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 inherently 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

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Gardner is former associate agronomist, Schatz is assistant plant scientist and Olson is superintendent, Carrington Irrigation Branch Station.
Timing Growth Stages to the Climate:

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 plans. The climate of the area around Carrington, ND is referred to as 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.

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 deficiencies, 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.

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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.
In terms of yield components, long term climatic and crop development 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 x 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 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 its 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

