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# MATURITY GROUPING IN SUNFLOWER (*Helianthus annuus* L.)

Y. Kaya[1*], D. Baltensperger[2], L. Nelson[1] and J. Miller[3]

[1]Trakya Agricultural Research Institute-EDIRNE, TURKEY,
[2]Agronomy Department, University of Nebraska-Lincoln, NE, USA.
[3]USDA Northern Crop Science Lab, Fargo, ND, USA.

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SUMMARY

Twelve commercial sunflower hybrids were evaluated as possible standards for classifying sunflower hybrids into maturity groups at the different growth stages of sunflower for maturity classification of new hybrids in the U.S. Due to the narrow range among hybrids only four maturity classes were determined. Hybrids earlier than NK 231 were classified as the earliest group, between NK 231 and D-3868 as the second maturity group, between D-3868 and C-187 as the third group and hybrids later than C-187 as the latest maturity group. This grouping system was based on mean separation procedures using LSD values, and lowest MSEs. For detailed evaluation of physiological maturity, H-311 and K-8806 could be used as additional standards of very early and very late hybrids to give six maturity groups.

**Key words:** **sunflower, PM, growth stages, maturity grouping**

## INTRODUCTION

Genotype, environmental conditions and their interactions determine the length of grain filling period and physiological maturity (PM) in sunflower. Grain filling period, from last anthesis to PM, is one of the most important factors determining the yield potential of sunflower (Connor and Sadras, 1992). Grain filling period is one of the main components determining yield in many seed crops. This period between last anthesis and PM in sunflower was one of three most important stages in the yield formation and one of the most critical periods for yield (Andrade, 1995). This period is usually about 27-28% of crop cycle under dryland conditions and 40% under irrigated conditions depending on cultivars (Connor and Hall, 1997). Sunflower PM was directly accelerated by temperature and indirectly affected by climatic conditions like drought reducing the grain filling period (Anderson *et al.*, 1978).

* Corresponding author, e-mail: yalcinkaya@ttae.gov.tr

Sunflower cultivars have a considerable genetic variation in time of maturity, but the number of days from planting to maturity can also be influenced by time of planting, quantity of water, temperature, and sunlight. Sunflower PM is also related to planting date. The yield response to planting date is influenced by maturity classification of cultivars (Blamey *et al.*, 1997). Successful sunflower production in some areas depends on early maturity to ensure successful harvesting, and allows timely planting of subsequent crops. Longer maturing cultivars usually produce the highest yields. However, early planting is not a successful way to accelerate maturity and enhance yields consistently. Additionally, early hybrids grow and dry faster than later hybrids especially areas with short growing seasons. Maturity is especially important if planting is delayed and in areas with short growing seasons. Therefore, farmers should choose hybrids based on growing season length in their region and their farming system.

Days to a particular growth stage and heat units accumulation (HU) are two common methods to measure the length of time between planting and PM that would show differences among genotypes. HU could be less variable than just day accumulations among locations, years, and planting dates due to climate and other factors.

Temperature is the main environmental factor affecting phenological development in sunflower (Connor and Hall, 1997). Sunflower is usually considered a short-day crop that would grow over a wide range of photoperiod zones. However, photoperiod usually influences plant development around floret initiation and does not directly influence PM in the sunflower (Connor and Sadras, 1992). Temperature and photoperiod by temperature interactions could affect sunflower phenology, development of growth stages, yield and oil quality. Therefore, models to predict sunflower phenology and growth stages and PM using these factors and interactions between environment and genotype have been developed.

Goyne *et al.* (1989) observed and classified genotypes and their response to temperature and photoperiod at different sunflower growth stages. Using thepattern analysis, Goyne *et al.* (1982) classified the sunflower cultivars into three maturity groups as very quick, quick and medium based on days from emergence to the head visible stage in Australia. Goyne and Hammer (1982) found that photoperiod and temperature mainly influenced the number of days to first anthesis in the controlled environment.

Photoperiod is less important in sunflower than in soybean for determining maturity classification. Fehr (1987) noted that temperature and photoperiod mostly influenced soybean maturity, a quantitative trait that had a heritability of 75% or more. Tanner and Hume (1978) mentioned that there were 13 maturity groups in soybean ranging from 000 (earliest) to X (latest) based on certain latitude zones. Due to the close relationship between day length and temperature, the system works in the soybean growing area of North America and these thirteen soybean maturity groups are used successfully by soybean breeders in selection and breeding programs. However, due to altitude and seasonal temperature differences, the cultivars can not fit these predicted maturity groups in the other parts of world.

