustment process can be most exasperating. Along with this adjustment challenge may come a feeling of disappointment in the yield of seed due to the sight of the blank seed being discharged in the residue behind the combine as it moves through the field. The universal question is, "What happened? What would the yield have been if all the blanks would have developed to filled seed?" These questions are shared and pondered by farmers and agricultural scientists alike.

OCCURS IN MOST FIELD CROPS

Unfilled seed in sunflower is not unique, as it occurs in most of our field crops. It has been observed under certain conditions in most varieties of wheat and barley where the tip of the spike or head is sterile and does not set seed. In corn it is manifested as incompletely filled kernels at the tip of the ear.

Explanations have been sought for this condition for generations. One explanation is that this condition is due to environmental stress and/or genetic make-up in the plant. Considerable research data have been accumulated which substantiate this explanation and conclusion.

Research on sunflower has a rather short history in contrast with wheat, barley and corn. When compared to most crops, very little is known about the sunflower plant. It has only been in recent years that many studies have been initiated to gain a more detailed understanding of some of the critical morphological, anatomical and physiological processes involved in pollination, fertilization and seed development. It is an accepted fact that scientific progress is quite likely to be limited and slow unless there is substantial ongoing basic research to provide answers to the numerous problems encountered along the way.

POLLINATION & FERTILIZATION

It has been documented that a head of oilseed sunflower plant may consist of 700 to 3,000 flowers, each flower representing a potential seed. In most sunflower heads, each flower is perfect in that it includes both male (anther) and female (ovary) parts. These flowers are arranged in a more or less continuing arc radiating from the center of the head. Head development or flowering involves the opening of the flowers, first on the outer edge, and then in successive whorls of one to four or more rows of flowers daily. Flowering terminates at the center of the head five to 10 days later depending upon head size and the weather. The flowering period may be longer if the heads are large or the weather is cool and/or cloudy.

The flowering process of a single flower usually occurs during a 24-hour period and follows a rather rapid sequence of events. Some of these events are visible to the naked eye and happen during a four- to six-hour period beginning shortly after sunrise. At that time, pollen is discharged from the anthers, which are joined to form a tube inside the flower. One part of the female portion of the flower (stigma) elongates and collects its own pollen on its hairy surface as it grows through the pollen producing part of the flower. This female part continues to grow out beyond the main flower part. The hairy surface then becomes exposed to other sources of pollen which might be deposited on it by honeybees. The pollen grains are spiny and readily collect on the body of a bee as it crawls about on the flowers collecting nectar or pollen. These bees might pick up and carry pollen from other sunflower plants or from other flowers on the same plant.

Pollination is followed by another major process — fertilization. One or more of the pollen grains on the stigma germinate and penetrate the stigma by producing a pollen tube. This tube grows down toward the ovule which is situated on the bottom of the flower. At the advancing end of the pollen tube are the sperms. The pollen tube eventually enters the embryo sac in the ovule (egg). Fertilization occurs when the sperm of the pollen tube unites with the ovule. It is at this point in the process that seed formation normally begins. Regardless of whether or not pollination and/or fertilization occurs, the hull proceeds to develop. It generally grows to normal length but will frequently be flat or pinched in appearance if fertilization did not occur.

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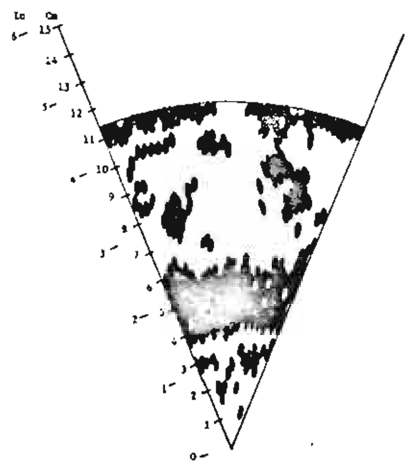

