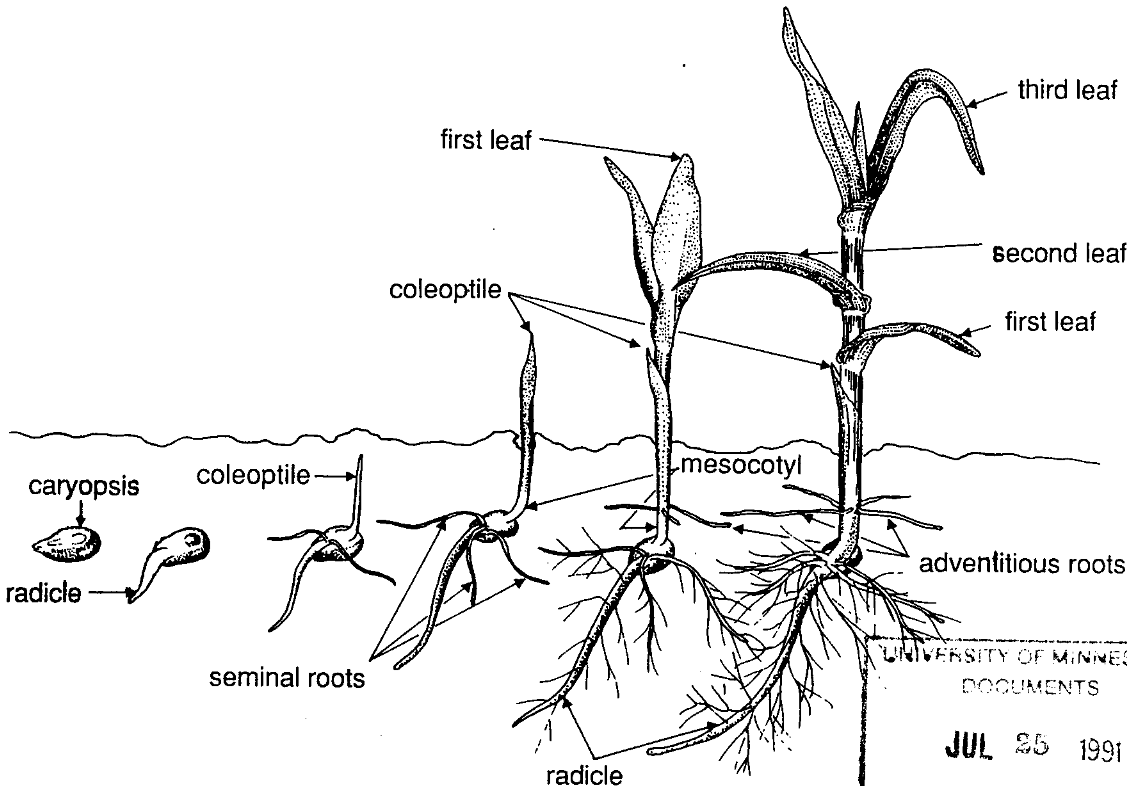
MINNESOTA EXTENSION SERVICE
UNIVERSITY OF MINNESOTA
AGRICULTURE

Corn Growth and Development

&

Management Information for

Replant Decisions



L.L. Hardman
Extension Agronomist-Crops
Dept. of Agronomy &
Plant Genetics
Univ. of MN, St. Paul

J.L. Gunsolus
Extension Agronomist-Weed Control
Dept. of Agronomy &
Plant Genetics
Univ. of MN, St. Paul

CORN GROWTH AND DEVELOPMENT

An understanding of how a corn plant develops can help you make important management decisions. This section discusses various seed and plant parts, explains how a corn plant develops (using the National Crop Insurance Services (NCIS) system) and describes some of the important factors affecting growth and development of a corn plant.

The seed of corn (kernel) consists of an embryo surrounded by a mass of stored food called endosperm and an outer covering called the pericarp. A front view and a longitudinal section of a mature corn kernel are shown in Figure 1. The pericarp consists of several layers of cells which help protect the endosperm and embryo from disease organisms and moisture loss. The endosperm provides about 75% of the weight of a kernel and is the stored energy reserve. It is about 90% starch and 10% protein, oils, minerals, etc. The embryo is a miniature plant consisting of a plumule (5-6 embryonic leaves) at one end and a radicle (root) at the opposite end. A scutellum (cotyledon) is connected to the midpoint of the embryo axis and serves as the absorption site for the food stored in the endosperm.

When planted in moist soil, kernels begin to absorb moisture, activating enzyme systems in the scutellum which digest and move nutrients into the developing embryo axis. Figure 2 illustrates the initial stages of growth and development of a corn plant. Growth begins with the emergence of the radicle (root) from the kernel which forms the primary root system. The plumule also begins to elongate and new leaves begin to form as the mesocotyl (middle part of embryo axis) elongates. Seminal roots form and grow horizontally to provide moisture and nutrients for the developing plant.

The developing plumule (also referred to as the epicotyl) is covered by a protective layer of cells called the coleoptile which elongates toward the soil surface. The tip of this coleoptile can reach the surface in about 6-10 days, at which time light causes it to split open revealing the first leaves of the corn plant. The first of these leaves has a slightly rounded tip (all later leaves have a sharp pointed tip).

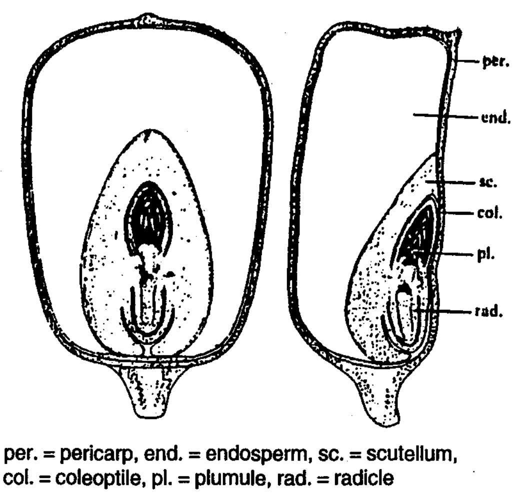
Soon after the coleoptile reaches the surface, the first adventitious roots develop from the elongated mesocotyl. This occurs just below the soil surface. Crown roots, which ultimately become the main root system of the corn plant, will develop later from the lower nodes on the main stem.

Leaves emerge at a rate of about one every 3 days. By the 10th day the young corn seedling is well established and during the next 4-5 weeks all leaves are formed in the growing point or shoot apex. All early formed leaves (first 3 or 4) are eventually sloughed off as development continues, but they capture light energy and produce food to support the developing tissues during this early period.