The sunflower industry needs a standard procedure to evaluate PM of new sunflower hybrids similar to the soybean industry in the US. Therefore, The National Sunflower Association expressed a need to identify a standardized PM grouping system to evaluate oil type sunflower hybrids. Our study was part of this project that included more than twenty locations in the US and twelve commercial sunflower hybrids to develop a standard set of PM groups and procedures.

Fick and Miller (1997) inferred that days from planting to maturity varied among sunflower cultivars with a range of 75-140 days, less than 100 days classified as early, 100-120 days as medium and 120-140 days could be considered late in maturity. Thompson and Dougherty (1998) classified three sunflower hybrids which were chosen from twelve commercial oil type hybrids, into four maturity groups according to data from 15 location in the U.S. They reported that hybrids that were earlier than H-311 would be in the first maturity group, between H-311 and C-270 would be in the second maturity group, between C-270 and P-6451 would be in the third maturity group and later than P-6451 would be in the fourth maturity group based on days from planting to PM. They also mentioned that using days from planting to PM was more suitable than days to flowering to classify sunflower into maturity groups.

This study was conducted to develop a uniform system of grouping sunflower hybrids for into maturity groups according to a standard set of hybrids similar to the soybean seed industries grouping of soybean varieties by PM, to compare day and HU to detect differences among hybrids and to identify specific hybrids that can be used as standards by the sunflower industry for classifying commercialized sunflower hybrids into maturity groups.

## MATERIAL AND METHODS

Research was conducted in Western Nebraska in 1997. Experiments were conducted with two locations, two planting dates (early and late), twelve commercial sunflower hybrids and four replications. Experimental design was split-split plot. Location one was conducted in dryland conditions in Sidney, NE. Early planting date in Sidney was on June 7 and late planting on June 20, 1997. The other location was under irrigated conditions in Scottsbluff, NE. The early planting in Scottsbluff was on May 20 and late planting on June 16, 1997.

Following data were collected: planting date, emergence date, dates when 50% and 100% of plants in the plot had first open ligule petals, petal dropping date, first date when the back of plants' heads turned to yellow from green color, the brown color observation dates at the bracts, the back of heads and at the stems of the plants, seed moisture and oil content% at one week before and after PM, and at PM, HU accumulation for all these data. Twelve hybrids in five maturity groups were evaluated. The hybrids were Hysun 311, IS 7000 at very early group; IS-6111, Pioneer 6230, NK 231 at early; SF 270, Dekalp 3868 at medium, Pioneer 6451, Cargill 187, Mycogen 980 at mid-late, T 571, Kaystar 8806 at late group.

Blooming and other observations were obtained and maturity data were collected until two weeks after the last frost date in the climatic data for the region. Visual observations at different growth stages were evaluated using the plant staging system developed by Schneiter and Miller (1981). They defined sunflower PM as first brown color (1-10%) at the back of the head of sunflower. Therefore, head first stage was called PM in our experiment.

Seed moisture samples were collected at one-week intervals in maturing period. Seed moisture samples were collected three times at Sidney and four times at Scottsbluff for early and late planting dates. First moisture content data were collected approximately 84 days after planting (DAP), second 92 DAP and third 99 DAP. The fourth date was collected only at the irrigated location, 110 DAP for early and 102 DAP for late planting.

Sixty seeds were removed from the head and fresh weights were obtained. Samples dried in the oven at 40°C for at least 48 hours (Cukadar-Olmedo *et al.*, 1997) were weighed and moisture data were obtained from using the formula, seed moisture (g/kg) =[(Fresh Weight-Dry Weight)/Fresh Weight]×1000. Samples were analyzed for oil using NMR.

For the HU equation, 6.67°C base temperature for sunflower was chosen as a reasonable compromise among several HU studies; base temperature of 6°C (Kiniry *et al.*, 1992), 6.6°C (Hammer *et al.*, 1982) and 7.2°C (Robinson, 1971). HU accumulations between planting date and determined observation dates were calculated for each day by averaging the minimum [at least 6.67°C base temperature] and maximum temperature and subtracting the 6.67°C base temperature. Daily maximum and minimum temperatures were taken from the National Meteorological Database for Sidney and Scottsbluff. Data were processed by analysis of variance procedures, correlation analysis using the SAS (Statistical Analysis System) program (SAS / STAT User's guides, 1990).

