

### 2.3.4. Crop Management Details

**Start from:** A Hybrid-Maize simulation can start from either planting or emergence. Make that choice and select the appropriate date from the month/date boxes on the right. When starting from planting, the planting depth needs to be specified because the depth of seed placement affects the time required for emergence, as simulated by the model.

Start from

Emergence

Planting

Seed depth (inch) 1.6

m/d

5 1

5 1

The GDD required for germination and for emergence per cm depth are set by the **Parameters settings**. Users may change the default values when necessary.

15 GDD10C requirement for GERMINATION; default = 15

6 GDD10C requirement for emergence per cm depth; default = 6

25 Maximum days allowed from planting to emergence

*NOTE: In most cases, differences between running the model from **Emergence** or from **Planting** are very small (usually within  $\pm 1$  to 2 bu/acre grain yield). When in doubt, use date of planting as the general starting mode.*

**Seed brand:** Choose the appropriate seed brand and Hybrid-Maize will select the appropriate function for describing the relationship between total GDD to physiological maturity and GDD to silking. GDD values differ somewhat among seed companies because of different definitions and methods used to measure them. The functions used by Hybrid-Maize can be viewed and edited by through **Settings** → **Parameter settings** → **Hybrid-specific** in the main menu. If the seed brand you wish to use is not included in the list of choices, choose **Generic** for your simulation. In this case, Hybrid-Maize will use a general relationship derived from many different seed brands.

Seed brand

Generic

**Maturity:** This sub-panel is used to specify when physiological maturity and silking are reached in a Hybrid-Maize simulation. Model predictions are *very sensitive to both* and decisions on this must be made with great care. *Silking* (R1 stage of maize) begins when any silks are visible outside the husk and 2 to 3 days are required for all silks on a single ear to be exposed and pollinated (Ritchie et al., 1992). In Hybrid-Maize, silking date refers to occurrence of about 50% silking in the field. *Physiological maturity* (R6 stage or black layer stage of maize) is reached when *all kernels on an ear* have attained their maximum dry weight and a black or brown abscission layer has formed at the kernel base (Ritchie et al., 1992). Note that black layer formation occurs progressively from the tip to the base of the ear, which must be considered when determining the exact date of maturity.

In Hybrid-Maize, crop maturity can be specified by one of the three options: total GDD (growing degree days, or growing degree units) the crop takes to reach physiological maturity, or the actual

date of maturity if it is known, or relative maturity (RM, in days). If the date of reaching maturity is not known (e.g., in Long-term runs and Current season prediction modes), maturity is predicted by Hybrid-Maize from available information about the specific hybrid grown (cumulative GDD required to reach maturity) and the weather data during the seasons simulated. The GDD refers to the cumulative GDD to physiological maturity and is calculated from the summation of the 'effective daily temperature' during the growing season from emergence to maturity. The effective daily temperature is the temperature above a base temperature of 10 °C (50 °F) and below a default upper cutoff temperature of 34 °C (93 °F). To utilize the GDD option, choose GDD50F (English units option, referring to a base temperature of 50 °F) or GDD10C (Metric units option, referring to a base temperature of 10 °C) and enter the appropriate GDD value for the hybrid grown. This information is readily available for most commercial hybrids from seed companies, either published in their seed catalogues or found online.

**Maturity**

- GDD50F 2500
- Date (m/d) [ ] [ ]
- Relative maturity (days) [ ]

**Optional:**

- Date of silking (m/d) [ ] [ ]
- GDD50F to silking \* 1287

\* Generic estimate

*NOTE: We recommend using the GDD to maturity mode for most Hybrid-Maize simulations because errors due to wrong identification of actual occurrence of physiological maturity in the field can be large. To prevent erroneous entries, customizable lower and upper limits of total GDD allowed are specified under **Settings** → **Parameter settings** → **Management**.*

*Also note that the starting time for GDD differs among seed companies. After the seed brand is selected, the model will use the corresponding GDD starting time according to the information obtained from the seed companies. For Generic brand, the default GDD starting time is planting, but it can be changed through Parameter settings. The GDD starting time for all other brands can also be viewed through Parameter settings. The GDD starting time for each simulation is noted in the result summary.*

If the exact date of maturity is known (e.g., in research studies using **Single year** simulation mode for analysis of a past growing season, see section 3.3.), select **Date** and enter the date on which physiological maturity is reached in the month/day drop down boxes.