Seminal roots decline in function as the permanent root system develops from the nodes of the crown area. By the time a corn plant has eight leaves it is about 15" - 18" tall and the root system has explored an area approximately 18" deep and 15" wide.

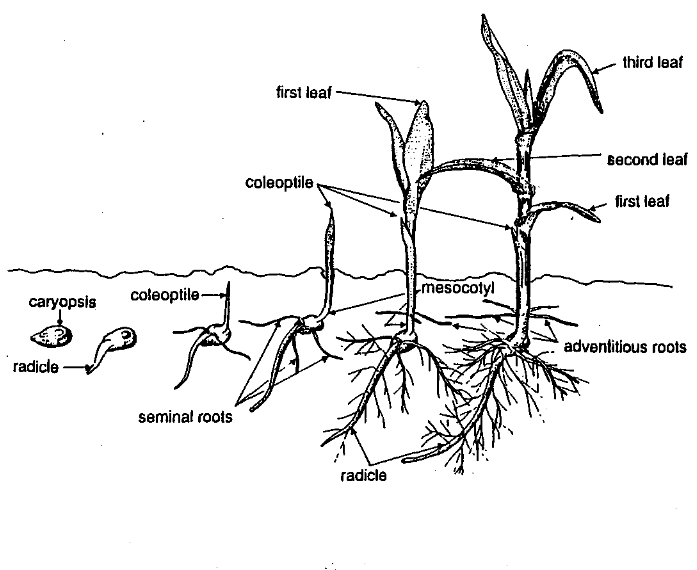
By the end of the fifth week the stem apex contains all the leaf, ear, bud and tassel initials which will be present on a mature plant. All ear buds appear alike at this time, but some of the lower ones can become tillers, others higher up the stem can become full or partial ears and those in between remain dormant. The growing point this time is near the soil surface (approximately 30 days after planting), and eight to ten leaves are visible. The slightly rounded or dome shaped stem apex becomes more cylindrical and within 3-7 days it is recognizable as a tassel. The time from tassel differentiation to pollen shed is about 5-6 weeks.

Figure 1.Sectional views of a corn kernel.



per. = pericarp, end. = endosperm, sc. = scutellum, col. = coleoptile, pl. = plumule, rad. = radicle

Figure 2.Early seedling development of corn (adapted from original drawings by R. Kent Crookston).



A rapid increase in plant height occurs as internodes elongate. Miniature ear buds develop at several nodes but will not fully differentiate for a couple of more weeks. The main ear will develop on a side branch about 6 nodes below the tassel.

Vegetative growth now begins to slow and energy is diverted to reproductive development. All major plant growth is complete and the leaves and stalks are full size. The tassel emerges from the uppermost leaf whorl and expands as it begins to shed pollen. Pollen is shed for 5-8 days with peak release by the 3rd day. Ears emerge and silks appear from the ends of husks 1-3 days after pollen shed begins. Silks from the base of the cob elongate first, those from the tip last, this process is completed in 3-5 days. Silks continue to elongate until pollinated. Each silk is attached to an ovule which will become a kernel if pollinated. Approximately 700-1000 kernels can be produced on a cob in an even number of rows.

Kernel development begins immediately after an ovule is fertilized. The embryo develops and the endosperm is filled with carbohydrate, protein, oil and minerals. About 8 weeks after pollination the maximum kernel and plant dry weight is achieved. Many hybrids require 50-60 days after pollination to achieve physiological maturity (PM) or maximum dry weight. A black layer or line becomes visible near the tip of a mature kernel where it attaches to the cob, indicating that transport of material into the kernel has stopped.

Table 1 provides the standardized corn growth stage description system developed by the National Crop Insurance Services (NCIS). There are other growth staging systems but the NCIS is widely used by crop scientists, crop insurance adjustors and farmers. This table also indicates the average number of days for each growth stage and the average number of days from emergence to each stage. This NCIS system identifies leaf stage by number. The indicator leaf is the uppermost leaf with 50% of its potential leaf tissue exposed and its tip pointing downward from a theoretical horizontal line (see Figure 3). To avoid confusion in staging corn growth, always describe the system being used, or specifically how the indicator leaf is identified. Many people like the NCIS system because the descriptions in all stages are self-explanatory.

Table 1. Corn growth staging terminology. (Adapted from Corn Loss Instructions, National Crop Insurance Services (NCIS) #6102 Rev. '84, 15 pages).

Stage title	Average number of days/stage	Approximate Days from emergence
germination	8	---
emergence	4	---
first leaf	3	3
second leaf	3	6
third leaf	3	9
fourth leaf	3	12
fifth leaf	3	15
sixth leaf	3	18
seventh leaf	3	21
eight leaf	3	24
ninth leaf	3	60
tasseled	3	63
silking	4	69
silks brown	4	73
pre blister	4	77
blister	4	81
early milk	4	85
milk	4	89
late milk	4	93
soft dough	5	97
early dent	5	102
full dent	10	107
mature	10	131
harvest	---	141

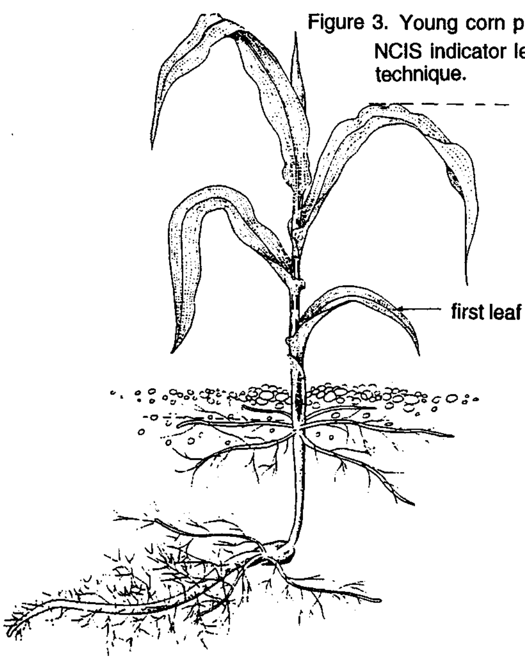


Figure 3. Young corn plant showing the NCIS indicator leaf determination technique.