## RESULTS AND DISCUSSIONS

The range among hybrids in days to PM stage over locations was 28 days. However, this range was 19 days in dryland, and 26 days in irrigated site, and 24 days with early planting dates and 18 days with late planting dates. Some hybrids such as SF 270 and H-311 changed in rank with other hybrids as maturity stages progressed. SF 270 was one of the earliest hybrids at flowering stages, but it moved to medium rank at PM. In contrast, H-311 advanced from medium rank to the earliest at PM and K 8806 became the latest hybrid at PM. Similar results were obtained by Thompson and Dougherty (1998). After turning yellow stage, H-311 was the earliest hybrid and K 8806 the latest hybrid at all growth stages overall average of locations.

This indicated that days from planting date to PM are more appropriate than days from planting to flowering to measure or compare maturity among sunflower hybrids. Similar conclusions were inferred by Thompson and Dougherty (1998).

There was a sharper increase in day accumulations for hybrids in the early and medium group until bract 50% stage than hybrids in late maturing group probably due to later hybrids having a long vegetative growth period (Figure 1).

Although PM is usually at the same time as bract 50%, some hybrids displayed different behaviors. For instance, DK 3868 (in the medium maturity group) and K 8806 (in late group) reached PM stage earlier than bract 50% stage. Because of this difference among hybrids and for easier data collection, only the head first stage was considered as PM in the experiment.

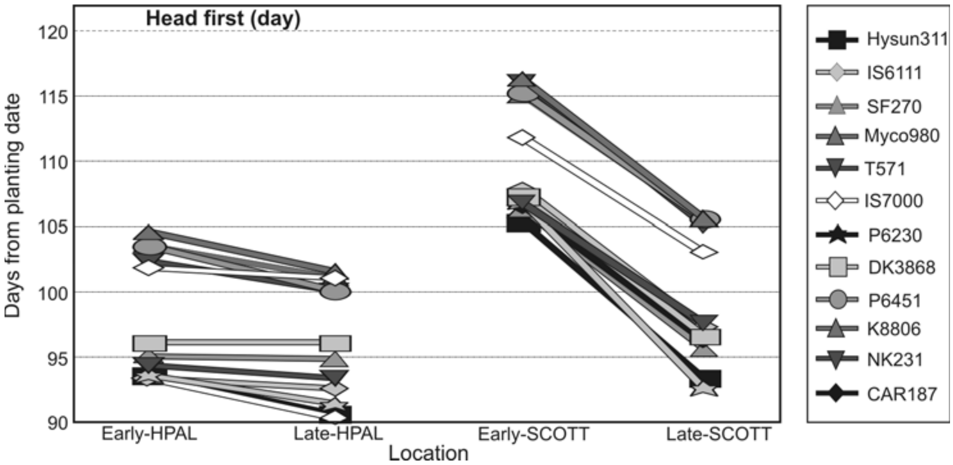


*Figure 1: Average days of hybrids measured from planting date to PM stage in two locations*

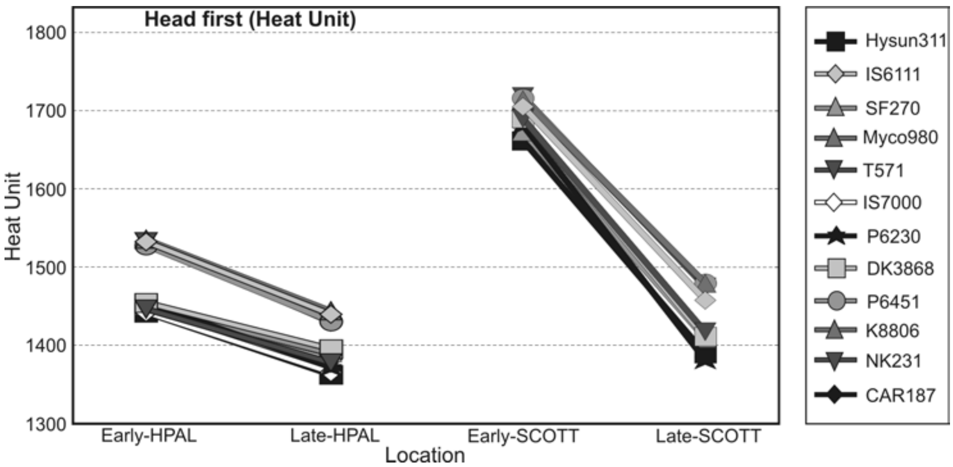


*Figure 2: Average HU of hybrids measured from planting date to PM in two locations*

