How Planting Date Affects Yield of Sunflower

J.C. Gardner, B.G. Schatz, H.M. Olson

Of the many crop plants recently introduced to the Northern Plains, perhaps none has been as successfully received as sunflower in North Dakota. Sunflower has proven valuable in rotation with small grains and diversified marketing opportunities into the oil complex. Sunflower has provided North Dakota a dependable, full season dryland row crop, capable of relatively stable yield from year to year. It is this adaptation to North Dakota's often cool and short growing season that makes sunflower unique.

Also unlike other row crop alternatives, sunflower has a relatively long period, or "window," of possible planting dates, stretching from the first of May to late June in central North Dakota. The yield components of sunflower, heads per acre, seeds per head, and weight per seed, are all determined during different periods of growth. The prevailing environmental conditions during these growth stages thus ultimately determine yield. Research on planting dates have been ongoing at the Carrington Experiment Station since 1978 and have demonstrated profound effects upon sunflower growth and development. This summary of findings at Carrington illustrates the importance of planting date in producing maximum yields of sunflower.

The Components of Yield

As sunflower progresses through its life cycle, changes in appearance make particular stages of development easy to recognize. Flowering in sunflower, for example, is especially obvious as compared to other crops such as wheat. Successful management of sunflower relies upon knowledge of the proper stage of growth for applications of certain pesticides and a convenient scheme for identification has been developed (Schneiter et al., 1981). To better understand the effect of planting date on yield, however, sunflower development can be simplified into three growth stages: planting to floral initiation, floral initiation to bloom, and bloom to physiological maturity.

Growth Stage 1 (GS1) This growth stage begins when the seed is planted and ends when floral parts of the sunflower are initiated. Floral initiation cannot be directly observed but occurs between the 10 to 14-leaf stage or approximately two-thirds of the way through the period from planting to bloom. Detection requires dissection of the plant and careful magnified inspection of the upper stem. It is at floral initiation that the growing point of sunflower switches from initiating leaves to floral tissues. In GS1 the yield component of plants, or heads, per acre is determined by how many seeds are planted and survive.

The length of this stage can be divided into two parts, 1) from planting to emergence and 2) from emergence to floral initiation. If sufficient moisture is available, the entire period is dependent solely on temperature. Later maturing hybrids make more leaves thus require more heat to achieve floral initiation. Time spent in the period from planting to emergence is influenced by management variables which affect temperatures such as planting depth and seedbed preparation.

Comparing the three growth stages, sunflower in GS1 is the most delicate and sensitive to stress, yet if stress occurs it has the least effect upon yield. The plant must only remain alive to maintain the yield component of heads per acre.

Growth Stage 2 (GS2) Though the beginning of this growth stage is not readily recognizable, it represents an important event determining ultimate yield. It is during GS2 that head size, or the number of seeds per head, is set. During the first part of this stage the floral parts which later become the harvested seed are formed with the final number of seeds a function of how fast the plant is growing and how long it continues to initiate seeds (Palmer and Steer, 1985). After the seeds are initiated they expand to form the visible bud and eventually the sunflower head which blooms and completes GS2.

Like GS1, the length of GS2 also depends upon temperature. However, it is during this stage that sunflower exhibits sensitivity to daylength or photoperiod. It is daylength during GS2 that may change a hybrid's maturity if observed across different latitudes or from opposite ends of the planting date window at a single location. Daylength is also at least partially responsible for greater differences in maturity among hybrids in the Northern Plains than the Southern Plains. Hybrid maturity is important since it determines how long the growing point will initiate seeds and explains why later maturing hybrids have inheriantly greater yield potential.

Any stress that limits the rate of growth during GS2 will be reflected in a reduced number of seeds per head. Drought stress during this stage reduces yield more than any other phase of sunflower development (Stegman, 1983). Further, fertility requirements and weed control must be accomplished by GS2 to realize the season's full yield potential.

Growth Stage 3 (GS3) The final stage of development begins when flowering is completed and ends at physiological maturity. During GS3 seed size or weight per

Gardner is former associate agronomist, Schatz is assistant plant scientist and Olson is superintendent, Carrington Irrigation Branch Station.

seed is determined. Like GS1, this stage is driven by temperature alone, but unlike GS1, sunflower now exhibits a trait that makes it particularly adapted to the Northern Plains. As physiological maturity approaches, sunflower is able to utilize progressively lower temperatures for seed growth while also becoming increasingly tolerant of drought. Stress during GS3 can reduce yield but usually not to the extent of the reduction which can occur during GS2, since seed weight is a relatively smaller contributor to yield than is seed number under most conditions.

Yield in pounds per acre is only one component of economic return from a sunflower crop. Oil percentage is an important factor with oilseed sunflower, just as seed size is critical when marketing confectionary sunflower. Stress from drought, nutritional deficiences, or cold temperatures occurring in this last growth stage have an important effect upon the quality of the harvested seed.