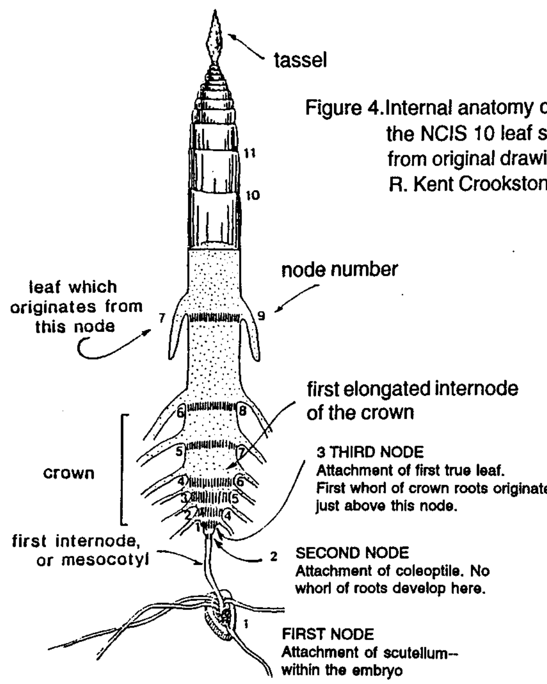
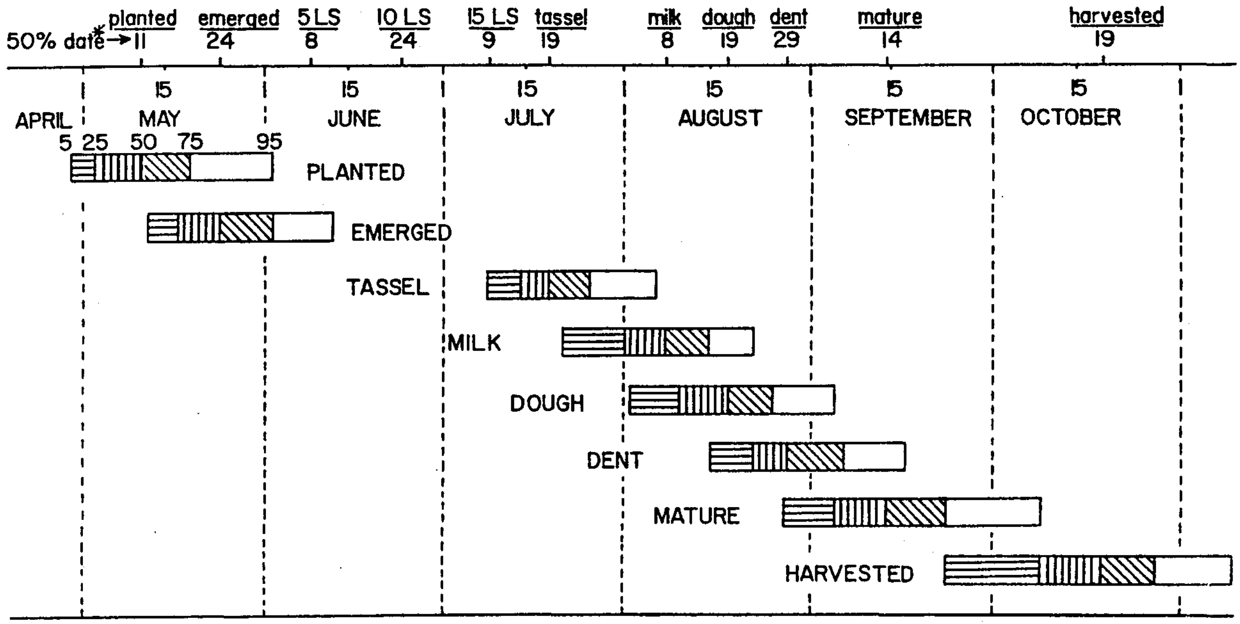


Figure 4. Internal anatomy of corn plant at the NCIS 10 leaf stage (adapted from original drawings by R. Kent Crookston).

Figure 5.Minnesota corn crop development calendar (adapted from Corn Plant Development in Minnesota, Crop News #45, D.R. Hicks).



*Calendar date when 50% of the corn acreage has reached various development stages.
Bars show the dates when various percentages of the acreage has arrived in each stage of development.

When all leaves are present on a young corn plant, it is very easy to describe the stage of development by leaf count, however, the earliest formed leaves only function for a short period before they are sloughed off. Staging then becomes difficult because you don't know how many of these leaves are missing. In such cases, leaf number determinations must be determined by a detailed examination of the stem. This is done by digging a plant and carefully removing excess soil from the roots. With a sharp knife or razor blade cut the stem into two identical halves lengthwise from the root area to about 4 inches above the original soil line. Carefully remove all the leaves and leaf sheaths to expose the stem. Figure 4 shows the stem from a plant in the NCIS 10 leaf stage which was prepared using this procedure. Various structures needed to correctly stage this plant are indicated in Figure 4, especially note node 3 and the first visibly elongated internode (between nodes 6 and 7). Leaves were originally attached at all nodes from number three to the top of the plant. Leaf 5 would have been attached to the top of the first noticeably elongated (3/8" or more) internode (node 7). All internodes above node 7 elongate to lengthen the stem.

A commonly used calendar describing the typical progress of corn development in Minnesota from planting to harvest is provided in Figure 5. The data for this calendar were provided by the Minnesota Agriculture Statistics Service (MASS) and shows the calendar dates at which various percentages of the corn crop arrive at key growth and/or maturity stages.

MANAGEMENT INFORMATION FOR REPLANT DECISIONS

Don't make a hasty decision to replant corn when the appearance, distribution, and number of plants in the field are not as good as you think they should be. The first consideration after a storm or other disaster is to evaluate the stage of plant growth, the number of living plants, their distribution, the amount of leaf damage, status of weed control, and the potential yield loss due to replanting at a late date. You must also consider seed availability as well as labor and cost of replanting. A careful and objective evaluation can save you money.

This section will assist you in determining the extent of damage to the plants in your field and help you compare yield losses due to low plant populations and leaf damage with losses due to replanting at a late date. This section will also offer recommendations for varieties or alternate crops to use in replanting if it is deemed necessary and discusses how weed management decisions can affect your replant decision.

Determining the Yield Potential of Remaining Plants

The first step is to determine the stage of growth at the time of the storm (refer to the growth and development section and Table 1 for information on this procedure). Next determine the number of surviving plants in the field for use in calculating the yield potential of the existing plants.

As a part of the assessment of a living or dead plant you will need to assess the health of the growing point. It is normally below the ground for 2-3 weeks after emergence of leaves and it is often protected from injury because of this. Check the condition of the growing point of several damaged plants by splitting the stalks down the middle. If healthy and undamaged it will be white in color and firm in texture. If damaged it will be discolored and watery due to bacterial and fungal infections. Plants with damaged growing points will not recover and should be counted as dead.