Hybrids displayed different patterns at each planting date for days from planting to PM likely due to different responses of hybrids to daylength, water deficiency and other environmental conditions. Especially, the early planting date at the irrigated site required more days to reach PM than the other planting dates and locations. The reason for this could be daylength sensitivity, irrigation and longer germination period. Due to heavy rain during the planting season in the region, the two locations could not be planted at the same time.

There were 13 days in dryland and 19 days in irrigated site difference between the early and late planting dates. In dryland conditions, DK 3868 and SF 270 were not influenced and CAR 187, NK 231 and IS 6111 were influenced very little by planting date. In contrast, H-311, K 8806, P 6451 and IS 700 were greatly influenced by the change in planting date. Under irrigation conditions, most of the hybrids were influenced by planting date in days to PM. This is probably due to drought stress hiding hybrid differences. The hybrids P 6230 and H-311 were the most affected by planting date at this site. Earlier maturing hybrids with early planting had less difference in DAP than at late planting. P 6230 was the earliest maturing hybrid at late planting, although it was ranked with earlier hybrids at early planting.

There was an 11-day difference in the average number of days from planting date to PM between early planting dates, 3-day difference between the late planting date in locations and 11-day difference between the averages of locations at PM stage. These results showed that PM was mainly affected by location and early planting based on day accumulations.

**HU Accumulations**

HU showed that the difference among development stages was 60 to 160 HU. The range among hybrids from planting date to PM stage over locations was 268 HU. However, this range at PM was 187 HU at the dryland site, 257 HU at the irrigated site, 246 HU at the early planting dates, and 143 HU at the late planting dates. Similar to day accumulations, the range at PM among hybrids at the irrigated site and early planting dates was larger than the late planting in dryland site (Figure 2). Unlike day accumulations, H-311 was the earliest maturing hybrid after the petal drop stage according to HU. Both day and HU accumulation data indicated that hybrids were aggregated in two groups as late and early at the blooming stages and in three groups at later stages.

Unlike day averages between planting dates and locations, early planting at the dryland site accumulated more HU than early planting at the irrigated site at blooming and petal drop stages and until bract 50% stages, although this site was planted 18 days earlier than that of the irrigated site. The reason for contrasting results is the adjusted temperature effect in HU. However, there was no difference between late planting dates in early stages. There was 94 HU difference between early planting, 36 HU between late planting dates and 65 HU differences between locations for HU at PM stage. Unlike early stages, sunflower hybrids at late planting date at the irrigated site accumulated more HU than dryland site.

Hybrids were more uniform in HU summations than DAP at PM stage. Hybrids were divided into two groups, early and late, and hybrid HU accumulation in the dryland site ranged from 1350 to 1550. The reason for small range was that hybrids dried very quickly due to high temperature and drought stress. Hybrids at the irrigation site were affected by change of planting date and day length more than those at the dryland site. Also, there was very sharp reduction in the HU from early to late planting at irrigated site.

### Seed Moisture and Oil Content

There was a sharper decrease in the average seed moisture content over time for early planting than late planting dates for both locations. Hybrids at the early planting dates reached turning yellow in mid-August which was the time that moisture samples were first collected. Due to high temperature in mid-August to mid-September, the loss of seed moisture was rapid for early planting dates with approaching maturity. Seed moisture loss in both late plantings declined dramatically until the second sampling date and then slowed due to decreasing temperature and more rainfall at the end of September. Also in earlier maturing hybrids, the loss of seed moisture was faster than later hybrids.

Similar results to seed moisture content were obtained from oil content analysis. Hybrids usually reached maximum oil content at the same date as PM for hybrids at each location. Although seed oil content data support the results days and HU from planting date to PM to determine PM, these data cannot be a characteristic largely to classify hybrids into maturity groups due to high cost and labor for collecting data and oil content analysis.