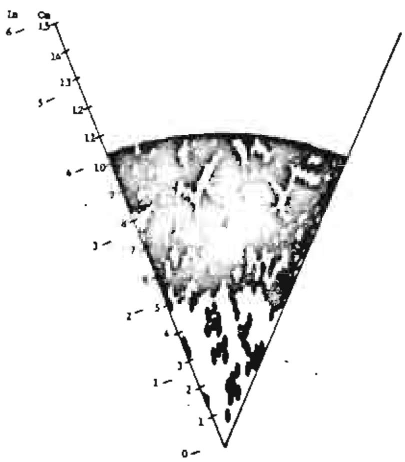

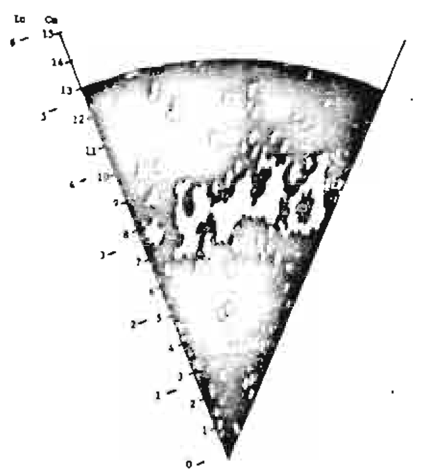

Left: The variation in seed setting patterns is exemplified by these drawings of sectors from sunflower heads of three different hybrid varieties harvested from a 1979 yield test in South Dakota. Blank or unshaded areas denote unfilled seed. The radius of the head is shown on scale (in both inches and centimeters) along the left margin.

ENVIRONMENTAL INFLUENCES

The processes of pollination and fertilization are dependent upon a number of distinct but related events and circumstances both within the plant and its environment. The failure or improper timing of any one of these related events may cause the seed to be blank. Plant breeders working with sunflower have observed that environmental factors, particularly temperature and humidity, do have a profound effect on the growth of a sunflower plant and especially upon pollination. This effect may be directly on the pollen in the case of both low and high temperature. Pollen viability may be lowered by very high temperatures. The same effect upon pollen results from low temperature. High temperatures in conjunction with low relative humidity probably cause rapid dehydration of the pollen. High relative humidity causes sunflower pollen to become sticky and form clumps. Free moisture from rain or heavy dew has been reported in some way to deactivate pollen.

Extremes of temperature have a distinct effect on the activity of honeybees. Bee activity is reduced as temperatures rise above 90°F and below 50°F. Cloudy, damp conditions have a similar effect. Rings of blank seeds have been observed under field conditions after prolonged periods of damp or rainy weather. Such a condition has been attributed to a cool, damp period at the time of flowering of those particular rings in the head. Speculation is that pollination did not occur, possibly due to deactivation of the pollen by water. Temperature at or near freezing may impair normal fertilization by damaging not only pollen but also the ovule.

Most sunflower scientists who have observed seed set in both California and the Upper Midwest (North Dakota, South Dakota and Minnesota) agree that the percentage of unfilled seed per head is much lower under California conditions. There appears to be a logical explanation. During the flowering period in California, it is most unusual for the weather to be either cool or damp. It may be quite hot for a few hours during the middle of the day, but generally the temperatures at night are mild so that the development and production of viable pollen continue at an adequate level for normal seed set. High temperature probably does not have a significant effect on fertilization.

Lack of rainfall or drought stress during flowering probably also contributes to reduced seed set. Inadequate soil moisture during flowering causes the flowering process to occur in a reduced period of time. This shortened flowering period exposes a larger per cent of the total head to a higher probability of being affected by adverse weather conditions. Under dry conditions, physiological processes may be adversely affected, which probably are expressed by increased numbers of blanks and partially filled seed. Both the pollination and fertilization processes no doubt are affected. In addition, the plant probably responds to extreme drought stress by aborting a number of fertilized seed, thus further compounding the production of filled seed. If a variety has the characteristic to produce a blank seed in the center of the head, this characteristic may be accentuated under drought stress and will be evidenced by an even larger amount of unfilled seed in each head.

Plant population, particularly high numbers, may indirectly result in lowered seed set. The plant response is similar in this condition to that in the drought stress condition. However, if soil moisture is not lacking, the major response to higher populations will be smaller head diameter, smaller seed and a smaller circle of unfilled seed in the center of the head rather than lowered seed set. The ratio of filled to unfilled seed where the plant population is high probably is similar to that observed under high soil moisture conditions and is due principally to a larger portion of each head being exposed to temperature extremes and rainfall occurrences during the shortened flowering period.

Date of planting has a direct effect upon date of flowering. Yield data has clearly established the fact that the same variety planted at two different dates may yield significantly different. One explanation for part or all of the difference may be that plants from one planting date flowered during unfavorable weather for pollination whereas plants from the other planting date did not. Of course, the occurrence of any unfavorable weather during the normal growing season cannot be predicted.