Examine plants from several areas of the field and determine the number of live plants per foot of row (make several counts in various areas of the field). Convert these numbers to plants per acre. Hail damage to corn can result in plants with their leaves tightly bound in a whorl (sometimes called buggy whips). The leaves are bound so tightly that the tassel cannot emerge by normal elongation of the internodes. Since it is impossible to predict if these will unfurl and resume normal development, they should be counted as dead when doing the remaining live plant counts.

Data from plant population studies show small yield differences for populations between 24,000 and 30,000 plant/acre for full season hybrids on fertile soils with good water holding capacity. Figure 6 shows the relationship between plant population, planting date, and yield. Large yield reductions can occur when plant populations drop below 18,000 plants per acre. Highest yields are therefore produced by earliest planting, high populations and full season hybrids. Optimum population varies with hybrid, fertility program and soil type.

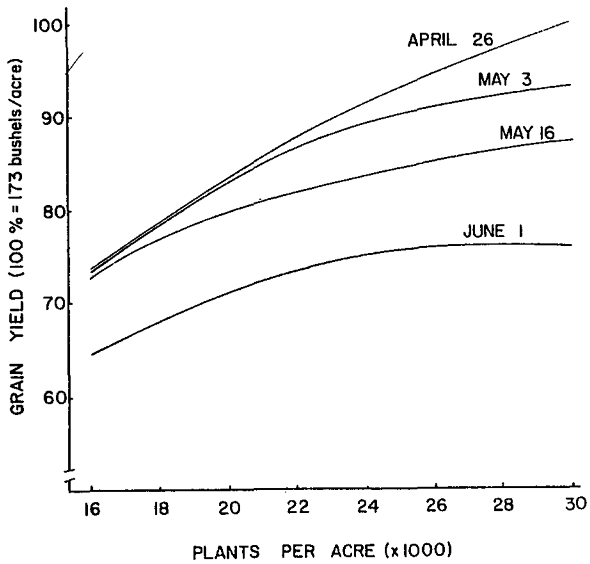


Figure 6.Effect of planting date and plant population on grain yields of a 110 RM (full season) corn hybrid (adapted from Corn Replanting: Is It Necessary, Crop News #46, D.R. Hicks).

Table 2, which was adapted from the 1984 Revision of the NCIS Corn Loss Instruction booklet, can now be used to determine the yield potential of the remaining plants in your field. This table is valid for assessing damage to corn up to the 10 leaf stage.

Table 2. Effect of early season (up to 10 leaf stage) stand reduction on corn yields

Percent Stand Remaining	% Yield Loss
100%	0%
75%	-10%
50%	-26%
25%	-43%

Next, determine the extent of leaf damage on the surviving plants. Carefully examine plants from several representative areas in the field to determine the amount of leaf area that is still functional.

Table 3 provides the estimated yield loss due to varying amounts of leaf area destruction for several stages of development. Note that the largest yield losses result from damage as the plant approaches tasseling and silking (NCIS 16 leaf through late milk stages). Use the previous defoliation and stage of growth data you gathered to determine from this table the amount of yield reduction due to leaf damage.

As you can see from these data, leaf damage at early growth stages does not affect yield the same way as it does at later growth stages because much of the plant's total leaf area is yet to be exposed.

Figure 7 shows the amount of leaf tissue exposed on a corn plant at four stages of development. Extensive damage to plants in the 10 leaf stage of growth does not result in a large yield loss because 75% of the leaf area is yet to be exposed and the plant can easily recover from early damage. On the other hand, severe damage to plants during tasseling results in a large yield loss because by that time 100% of the leaf area has been exposed and cannot be replaced.

Table 3. Effect of corn leaf area loss at various growth stages*

	Percent leaf area destroyed					
Growth Stage	**10%**	**20%**	**40%**	**60%**	**80%**	**100%**
	% yield loss					
7 leaf	0	0	0	4	6	9
10 leaf	0	0	4	8	11	16
13 leaf	0	1	6	13	22	34
16 leaf	1	3	11	23	40	61
Tasseled	3	7	21	42	68	100
Late milk	1	3	10	21	35	50
Dented	0	0	3	10	17	24

*Adapted from Corn Loss Instructions NCIS publication #6102, Rev. '84.

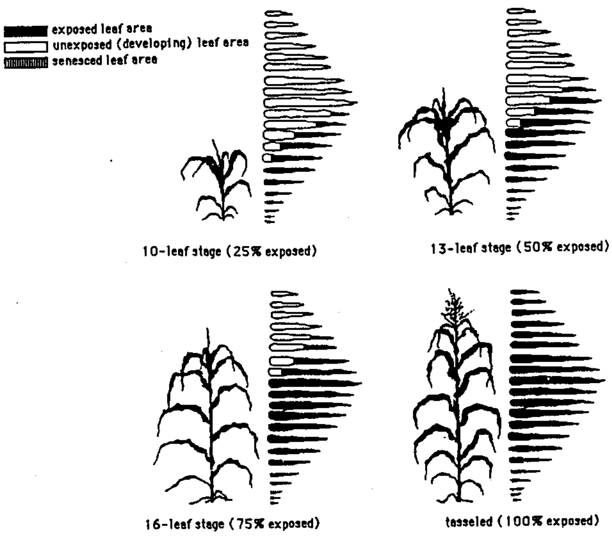


Figure 7. Percent of leaf area exposed at four stages of growth (adapted from NCIS #6102, Rev. '84).

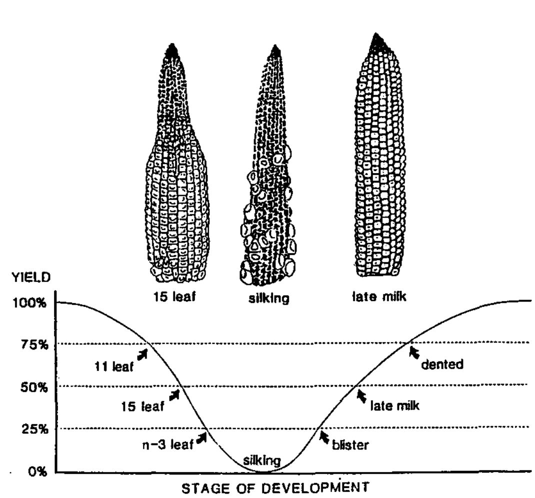


Figure 8. Effect of complete leaf removal on corn grain yield at various growth stages (data and sketches adapted from originals by R.K. Crookston).

Figure 8 shows ears produced on plants that were completely defoliated at the 15 leaf, silking and late milk stages. The graph below the sketches shows the pattern of yield reduction due to damage at various stages of growth. You can easily see from the sketches that yield reduction from defoliation at the 15 leaf stage is mainly due to fewer filled kernels on each ear. Since the ear is filled from the butt end to the tip the plant was able to fill only about 50% of the kernels after the damage. This plant had between 50% and 75% of its leaf area exposed by the damage date (see Figure 7).