### Maturity Classification

All data showed that there were two or three maturity groups; early and late; or an early, medium and late. DK-3868 was the most stable hybrid, and had different maturity than either the early or late maturing hybrids. It was medium maturity at most of development stages, and based on seed moisture and oil content data. There is no difference among early hybrids and among late hybrids for most characteristics. One of the goals of this study was to identify hybrids as standards to be used by the sunflower industry for classifying commercialized sunflower hybrids into maturity groups. Mean square error (MSE) of hybrids from each maturity combinations compared the accuracy for assigning maturity groups. Hybrids were divided into three or five maturity groups depending on mean separation group results based on LSD. Hybrid maturity combination group which had lower MSEs of location by hybrid (L×H), date by hybrid (D×H) and location by date by hybrid (L×D×H) interactions will be superior as a standard group for evaluation of PM in the sunflower industry.

Table 2: MSE of hybrid maturity group combinations using day summation data at PM

| Nr. | HYBRID MAT.GROUP COMBINATIONS | CV (%) | L×H | D×H | L×D×H |
|---|---|---|---|---|---|
| 1 | HYSN 311+IS 6111+DK3868+MYC980+K8806 | 17 | 7.4* | 3.2ns | 2.3ns |
| 2 | HYSN 311+P6230+DK3868+P6451+K8806 | 14 | 4.1ns | 4.6* | 5.3** |
| 3 | HYSN 311+NK231+DK3868+MYC980+K8806 | 15 | 3.9ns | 5.8** | 4.4ns |
| 4 | HYSN 311+P6230+DK3868+MYCO980+T571 | 14 | 6.5** | 5.3* | 3.7** |
| 5 | IS700+IS 6111+DK3868+MYCO980+K8806 | 18 | 8.5** | 6.6ns | 2.8ns |
| 6 | H-311+DK3868+K8806 (1-8-10) | 16 | 4.2ns | 4.8ns | 2.3ns |
| 7 | H-311+SF270+P6451 (1-3-9) | 15 | 6.9* | 4.0ns | 4.6ns |
| 8 | H-311+DK3868+T571 (1-8-5) | 17 | 12.4** | 4.6ns | 1.2ns |
| 9 | H-311+DK3868+MYCO980 (1-8-4) | 14 | 4.6ns | 4.8ns | 3.5ns |
| 10 | HYSN311+DK3868+CARGL187 (1-8-12) | 19 | 2.3ns | 8.3ns | 1.9ns |
| 11 | P6230+DK3868+K8806 (7-8-10) | 17 | 4.2ns | 8.3* | 4.8ns |
| 12 | IS700+DK3868+K8806 (1-8-10) | 18 | 14.1ns | 2.6ns | 3.6ns |
| 13 | IS611+DK3868+K8806 (2-8-10) | 22 | 14.1* | 2.6ns | 2.3ns |
| 14 | NK231+DK3868+K8806 (11-8-10) | 19 | 7.0*** | 3.6ns | 2.6ns |
| 15 | NK231+DK3868+MYCO980 (11-8-4) | 17 | 7.3ns | 0.8ns | 3.6ns |
| 16 | IS6111+DK3868+MYCO980 (2-8-4) | 21 | 14.1* | 0.4ns | 3.8ns |
| 17 | NK231+DK3868+P6451 (11-8-9) | 17 | 9.3* | 2.6ns | 5.1ns |
| 18 | NK231+SF270+P6451 (11-3-9) | 18 | 8.4* | 2.4ns | 4.5ns |
| 19 | H-311+SF270+K8806 (1-3-10) | 16 | 3.6ns | 4.2ns | 1.9ns |
| 20 | IS700+SF270+K8806 (6-3-10) | 16 | 13.1** | 2.1ns | 3.1ns |
| 21 | P6230+SF270+K8806 (7-3-10) | 15 | 3.6ns | 7.6* | 4.6ns |
| 22 | IS6111+SF270+K8806 (2-3-10) | 20 | 13.1* | 2.3ns | 2.0ns |
| 23 | NK231+SF270+K8806 (11-3-10) | 19 | 6.3ns | 3.4ns | 2.1ns |
| 24 | IS700+SF270+MYC980 (6-3-4) | 13 | 13.2*** | 1.3ns | 3.8ns |
| 25 | NK231+SF270+MYCO980 (11-3-4) | 17 | 6.5ns | 0.8ns | 3.1ns |
| 26 | IS6111+SF270+MYCO980 (2-3-4) | 17 | 13.2** | 0.3ns | 3.4ns |
| 29 | P6230+SF270+MYCO980 (7-3-4) | 13 | 4.1ns | 8.6** | 6.6** |
| 30 | H-311+SF270+MYCO980 (1-3-4) | 13 | 4.1ns | 4.3ns | 3.1ns |
| 31 | H-311+SF270+C187 (1-3-12) | 19 | 2.1ns | 8.1ns | 1.6ns |
| 32 | IS6111+SF270+ C 187 (2-3-12) | 23 | 17.5* | 0.9ns | 1.6ns |
| 33 | IS6111+DK3868+C187 (2-8-12) | 25 | 18* | 0.8ns | 1.9ns |
| 34 | IS6111+DK3868+P 6451 (2-8-9) | 21 | 15.1* | 1.8ns | 5.6ns |
| 35 | NK231+DK3868+C187 (11-8-12) | 21 | 79 | 0.4ns | 2.3ns |
| 36 | HYSN 311+IS6111+SF270+MYC980+K8806 | 16 | 6.9* | 3.0ns | 2.0ns |
| 37 | HSN311+NK231+DK3868+CRG187+K8806 | 18 | 5.0ns | 5.7ns | 1.5ns |
| 38 | HYSN311+IS6111+DK3868+CRG187+K8806 | 20 | 9.4* | 5.1ns | 1.5ns |
| 39 | HYSN 311+IS6111+SF270+CRG187+K8806 | 19 | 9.1* | 5.0ns | 1.3ns |
| 40 | P6230+IS6111+DK3868+CARG187+K8806 | 20 | 9.4* | 7.8ns | 3.3ns |