PRODUCTION SYSTEM EFFECTS

Hybrid varieties are produced through the utilization of a biological system which causes the production of viable pollen to be impaired in the inbred line used as female in the planting seed production field. It has been speculated by some sunflower breeders that this system itself may have adverse effects upon total seed set in some hybrid combinations. At the present time, data are not available to confirm or refute this speculation.

The varieties of oilseed sunflower presently being offered for sale generally have been evaluated under field test plot conditions for two or more years and over a wide range of environments. The principal criterion of performance is the weight of seed produced on relatively small plots with comparable plant populations. This procedure is scientifically sound for seed yield measurements, but a measure of total seed yield may not reflect the seed set for the variety. For example, the size of seed may increase as the number of filled seed in a head is reduced. Limited data on seed set for some of the more common hybrids have been collected, and systems for analyzing individual heads are beginning to be developed. There do appear to be measurable differences in seed set among varieties, and the inbred lines used in hybrid planting seed production may vary more widely than hybrids. The lines used as male parents (restorer lines) generally have the highest seed set of lines or hybrid varieties. Weather factors affect all varieties to some degree.

QUESTIONS REMAIN

Much research is yet to be conducted before the process of pollination and fertilization in sunflower are adequately understood. In addition, the interaction of climatic factors with these processes must be investigated. Sunflower breeders need to establish criteria for characterization of a plant and a variety for seed set. A system of measurement of seed set must be comprehensive. It must take into account such factors as head diameter, seed size, seed weight, center of head, plant density, air temperature, free moisture in the air, cloud cover, soil moisture, bee activity and availability of foreign pollen. Sunflower breeders agree that no hybrid variety presently in use has perfect or 100 per cent seed set.

There is unanimity of opinion that the USDA Hybrid 894 has an acceptable level of seed set and that its yield performance plus seed set is predictable since it has been tested in diverse environments over a number of years. Such a base or check variety is most useful and generally necessary. This hybrid will likely be utilized when making comparisons for seed set.

Numerous research projects have been initiated by both public and private groups, directed toward the accumulation of data relative to seed set. The Sunflower Association of America has recently made grants to public institutions to support research programs directed towards learning more about seed set. There is a continuing exchange of ideas and research information among sunflower breeders. It can reasonably be expected that much more knowledge will become available in the foreseeable future about the phenomenon of seed set in sunflower.

In the final analysis, the sunflower grower will be one of the primary beneficiaries of this research, as this new knowledge will be used by sunflower breeders to develop higher seed yielding hybrids.

EFFECT OF POLLINATION AND COMPATIBILITY ON SEEDSET

By Douglas George and Steven Shein[1]

CALIFORNIA STUDY NOTES SIGNIFICANCE

Pollination and fertilization are the separate and vital processes that determine seedset and eventual yield in sunflower. The objectives of this study were to determine how self-compatability and self-pollination influence seedset in different hybrids and the role of insect pollinators in affecting these two processes.

Pollination is defined as the physical transfer of pollen from anther to stigma. Self-pollination refers to pollen transfer within a given head and cross-pollination to transfer from one head to another. Types of self-pollination have been distinguished in the hybrids studied — self-pollination, which involves pollen transfer within the head by insects, and autogamous self-pollination, which occurs in the absence of insects. Self-compatibility is defined as the ability of a plant to set seeds when self-pollinated. Thus, self-compatibility can be determined only after optimum self-pollination has been ensured.

A sunflower head consists of two types of flowers. The outer flowers, which are usually yellow, are the raw flowers or petals. These flowers do not set seed but do attract insect pollinators. The great bulk of the head consists of up to 3,000 disk flowers. These provide the potential yield because each flower can produce one seed. Each disk flower is hermaphroditic and consists of both male (anther) and female (stigma, style, ovary) parts (Figure 1). The anthers form a tube surrounding the style which connects the two-lobed stigma to the ovary containing the egg (ovule).

A sunflower head blooms from the outside to the inside. Pollen is produced and released within the anther tube. As the style elongates and pushes up through the anther tube, the pollen is mechanically forced out. The style continues to elongate until the stigmas emerge from the anther tube and the lobes separate, exposing their pollen receptive surfaces.

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