**Maturity**

- GDD50F [ ]
- Date (m/d) 9 [ ] 3 [ ]
- Relative maturity (days) [ ]

**Optional:**

- Date of silking (m/d) [ ] [ ]
- GDD50F to silking [ ]

*NOTE: Model results are very sensitive to this setting and simulated yield can be seriously affected by entering an incorrect maturity date. Accurate simulations require precise estimates of physiological maturity (R6 or black layer stage) based on careful field observations. Strictly follow the definition of R6 stage provided above (Ritchie et al., 1992) and monitor the crop during its final stages on a **daily basis**. If unsure, use the GDD option described above.*

The last option for setting maturity is by **Relative maturity** (RM, in days). Enter the RM value for the hybrid and also make sure the seed brand is selected correctly. Note that RM measures the days to the stage when grain moisture content is suitable for harvest, instead of the days to the stage when grain filling stops (i.e., at blacklayer). Although there exists a correlation between RM and total GDD for a specific seed brand, the goodness of the correlation does vary across brands (refer to section 4.3 for detailed discussion). For this reason, caution must be taken when using this option to set maturity. When using this option for the first time in a session, a warning message will pop up, reminding the user about possible inaccurate simulation results in this case.

Maturity also has two associated optional parameters: **Date of silking** (50% silking observed in the field) and **GDD to silking**. The time of silking is very important for simulation of grain yield, because it is the time when the crop shifts from vegetative growth to reproductive growth (i.e., grain filling). By default, Hybrid-Maize uses the total GDD (either specified by the user or calculated when the date of maturity is specified) to predict the GDD required to reach silking, and thus to predict the date of silking. The prediction is based on brand-specific functions between GDD-to-silking and total GDD as derived from data of published seed catalogs. If hybrid-specific information on GDD-to-silking or the exact date of reaching silking (50% silking) is known, entering this information may improve the accuracy of model simulations. Only one option can be set, date of silking or GDD to silking.

**Maturity**

GDD50F 2643

Date (m/d) 9 5

Relative maturity (days) 110

**Optional:**

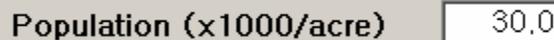
Date of silking (m/d) 7 3

GDD50F to silking

The option **Date of silking** is not available in simulation mode **Long-term runs** because a fixed date of silking across different years does not occur. In simulation modes **Single year with long-term runs** or **Current season prediction**, setting the date of silking for the year of interest will also affect the long-term runs. The model will determine the occurrence of silking for the long-term runs based on the GDD-to-silking value that corresponds to date of a silking entered for the single year or current season of interest. Similarly, in the **Current season prediction** with the option **Include yield trend**, the yield predictions for the dates prior to the given date of silking are also based on the GDD-to-silking value that corresponds to the date of silking entered for the current season. Although this scheme emphasizes the value of real time information (i.e., the actual date of silking), it also bears the risk of erroneous simulations for those runs that depend on such real-time information.

*NOTE: Model results are very sensitive to this setting and simulated yield can be seriously affected by entering an incorrect silking date. Strictly follow the definition of silking stage provided above (Ritchie et al., 1992) and monitor the crop during this period on a daily basis. For most practical applications, we recommend leaving 'Date of silking' and 'GDD to silking' blank or only enter the published 'GDD to silking' from the available hybrid-specific information (see seed catalogs).*

**Plant population:** Enter the final plant density at maturity, in 1000 plants per acre (English) or 1000 plants per ha (metric), estimated from plant counts. Note that these values are actual stand counts and not the number of seed sown per acre or ha because not all seeds germinate. For greatest accuracy, stand counts should be taken at several locations in the field. If stand counts are not known, use a plant population that is ~94% the number of seed sown. For example, if 32,000 seed were sown per acre, the final plant population would be estimated at 30,080 plants per acre ( $0.94 \times 32,000$ ). Rounding the estimated plant population to the nearest thousand gives 30 in the window as shown below.

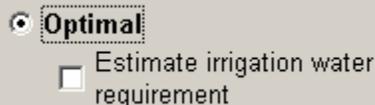


Population (x1000/acre) 30.0

*NOTE: Hybrid-Maize has mostly been tested with plant populations ranging from about 28,000 to 45,000 plants/acre (70,000 to 110,000 plants/ha). An empirical equation derived for this range is used to describe the effect of plant density on the rate of grain filling (see section 4.1.9.). The model should be used with caution outside this range without further verification. Actual crop response to plant population may also vary significantly among maize hybrids. Effects of different **row spacing** are not accounted for in Hybrid Maize. The lower and upper limits of population are specified in **Settings** → **Parameter settings** → **Management** and can be changed to avoid entering values outside the validated range. The default range is 30,000 to 125,000 plants/ha.*

### 2.3.5. Water

**Optimal:** This option is selected for simulating maize yield potential under non-limiting conditions, assuming adequate water supply throughout the entire growing season (see Chapter 1). When selecting **Optimal** water regime, the user also has the option to let the model estimate the minimum requirement for irrigation water in order to achieve water stress-free growth. This option requires specification of soil properties as in the rainfed/irrigated option.