The three main yield components of sunflower are thus determined at different stages of development but they are not independent of one another. Sunflower has a tremendous ability to compensate for thin stands by increasing head size. Seed size can also, at least partially, compensate for heads with poor pollination or hollow centers. Yield component compensation, however, can only occur in the proper developmental sequence. For example, stand reduction from a hail storm which occurs after floral initiation cannot be compensated for by head size since the potential number of total seeds has already been set. Having each growth stage occur during optimum conditions is the best approach in managing sunflower for maximum yields.

Timing Growth Stages to the Climate: Planting Date

Any one growing season's temperatures and precipitation is referred to as the weather. Averaging many years of weather records determines a location's climate. While weather is highly variable, climate is fairly stable and provides a good source of information on which to base future crop management plants. The climate of the area around Carrington opens the sunflower planting date window about May 1, when the soil temperature has warmed to 45°F which is necessary for seed germination. The window closes in late June since later planting normally does not contain enough heat for maturity before the first sunflower killing frost of around 28°F, normally occurring in late September.

Growth and development of several sunflower hybrids planted throughout the planting date window have been studied at the Carrington station on dryland previously cropped to wheat or barley. Using the crop developmental data from these studies, sunflower response to the climate can be predicted. Figure 1 illustrates when bloom can be expected from any planting date within the window for medium maturing hybrids (USDA 894 maturity) and hybrids approximately a week earlier and later in maturity. The expected date of physiological maturity, at the end of GS3 when seeds are approximately 35 percent moisture, is similarly displayed in Figure 2. Though actual sunflower development is driven by temperature, defining average calendar dates for these stages provides a guide for future planning.

Knowledge of sunflower yield components, the climatic data, and crop development must be viewed together to understand how planting date affects yield. Using information such as that found in Figures 1 and 2, the development of an early, mid-season, and late planting date for an 894 maturity hybrid is graphically compared to Carrington's normal climatic data in Figure 3. It is obvious that both the early and the late planting expose the crop to temperatures which slow growth. GS1 is prolonged by early planting while GS3 is affected by late planting. Using these long term average data, it appears that mid-season planting dates would time sunflower development to coincide with temperatures allowing optimum growth through all growth stages.

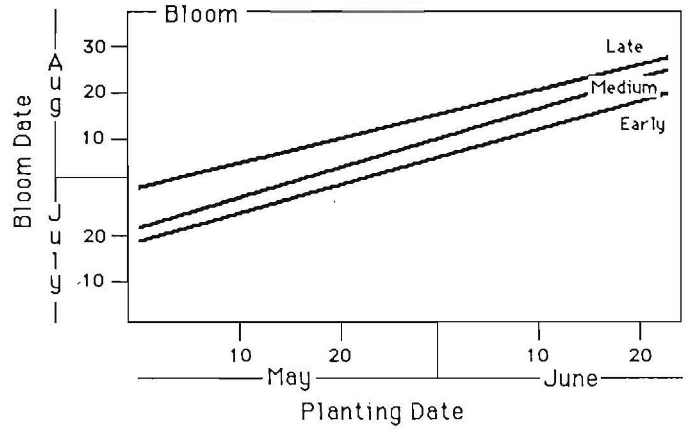

Figure 1. Average day for full bloom from an early, medium (894), and late sunflower hybrid planted within the planting date window at Carrington, ND.

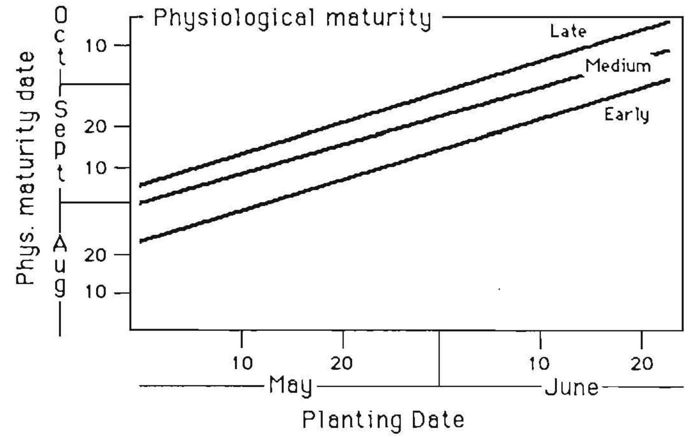

Figure 2. Average date for physiological maturity from an early, medium (894), and late maturing sunflower hybrid planted within the planting date window at Carrington, ND.