*, **, ***, indicate significance level at 0.1, 0.05, and 0.01, ns: non significant. L×H= Location by hybrid interaction, L×D= Location by plating date (PD) interaction L×D×H= Location by PD hybrid interaction

Table 2: MSE of hybrid maturity group combinations using HU at PM

| Nr. | HYBRID MAT. GROUP COMBINATIONS | CV | L×H | D×H | L×D×H |
|---|---|---|---|---|---|
| 1 | HSN311+IS6111+DK3868+MYC980+K8806 | 13 | 489ns | 4815*** | 419ns |
| 2 | HYSN 311+P6230+DK3868+P6451+K8806 | 11 | 282ns | 4429*** | 632** |
| 3 | HSN311+NK231+DK3868+MYC980+K8806 | 11 | 285ns | 5119*** | 236ns |
| 4 | HSN 311+P6230+DK3868+MYC980+K8806 | 11 | 458ns | 4316*** | 576* |
| 5 | IS700+IS 6111+DK3868+MYCO980+T571 | 11 | 605* | 4621*** | 273ns |
| 6 | H-311+DK3868+K8806 (1-8-10) | 13 | 471ns | 5400*** | 305ns |
| 7 | H-311+SF270+P6451 (1-3-9) | 11 | 380ns | 6485*** | 208ns |
| 8 | H-311+DK3868+T571 (1-8-5) | 13 | 842ns | 5951*** | 272ns |
| 9 | HYSN 311+DK3868+MYC980 (1-8-4) | 12 | 279ns | 4931*** | 253ns |
| 10 | HYSN 311+DK3868+CRG187 (1-8-12) | 16 | 660ns | 1750* | 230ns |
| 11 | P6230+DK3868+K8806 (7-8-10) | 10 | 422ns | 3814*** | 292ns |
| 12 | IS700+DK3868+K8806 (6-8-10) | 10 | 806* | 5046*** | 37ns |
| 13 | IS611++DK3868+K8806 (2-8-10) | 14 | 922ns | 5215*** | 118ns |
| 14 | NK231+DK3868+K8806 (11-8-10) | 10 | 526ns | 5070*** | 37ns |
| 15 | NK231+DK3868+MYCO980 (11-8-4) | 9 | 370ns | 4614*** | 165ns |
| 16 | IS6111+DK3868+MYCO980 (2-8-4) | 13 | 346ns | 4684*** | 257ns |
| 17 | NK231+DK3868+P6451 (11-8-9) | 9 | 465* | 5431*** | 229ns |
| 18 | NK231+SF270+P6451 (11-3-9) | 9 | 440ns | 6186*** | 177ns |
| 19 | H-311+SF270+K8806 (1-3-10) | 12 | 447ns | 6087*** | 271ns |
| 20 | IS700+SF270+K8806 (6-3-10) | 9 | 774** | 5777*** | 32ns |
| 21 | P6230+SF270+K8806 (7-3-10) | 8 | 403* | 4746*** | 348ns |
| 22 | IS6111+SF270+K8806 (2-3-10) | 12 | 888* | 5925*** | 158ns |
| 23 | NK231+SF270+K8806 (11-3-10) | 10 | 499ns | 5798*** | 32ns |
| 24 | IS700+SF270+MYC980 (6-3-4) | 8 | 730*** | 5286*** | 119ns |
| 25 | NK231+SF270+MYCO980 (11-3-4) | 9 | 350ns | 5305*** | 119ns |
| 26 | IS6111+SF270+MYCO980 (2-3-4) | 11 | 875* | 5427*** | 510ns |
| 29 | P6230+SF270+MYCO980 (7-3-4) | 7 | 116ns | 4315*** | 799*** |
| 30 | H-311+SF270+MYCO980 (1-3-4) | 10 | 262ns | 5582*** | 178ns |
| 31 | H-311+SF270+C187 (1-3-12) | 16 | 654ns | 2082** | 160ns |
| 32 | IS6111+SF270+ C 187 (2-3-12) | 18 | 1609ns | 1985* | 427ns |
| 33 | IS6111+DK3868+C187 (2-8-12) | 19 | 1623ns | 1631ns | 423ns |
| 34 | IS6111+DK3868+P 6451 (2-8-9) | 14 | 894ns | 5581*** | 617ns |
| 35 | NK231+DK3868+C187 (11-8-12) | 14 | 819ns | 1539** | 115ns |
| 36 | HYSN 311+IS6111+SF270+MYC980+K8806 | 12 | 474ns | 5224*** | 408ns |
| 37 | HSN311+NK231+DK3868+CRG187+K8806 | 14 | 688ns | 3433*** | 182ns |
| 38 | HSN311+IS6111+DK3868+CRG187+K8806 | 16 | 979ns | 3497*** | 385ns |
| 39 | HSN 311+IS6111+SF270+CARG187+K8806 | 15 | 968ns | 3810*** | 375ns |
| 40 | P6230+IS6111+DK3868+CARG187+K8806 | 11 | 1093* | 4963*** | 201ns |