A plant 100 percent defoliated during tasseling and silking will still fill some scattered kernels. These kernels were filled from storage reserves in the stem, cob and husk tissue as the corn plant attempted to produce some viable seed. This plant had 100% of its leaf area exposed by the damage date (Figure 7).

Yield reductions due to severe damage in the late-milk stage are from smaller kernel size, since kernel number has already been determined and filling had begun. These kernels will be shrunken and chaffy compared to normal plump kernels from an undamaged plant's ear.

Determining the Yield Loss Due to Replanting

Next, determine the yield if you were to replant today. Early planting dates result in highest grain yields, earlier maturity in the fall, and grain lower in moisture content at maturity. Corn planting can begin in southern Minnesota by April 20 and in northern Minnesota by April 25. Figure 5 shows a commonly used calendar that describes the progress of corn development in Minnesota from planting to harvest. Corn yields are reduced about 0.5% per day (1/2 bu/A/day) through May (see Table 4 for percent yield loss for successively later May planting dates). When planting is delayed into June the yield penalty is much greater. Early planting dates allow use of full season hybrids which are usually higher yielding. Data collected by the Minnesota Agricultural Statistics Service indicate that 5% of the corn acreage is planted by April 25th increasing to 95% planted by May 30. About half the corn acreage is planted on or before May 11th each year (Figure 5).

Table 4. Percent grain yield loss from various May planting dates.

Date of Planting	Percent Yield Loss
< May 1	0
May 1-10	- 7%
May 11-25	-13%
> May 25	-24%

Figures 9 and 10 show the effect of planting date, and hybrid maturity on calendar date for achievement of physiological maturity (32% kernel moisture) in central and southern Minnesota, respectively. These figures should be used to make the best hybrid maturity choice for late planting or replants after damage. Now use Table 4 and Figure 9 or 10 to determine the yield reduction for replanted corn. Compare the yield potential of the existing stand to the yield potential of the late planted hybrids.

Hybrid and Alternate Crop Choices for Replanting

Table 5 shows the recommended relative maturities of corn hybrids for various planting dates and zones in Minnesota. Following these suggestions should ensure a harvestable grain crop of good yield and quality. Note that as planting is delayed, earlier maturing hybrids are recommended. Use this table to select hybrids of the proper relative maturity for late planting or replanting. Figure 11 shows the boundaries of the maturity zones on a map of Minnesota. Sometimes replant decisions may be made so late into the growing season that replanting corn may not be economical so you might have to switch to another crop. See Figure 12 for information on planting date guidelines for some of these alternate crops.

Figure 9. Effect of planting date and hybrid relative maturity on date of physiological maturity (32% kernel moisture) in central Minnesota (adapted from Corn Hybrid Maturity for 1986, Crop News #72, D.R. Hicks).

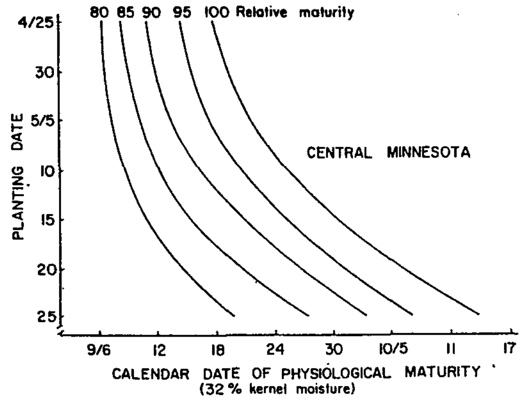


Figure 10. Effect of planting date and hybrid relative maturity on date of physiological maturity (32% kernel moisture) in southern Minnesota (adapted from Corn Hybrid Maturity for 1986, Crop News #72, D.R. Hicks).

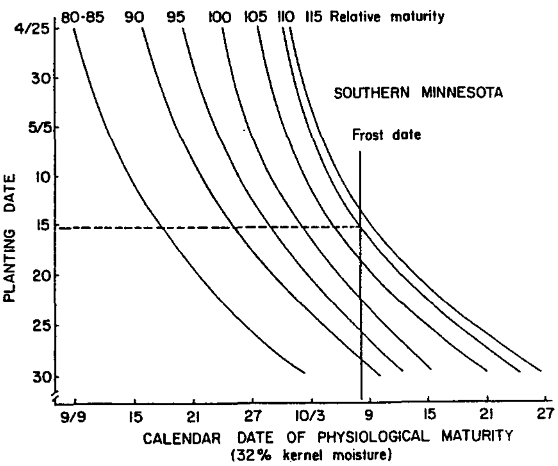


Table 5. Relative maturity* recommendations for corn hybrids for various planting dates (adapted from Replanting Corn and Soybeans after Hail Damage, Extension Folder 314, D.R. Hicks and G.R. Miller):

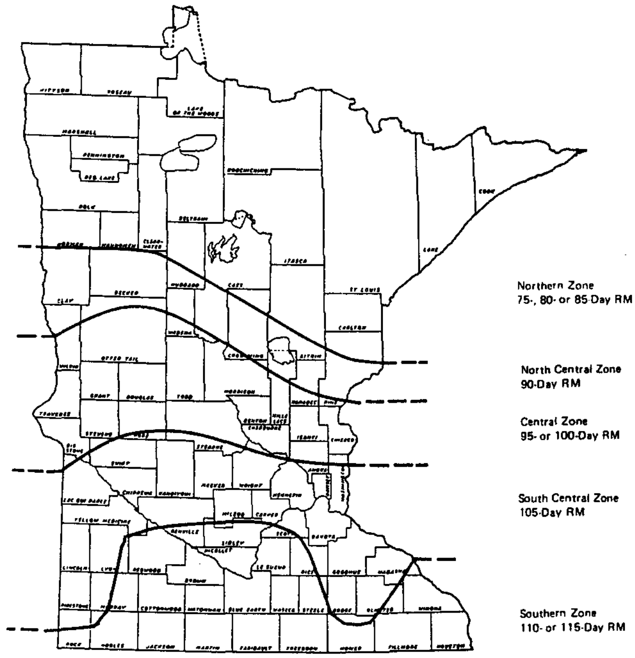
Zone	Planting Date: May 15	June 1	June 15	July 1
	Suggested RM (days)			
Northern	80	---	---	---
North Central	90	85	---	---
Central	95-100	85-90	70	---
South Central	105	90-95	85	75 (silage)
Southern	110-115	100-115	90	85 (silage)

*The Relative Maturity (RM) given in this table are "full season" for each date and zone (see Figure 11 for zone boundaries). Earlier maturity hybrids can be used.