Moisture is usually the factor most limiting yield in the Northern Plains. Unfortunately, it is also difficult to predict when and how much precipitation will be received. Figure 3 illustrates long term monthly averages but such data and yield are often unrelated. Even moderate amounts of rainfall received at critical stages of growth, such as the first phase of GS2, can stimulate yield potential far beyond what a monthly total will indicate. The trend evident in the precipitation averages, however, would suggest that delayed planting further removes crop development from the months when rainfall is most expected.

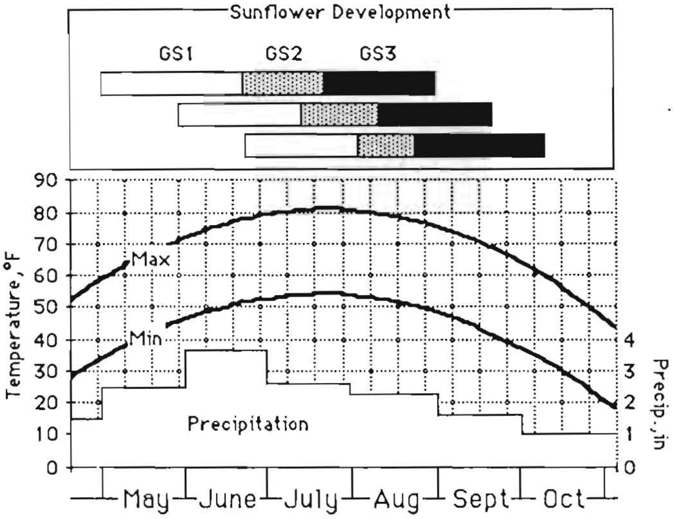

Figure 3. Thirty year average daily maximum and minimum temperatures, monthly precipitation, and corresponding sunflower development for a USDA 894 maturity hybrid planted May 1, May 30, and June 24 at Carrington, ND.

In terms of yield components, long term climatic and crop developmental data indicate that planting early in the planting date window could limit the number of seeds per head, but conditions for filling the seed should be optimized. Planting late in the window could reduce seed weight.

Actual Planting Date Performance 1978-1983

To test what long term climatic data would suggest, sunflower seed yield, oil percentage, and test weight were recorded at harvest from the planting date studies at the Carrington Station. Regression analysis was used to isolate the effect of planting date removing individual year and hybrid effects. Results from this analysis represent the average performance of sunflower from the entire planting date window for the years 1978 to 1983. Total seed yield and oil yield (oil percentage × total seed yield) in pounds per acre are illustrated in Figure 4, and test weight and oil percentage are displayed in Figure 5.

Total seed yield from early June plantings increased yields by over 500 pounds per acre as compared to early May planting dates. Since plant population from all plots was held constant between 18 to 20,000 plants per acre, the yield increase resulted from increasing head size. When considering oil production, the actual commodity being produced with oilseed sunflower, optimum planting dates were more sharply defined than with total seed yield alone. As planting was delayed beyond the end of May, increases in total seed yield from more seeds per head could not compensate for the rapid decline in oil concentration. For central North Dakota, planting dates in late May allocated the growing season for the best compromise in performance among yield components as a whole.

Total yield level maintained from late plantings seem higher than might be suggested by inspection of normal climatic conditions in Figure 3. Three of the years contained within this study, however, had unusually high amounts of precipitation in August and September. It is doubtful that

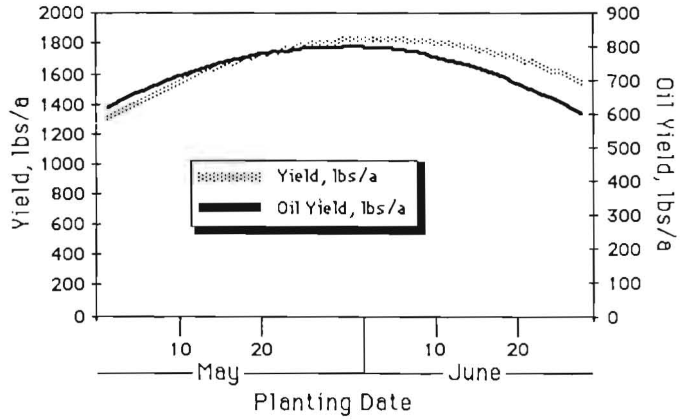

Figure 4. Average seed yield and oil yield (seed yield × oil percentage) in pounds per acre from 1978 to 1983 for all hybrids by planting date at Carrington, ND.