*, **, ***, indicate significance level at 0.1, 0.05, and 0.01, ns: non significant. L×H= Location by hybrid interaction, L×D= Location by plating date (PD) interaction L×D×H= Location by PD hybrid interaction

A total of 40 maturity combinations, 10 combinations with five hybrids and 30 combinations with three hybrids were compared (Tables 1 and 2). Due to the narrow range between the earliest and the latest hybrid in the data sets, the numbers of hybrids in the maturity group were reduced from five to three standard hybrids to determine PM. Another reason for the choice of groups with three hybrids is that sunflower breeders and producers cannot feasibly include more standard hybrids in their experiments to identify PM of their hybrids or lines. Maturity combinations with five hybrids were also compared to find standards for more detailed maturity classifications when needed.

According to MSE of genotype by environment (L×D×H) interactions at PM, maturity group number 37 in the day accumulation and group number 37, 38, and 39 in HU had lower MSE than other maturity groups with five hybrids. Maturity group number 37 had the lowest MSE for date by hybrid interaction in HU. Furthermore, if both two-way and three-way interactions in HU and day accumulations were combined, maturity group number 37 (H-311 - NK 231 - DK 3868 - C-187 - K-8806) had the lowest MSE values (Tables 1 and 2). Therefore, it could be concluded that this maturity group could be used as standards for maturity. H-311, NK 231, DK 3868, C-187 and K-8806 would be the standards for more detailed evaluation of maturity. This classification of sunflower hybrids into six standard maturity groups will help sunflower breeders and producers for classifying hybrids with large maturity differences.

Maturity groups number 9, 30, 25, 15, 35 and 16 had lower MSE values in the three hybrid groups considering D×H, L×H and L×D×H interactions in HU (Table 2) at PM as with day accumulations data (Table 1). Maturity group number 19, 9, 6, 31, 35, 30 and 25 had lower MSEs than other combinations. However, maturity groups number 32, 33, 35, 25 and 16 had lower value when considering location and date by hybrid and genotype by environment interactions.

Considering both day and HU data set MSE results, maturity group number 35 (NK 231- DK 3868 - C 187) seemed less variable than other groups for all interactions (Tables 1 and 2). These three hybrids also were less influenced by planting date in the experiment and existed in the maturity combination group with five hybrids with the lowest MSE. Therefore, NK 231, DK 3868, and C 187 should be used to classify hybrids by the sunflower industry.