Weed Management Decisions

Even if enough healthy plants (with good distribution in the row) remain after a hail storm to warrant leaving the stand, the weed status of the field is an important consideration in determining whether or not to replant. Corn will grow slowly following damage, depending on the amount of leaf loss and the weather.

Figure 11. Crop maturity zones in Minnesota (based on climatological data) (adapted from Minnesota Relative Maturity Rating of Corn Hybrids, Agronomy Fact Sheet #27, R.H. Peterson and D.R. Hicks).



The rate at which corn recovers will influence its competitive ability with weeds and its sensitivity to various weed control practices.

In relatively weed free fields, corn that is not too severely injured will probably recover and grow fast enough so that combinations of cultivation and application of postemergence herbicides will be effective. Effective cultivation requires weeds to be small (1-3 inches) and the crop tall enough to prevent it from being buried by soil. It is not necessary to cultivate deeper than 1 to 2 inches for most weeds. A shallow cultivation will effectively control annual weeds with little crop stress or soil moisture loss.

Early in the growing season, if a field to be replanted is especially weedy, a soil-applied herbicide may be needed on the second planting. To reduce the chance of crop injury to the replanted crop, select a herbicide that is suited to the soil and weed situation (see the current edition of Cultural and Chemical Weed Control in Field Crops, Minnesota Extension Service, AG-BU-3157), but which is not in the same chemical family as the first herbicide (Table 6). For example, if the first crop of corn was treated with pendimethalin (Prowl), replanted corn should not be treated with Prowl. Use the Cultural and Chemical Weed Control in Field Crops bulletin (AG-BU-3157) to choose a herbicide from another chemical family that will control the weed species present in the field. Care must also be taken to choose a herbicide that, when applied this late in the growing season, will not present a carryover problem to next year's crop. For example, if the first crop was corn treated with Prowl, replanted soybeans should not treated with Prowl, or chemicals similar to Prowl, such as ethalfluralin (Sonalan) or trifluralin (Treflan). See the individual herbicide labels for crop rotation restrictions. If you do retreat the crop with the herbicide that was previously used, remember to check the label for the maximum registered amount of herbicide that can be **legally** applied and act accordingly.

Table 6. Soil-applied herbicides by chemical families[1].

Chemical Family	Herbicides
Acetanilides	Alachlor (Lasso) Metolachlor (Dual) Propachlor (Ramrod)
Benzoic Acids	Dicamba (Banvel)
Dinitroanalines	Ethalfluralin (Sonalan) Pendimethalin (Prowl) Trifluralin (Treflan)
Imidazolinones	Imazethapyr (Pursuit)
Isoxazolidinones	Clomazone (Command)
Sulfonylureas	Chlorimuron-ethyl (Classic)
Thiocarbamates	Butylate (Sutan+) EPTC (Eradicane, Eradicane Extra)
Triazines	Atrazine Cyanazine (Bladex) Metribuzin (Sencor, Lexone) Simazine (Princep)
Ureas	Linuron (Lorox)

[1]This table does not include package mixtures. Package mixtures contain two of the herbicides listed above and are often referred to by trade names that differ from those listed in the table. See the current edition of AG-BU-3157, Cultural and Chemical Weed Control in Field Crops for a list of package mixture contents.

In fields that require replanting but still have good weed control or in fields planted after mid-June, another application of a soil-applied herbicide is probably not necessary. The more persistent soil-applied herbicides used on the first planting should remain in sufficient quantity to give some weed control in the replanted crop and most weed seeds near the soil surface should have already germinated with the first crop. In weed-free fields the crop should be planted without any soil tillage or if necessary, soil should be tilled no more than 1.5 to 2 inches deep to avoid bringing weed seeds and untreated soil to the surface. Soil and air temperatures should be favorable for fast germination, emergence, and growth of the crop, giving the crop a competitive advantage over weeds. Germinating weeds can be controlled with rotary hoeing, cultivation, postemergence herbicides, or combinations of these practices. Rotary hoeing is effective on newly germinated weeds before they emerge from the soil (weeds in the white stage). After weeds emerge, the effectiveness of the rotary hoe rapidly diminishes. Corn up to the 2-leaf stage can be rotary hoed. However, be aware that rotary hoeing may compound injury to hail-stressed corn.

Postemergence herbicide applications can control many annual weeds in corn, provided the weeds are small enough (Table 7). **Postemergence herbicides should not be applied until the corn has recovered from the hail damage and resumed growth.** Until the weeds resume growth, hail stress may reduce herbicide effectiveness on both the broadleaf and grass weeds.

By the time corn plants have resumed growth, many weeds may be too big to control with herbicides. Therefore, if corn fields are severely hail-stressed and weedy and the grass and broadleaf weeds are near the weed sizes listed in Table 7 there is a difficult

Table 7. Maximum weed sizes controlled at labeled rates of postemergence corn herbicides.[a]

Herbicide[b]	Product Rate	Pigweed	Lambs-quarters	Velvetleaf	Cocklebur	Eastern Black Nightshade	Foxtail
		leaf stage[c]/weed height (inches)					
Atrazine 4L	4.0 pt/A[d]	-[e] / 6	- / 6	- / 4	- / 4	- / 1.5	- / 1.5
Atrazine 4L	2.4 pt/A	- / 6	- / 6	- / 4	- / 4	NL[f]	NL
Bentazon 4S (Basagran)	2.0 pt/A	NL	4-8 / 2	4-6 / 5	6-10 / 10	NL	NL
Bromoxynil 2EC (Buctril)	1.5 pt/A	4 / 2	- / 8	6 / 5	8 / 10	6 / 6	NL
Clopyralid (Stinger)	0.5 pt/A	NL	NL	NL	5 / -	4 / -	NL
Cyanazine 90 DF (Bladex)	2.2 lb/A	- / 1.5	- / 1.5	- / 1.5	- / 1.5	- / 1.5	- / 1.5
Dicamba 4S (Banvel)	1.0 pt/A	- / 4-6	- / 4-6	- / 4-6	- / 4	- / 2-3	NL
Dicamba 4S (Banvel)	0.5 pt/A	- / 4	- / 4	- / 2	- / 2	- / 1	NL
Nicosulfuron (Accent)	0.66 oz/A	- / 4	NL	NL	NL	NL	- / 4
Primisulfuron (Beacon)	0.76 oz/A	- / 4	- / <1.5	- / 4	- / 4	- / 4	NL
2,4-D	1.0 pt/A	- / 1-3	- / 4	- / 1-2	- / 2-4	- / 2-3	NL

[a]Maximum weed sizes were taken from the label, where possible. The labeled maximum weed sizes would reflect control under ideal conditions. Hail stress may decrease the weed size at which satisfactory control is achieved.
[b]Please see the label for the proper addititive to use with each herbicide.
[c]When dealing with the leaf stage of hail damaged weeds, be sure to count leaf scars to determine the weeds' real size.
[d]Certain counties in Minnesota, as well as certain states, may have rate limitations in regard to Water Quality Best Management practices. Consult your state lead pesticide control agency or Extension Service for more information.
[e]Leaf stage or weed height not given on label. [f]NL = Not labeled.