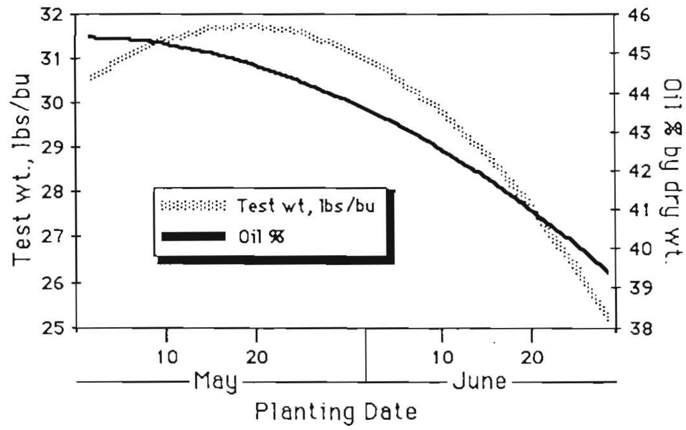

Figure 5. Average test weight in pounds per bushel and oil percentage by dry weight from 1978 to 1983 for all hybrids by planting date at Carrington, ND.

these late plantings would perform as well without unusual amounts of late season rainfall. Even with moisture, individual seed weight as well as oil concentration rapidly decline as planting is delayed because of lower temperatures in GS3.

To the non-oilseed or confectionary sunflower producer, seed size and weight are critical quality factors. Climatic data suggest early planting should time GS3 to occur during the warmest possible conditions. Oil percentage data in Figure 5 confirms this assumption. However, test weights from the earliest plantings were consistently lower than plantings 10 to 14 days later. This response can probably by attributed to insects, which can seriously affect sunflower performance but are beyond the scope of this discussion. Even with the control measures available for plot use, they could not prevent feeding by seed infesting insects which have a tremendous attraction to the first fields of sunflower in bloom. Optimum seed quality should be obtained from the earliest plantings, but it may be practically impossible due to limited methods available for pest control.

Summary

The yield performance from sunflower, like any other crop, is a reflection of the conditions in which it grows and develops. Each growing season is unique, with it's own weather and departure from the climatic "normal." This often results in confused interpretations of planting date performance when only the most recent years are used as the basis for future decisions. While weather is hard to predict, long term climatic norms have been established for most locations and can be utilized when planning for planting dates.

Sunflower's yield components are determined at different stages of growth and planting dates can be used to help time specific growth stages with the environment desired. The Northern Plains grower desiring optimum quality confectionary sunflower or high oil percentages should plant early in the local planting date window. Maximum yields will usually be received from the middle of the window since this represents the best allocation of the short season available to the northern grower among all the yield components ultimately determining yield.

References

Palmer, J.H. and B.T. Steer. 1985. The generative area as the site of floret initiation in the sunflower capitulum and its integration to predict floret number. Field Crops Res. 11:1-12.

Schneiter, A.A., J.F. Miller and D.D. Kopp. 1981. Stages of sunflower development. NDSU Coop. Ext. Ser. Bull. 14 AGR-3-3.

Stegman, E.C. 1983. Corn and sunflower yield vs. management of leaf xylem pressures. Trans. of the ASAE 26:1362-1368.

Continued from page 2

Agricultural scientists and technicians will undoubtedly be in demand well into the 21st Century. Currently there are 14,000 openings available annually and only 11,600 qualified college graduates to fill them. Many of the current positions require graduate education at either the master's or doctoral level. However, every scientist needs one or more technicians to get the job done. Thus opportunities are excellent for college graduates with a bachelor's degree.

The types of positions in this category of agricultural scientists/technicians include food scientists, biotechnologists, plant scientists, weed scientists, veterinarians, microbiologists, soil scientists, entomologists, animal scientists, horticulturalists, toxicologists, etc. Student interested in such positions will need to begin their science education at the high school level. Many colleges of agriculture around the country are requiring three years of science (biology, chemistry, physics) and mathematics (algebra, geometry, trigonometry, etc.) along with a strong background in English (4 years).

No longer can the statement "you are too good a student to go into agriculture" be tolerated. In fact, some of the agricultural programs at NDSU, such as biotechnology, suggest a minimum ACT of 25 or better for entry. Graduates of this major will exceed any requirement for medical/dental schools and graduate schools around the country. The science of agriculture needs and demands the best qualified people.

Another high area of demand is for agricultural managers and financial specialists. Estimates indicate about 6,900 positions available annually and only 85 percent of these will be filled with qualified graduates. Such positions would include agricultural economists, financial analysts, credit specialists, etc. The agricultural economics curriculum at NDSU and other schools demands a strong math background at the high school level.

One-third of all college graduates in agriculture will be needed to meet the growing demand for agricultural marketing/merchandising/sales representatives. It is estimated there are over 15,000 positions available annually. Such college graduates will need a strong technical background in one or more disciplines such as agronomy, animal science, horticulture, agricultural mechanization/engineering, soil science, plant pathology, etc., along with courses in business, communication skills, and sales techniques. The business option in any curricula in the college of agriculture will qualify students for these positions.

The employment opportunities in the agricultural industry are projected to be excellent for college grads. Now we need the people to fill them.