## CONCLUSIONS

Hybrids reached flowering at an average of 62 to 70 days after planting date (DAP) and reached PM at 96 to 107 DAP. Consequently, hybrids reached flowering at 900 to 1000 HU and reached PM at an average of 1400 to 1510 HU after planting date. Seed moisture contents of hybrids at PM were approximately 30 to 40%, and maximum seed oil content occurred at this time. Later maturing hybrids at late plantings in both irrigated and dryland site could not accumulate enough HU to reach harvest maturity (about 1600 HU) until after two weeks first average fall frost date when the last data collected. There was more variation in HU accumulation than days based on standard deviation and MSEs at different growth stages over location.

Mean separation groups based on LSD indicated that hybrids usually clustered into three groups at PM as early, medium and late. The narrow range between the earliest and latest hybrid did not allow identification of more maturity groups. Also, it would be impractical for sunflower breeders and producers to include more hybrids in trials to evaluate PM. Therefore, only three hybrids were chosen as standards to identify sunflower PM. However, maturity groups with five hybrids were also chosen as standard for very early and very late maturity groups in the classification of these hybrids when needed by the sunflower industry.

The smallest MSE of genotype by environment, planting date by hybrid and location by hybrid was used to choose combinations which were least influenced by environment and planting date. Based on MSEs, NK 231, DK 3868 and C 187 were chosen as standards to classify sunflower maturity. Hybrids earlier than NK 231 would be the earliest maturity group, between NK 231 and DK 3868 would be the second maturity group, between DK 3868 and C 187 would be the third maturity group and hybrids later than C 187 would be the latest maturity group. For detailed evaluation of maturity, H-311 and K 8806 could be used as standards for very early and very late maturing groups. This group had the lowest MSEs in the groups with five hybrids. Sunflower breeders could classify maturity of new lines and hybrids according to this set of standard hybrids.

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## CLASIFICACIÓN DE GIRASOL (*Helianthus annuus* L.) POR GRUPOS DE MADURACIÓN

RESUMEN

En el trabajo se evaluaron 12 híbridos de girasol comerciales, para que se determinara si se pudieran utilizar como estándares para la clasificación de nuevos híbridos de girasol por grupos de maduración en diferentes fases de crecimiento en los E.E.U.U. Debido al estrecho rango entre híbridos, se han determinado sólo cuatro grupos de maduración. Los híbridos anteriores de NK 231, se han clasificado como el grupo más temprano, los híbridos entre NK 231 y D-3868, como el segundo grupo de maduración, los híbridos entre D-3868 y C-187 como tercer grupo, y los híbridos más tardíos que C-187, como el grupo más tardío. Este sistema de agrupación está basado en los procedimientos de la separación media, junto con la utilización de los valores LSD y de los MSE más bajos. Para una detallada calificación de madurez fisiológica, podrían utilizarse los híbridos H-311 y K-8806, como unas normas adicionales de los híbridos muy tempranos y muy tardíos, para obtener seis grupos de maduración.

## CLASSIFICATION DE TOURNESOL (*Helianthus annuus* L.) SELON LES GROUPES DE MATURATION

RÉSUMÉ

Aux Etats Unis, douze hybrides commerciaux de tournesol sont évalués afin de vérifier la possibilité d'être utilisés comme les hybrides standard pour la classification de nouveaux hybrides de tournesol selon les groupes de maturation dans les phases différentes de développement des plantes. En raison du diapason restreint parmi les hybrides, seulement quatre groupes de maturation sont déterminés. Les hybrides qui mûrissent plus tôt que les hybrides NK 231, sont classifiés comme groupe qui mûrit le plus tôt, les hybrides entre NK 231 et D-3868 sont classifiés comme deuxième groupe de maturation, les hybrides entre D-3868 et C-187 sont classifiés comme troisième groupe de maturation et les hybrides qui mûrissent plus tard que les hybrides C-187 sont classifiés comme quatrième groupe de maturation. Ce système est basé sur le procédé de séparation moyenne en utilisant les valeurs LSD et les plus bas de MSE. Pour une évaluation plus détaillée de maturation physiologique, les hybrides H-311 et K-8806 pourraient être utilisés comme hybrides standard de groupes qui mûrissent très tôt et trop tard pour obtenir six groupes de maturation.