Table 8. Forage, feed and grazing restrictions for corn herbicides.[1]

Herbicide	Restrictions
Alachlor (Lasso 4EC)	No restrictions.
Alachlor (Lasso MT)	No restrictions.
Atrazine (Atrazine)	Do NOT graze or feed forage for 21 days after application.
Bentazon (Basagran)	Do NOT graze or feed forage for 12 days after application.
Bromoxynil (Buctril)	Do NOT graze or feed forage for 30 days after application.
Butylate + safener (Sutan+)	No restrictions.
Clopyralid (Stinger)	Do NOT graze or harvest silage for 40 days after application.
Cyanazine (Bladex)	No restrictions.
Dicamba (Banvel)	Prior to the ensilage (milk) stage, do NOT harvest or graze forage.
EPTC + safener (Eradicane) (Eradicane Extra)	No restrictions.
Glyphosate (Roundup)	Do NOT harvest or feed forage for 8 weeks after application. Allow 14 days following spot treatment before grazing livestock.
Linuron (Lorox)	No restrictions.
Metolachlor (Dual)	No restrictions.
Nicosulfuron (Accent)	Do NOT graze or feed forage or grain for 30 days after application
Pendimethalin (Prowl)	No restrictions.
Primisulfuron (Beacon)	Do NOT graze or feed forage for 30 days after application.
Propachlor (Ramrod)	No restrictions.
Simazine (Princep)	Do NOT graze.
2,4-D (ester/amine)	Do NOT graze or feed forage for 7 days after treatment.

[1]Restrictions for package mixtures are generally taken from the most restrictive product in the mixture. See the label for more details. See the current edition of AG-BU-3157, Cultural and Chemical Weed Control in Field Crops for a list of package mixture contents.

decision to be made. If the weed population is large and it isn't too late to replant, then replanting is advisable even though the crop plants would probably recover. If it is too late to replant a crop then cultivation is the only choice.

The use of postemergence herbicides to control later weed flushes poses several unique problems. A grower should be aware of applicable forage, feed, and grazing restrictions imposed by the Environmental Protection Agency (EPA) (Table 8). These restrictions are included on the herbicide label and are imposed by the EPA to prevent unacceptable levels of herbicides from entering grain and livestock food sources. Table 8 lists the forage, feed, and grazing restrictions for corn herbicides. **It is very important that the applicator adhere to all label restrictions.**

Another important consideration when using postemergence herbicides is the size or stage of growth of the corn plant at the time of herbicide application. Some herbicide labels refer to a particular leaf stage of corn development, others refer to corn height. Descriptions of corn leaf stage, as written on herbicide labels, are **not** based on the NCIS System described in Table 1. Rather, the herbicide labels refer to the number of visible corn leaves. For example, cyanazine (Bladex) must be applied before the fifth corn leaf is visible. Therefore, a postemergence Bladex treatment would include applications from corn emergence through the "4-leaf stage." All reference in the label is to visible leaves, not to collars or exposed leaves with tips pointed downward. Several postemergence corn herbicide labels refer only to corn height. Corn height is the free-standing height of the plant as measured from the base of the plant to the top of the whorl. Corn height is **not** the extended leaf height. Be sure to read the herbicide label carefully to understand its definition of crop size or stage of growth.

It is important to read and follow a postemergence herbicide label's time of application instructions very carefully. Several of the postemergence herbicides can severely injure the corn crop if applied at the wrong stage of growth. Atrazine should only be applied on corn up to 12 inches tall. Corn injury is most likely to occur when atrazine and oil are applied to corn growing under cold and wet conditions. Bentazon (Basagran) can be applied at any stage of corn growth. Bromoxynil (Buctril) can be applied to corn up to the tassel stage. Corn tolerance is good, but leaf burn can occur under conditions of high temperatures or humidity. Clopyralid (Stinger) can be applied to corn up to 24 inches in height. Corn tolerance is good and no adjuvant (i.e. surfactants or crop oils) should be added to Stinger. Cyanazine (Bladex) must be applied before the fifth corn leaf is visible. Do not use Bladex 4L postemergence. Vegetable oils or surfactants may be added under dry conditions to improve weed control effectiveness, but these additives increase the potential for corn injury and stand loss if heavy rain or dew and cool temperatures occur soon after application. Tank mixtures of tridiphane (Tandem) with atrazine plus oil or Tandem with Bladex can improve control of annual grasses in the 1 to 3-leaf stage and controls most annual broadleaf weeds, however, these mixtures with Tandem are subject to atrazine and Bladex application restrictions. Dicamba (Banvel) may be used at a rate of up to 1 pt/A on corn through the fifth leaf stage or 8 inches in height, whichever comes first. Apply 1/2 pt/A before corn is 3 feet tall or until 15 days before tassel emergence, whichever comes first. Do not use oils or other additives with Banvel. Late application of Banvel may increase crop injury and vapor drift to off-target crops. Crop safety is improved by using drop nozzles in corn over 8 inches tall. Nicosulfuron (Accent) may be applied over-the-top or corn that is 24 inches in height or less. Corn that is 24 to 36 inches high may only be treated with drop nozzles. Accent cannot be applied to corn that exceeds 36 inches in height or exhibiting 10 leaf collars, whichever occurs first. Generally, when height restrictions are followed crop tolerance is good, however, **do not** apply Accent to corn previously treated with any formulation of terbufos (Counter 15G or 20CR). The only exception is the application of Accent to corn previously treated with Counter 20CR applied in a band at planting. See the American Cyanamid Counter 20CR label for details. Primisulfuron (Beacon) may be applied over-the-top of corn that is between 4 and 20 inches in height. Corn plants less than 4 inches or greater than 20 inches tall may be more susceptible to injury. **Do not** apply Beacon if any formulation of terbufos (Counter 15G or 20CR) is applied to the crop **at any time** during the growing season. Also, check the local label restrictions regarding corn hybrids that are known to be susceptible to Beacon herbicide. To reduce 2,4-D induced crop injury, broadcast applications should be limited to corn in the 2- to 5-leaf stage or before corn is 8 inches tall. After corn exceeds the 8 inch height, use drop nozzles to prevent crop injury and reduce vapor drift. The amine formulation of 2,4-D is less likely to volatilize or injure corn than the ester formulation. To reduce crop injury, do not apply 2,4-D when corn is rapidly elongating (growing) and the weather conditions are hot (>85°F) and humid. Do not apply 2,4-D from one week prior to tasseling through the dough stage or poor kernel set may result. After the brown silk stage of corn, 2,4-D may again be safely applied.