**Optimal**  
 Estimate irrigation water requirement

*NOTE: In estimating irrigation water requirement, irrigation events are assumed to occur in a single day, which may not be possible with some irrigation systems. The maximum irrigation water amount that can be delivered depends on the irrigation equipment available. This value can be set under **Settings** → **Parameter Settings** → **Management**.*

**Rainfed/Irrigated:** Select this option to simulate the water-limited yield under either rainfed (dryland) or irrigated conditions, taking into account daily rainfall as well as past or scheduled irrigation events. Selecting this option activates the irrigation scheduler as well as the sub-panel for entering soil information. A maximum of 60 irrigations are permitted. The dates must be entered as numeric values for both month (1, 2,...12) and day (1,2,...31). Enter irrigation amounts in inches (English unit mode) or mm (Metric unit mode). Note that a later irrigation

event can be entered after an earlier irrigation event and blank rows are allowed. This is particularly useful for testing irrigation effects by removing events or adding new events to the end of a schedule. The irrigation schedule entered can be saved/retrieved together with all other model settings. To delete all irrigation events, click **Reset entries** at bottom left of the box.

**Irrigation schedule**

Month	Day	Amount (inch)
6	25	1.2
7	2	1.0
7	15	1.3
7	22	1.2
7	30	1.2

The option **Assume no water stress in prediction phase** becomes available when running **Current season prediction** mode with the **Rainfed/Irrigated** water option. Under rainfed conditions (no irrigations entered), checking this option will have no effect, i.e., the model will automatically uncheck it and assume water-limited conditions throughout, based on actual and historical rainfall data only. In irrigated maize, checking this option forces the model to assume optimal water conditions for the period after the date on which the real-time simulation is made, i.e., up-to-date weather data for the current season are used until the date of the simulation, but no water stress is assumed thereafter in the forecasting phase. If the option **Include yield trend** is checked and there are irrigation entries in the irrigation schedule table, the option **Assume no water stress in prediction phase** must be checked, or a message will pop up, prompting the user to check it. This is because the predictions for the dates prior to the current date will have missed the irrigation applied thereafter, making their yields strongly biased downwards.

**Rainfed / Irrigated**

**Assume no water stress in prediction phase**

**Irrigation schedule**

Month	Day	Amount (inch)

*NOTE: This version of the model simulates maize growth and yields under optimal water regime (yield potential) as well as water-limited conditions. Most of the model validations so far have been conducted under optimal water conditions in the western and central Corn Belt of the USA, whereas model validation for water-limited conditions is still ongoing. Therefore, caution must be exercised when interpreting simulation results under water-limited conditions, particularly in areas that are prone to severe drought stress at key growth stages.*

### 2.3.6. Soil

Soil properties are only required under **Rainfed/Irrigated** water conditions, or in **Optimal** water mode when the additional option of **Estimating irrigation water requirement** is selected.

**Moisture status of topsoil and subsoil at start:** Topsoil refers to the top 30 cm or 1 ft of soil and subsoil is considered to be soil below topsoil up to a depth of about 1 m. Select one of the five levels of soil moisture.

For each of the five possible choices associated levels of soil moisture are shown as percentage of the field capacity (FC). Those default values can be changed on the **Soil** page of **Parameter Settings** in the main menu. Any changes in the values will be mirrored in the names. Use the following principles to set initial soil moisture for both topsoil and subsoil:

- if winter snow and pre-planting rains have been normal or above average, select **Wet** (100% field capacity) as the initial moisture status;
- if precipitation has been slightly below normal and the soil profile is not filled fully, choose **Moist** (75% field capacity);
- if precipitation has been much below normal use **Dry** (50% FC) or **Very dry** (25% FC).

*NOTE: Users in Nebraska can obtain historical and real-time information on soil moisture status from the Nebraska Soil Moisture project at the HPRCC (<http://hprcc.unl.edu/soilm>).*

**Maximum rooting depth:** The maximum rooting depth of maize is normally about 1 m (or 3 to 4 ft) in fields without compacted subsoil layers. Under rainfed conditions rooting depth may exceed 1 m. The smallest possible maximum rooting depth that can be specified is > 40 cm (or 16 inches) simply because it is unlikely that maize will be grown in fields with a shallower maximum rooting depth.

**Texture and bulk density:** Select soil texture types for both topsoil (top 30 cm or 1 ft of soil) and subsoil (the soil below the topsoil) from the drop-down list provided. For each of these texture classes, default soil physical properties will be used for simulating the soil water balance. The user may change these texture specific soil properties under **Settings** → **Parameters** → **Soil** (see section 4.2, and Appendix 6.2). For topsoil, also enter the estimated bulk density after selecting soil texture class. The bulk density of topsoil typically ranges from 1.1 to 1.4 g cm<sup>-3</sup> depending on soil texture and structure, tillage, and residue management. If in doubt, leave the topsoil bulk density value unchanged at 1.3 g cm<sup>-3</sup>. Subsoil bulk density will be estimated from soil porosity of the selected texture class. Soil porosity is set on the **Soil** page of **Parameter settings** on the main menu.