In some situations, it may be too late to replant corn, necessitating a change to another crop (see Figure 12). The herbicide used on corn may limit the choice of crops that can be replanted. Most preplant incorporated or preemergence herbicides will persist in the soil at least 4 to 12 weeks and could injure the newly planted crop. In addition, labelled crop rotation restrictions may also limit the crops that can be planted. Of course, any crop for which the chemical is labeled may be planted. Label information regarding replanting should be followed carefully because some labels suggest tilling the soil before replanting, others do not. See the individual herbicide label for more details. Alternative crops which can be planted when various herbicides were used on the first crop are given in Table 9.

Table 9. Alternative crops for second planting when the first planting was treated with various corn herbicides[1].

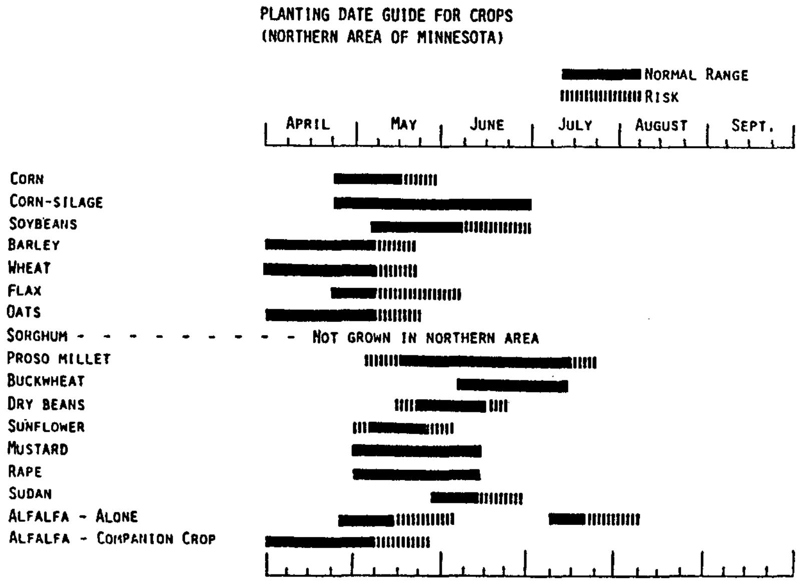
First Chemical Used	Crops That Can Be Planted[2]
Alachlor (Lasso)	Corn, soybeans, dry beans, grain sorghum (use seed protectant), sunflowers
Atrazine	Corn, grain sorghum
Bentazon (Basagran)	No restrictions
Bromoxynil (Buctril)	Corn, grain sorghum, flax, alfalfa
Butylate (Sutan+)	Corn, soybeans (4-6 weeks after application)
Clopyralid (Stinger)	Corn, wheat, barley, oats, grasses, sugar beets
Cyanazine (Bladex)	Corn, grain sorghum
Dicamba (Banvel)	Corn, grain sorghum
EPTC (Eradicane; Eradican Extra)	Corn, soybeans (3-5 weeks after application), dry beans, flax, alfalfa, clover, sunflowers
Linuron (Lorox)	Corn, soybeans, grain sorghum
Metolachlor (Dual)	Corn, soybeans, dry beans, grain sorghum (use seed protectant)
Nicosulfuron (Accent)	Corn (field and seed)
Pendimethalin (Prowl)	Soybeans, dry beans, alfalfa, sunflowers
Primisulfuron (Beacon)	Field corn may be replanted 14 days after application
Propachlor (Ramrod)	Corn, grain sorghum, flax
Simazine (Princep)	Corn
2,4-D (ester/amine)	Corn

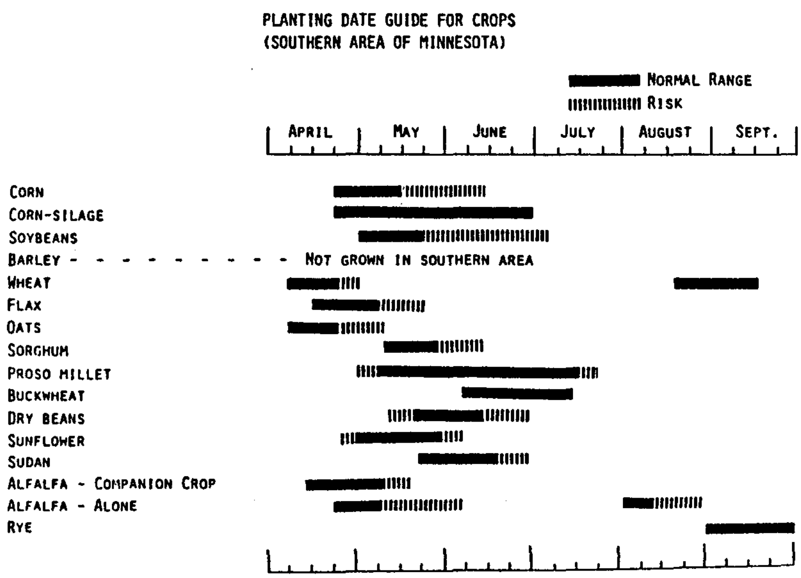
[1]Restrictions for package mixtures are generally taken from the most restrictive product in the mixture. See the label for more details. See the current edition of AG-BU-3157, Cultural and Chemical Weed Control in Field Crops for a list of package mixture contents.

[2]See appropriate label for any additional restrictions or precautions.

Note: Herbicide names and application and use restrictions were based on information available for the 1991 growing season. **Always refer to current herbicide labels for the latest information.** This publication is for your information. The University of Minnesota or its officers or employees make no claims or representations that the chemicals discussed will or will not result in residues on agricultural commodities and assume no responsibility for results from using herbicides.

FIGURE 12. NORMAL AND RISK RANGES OF PLANTING DATES FOR VARIOUS CROPS IN NORTHERN AND SOUTHERN MINNESOTA.





Corn Bibliography

Corn Loss Instructions NCIS Publication #6102 Rev. '84, 15 pages. National Crop Insurance Service, 7301 College Blvd. #170, Overland Park, Kansas 66210.

Varietal Trials of Selected Farm Crops (1991 edition), Minnesota Report 221, AD-MR-5615, Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul.

Cultural and Chemical Weed Control in Field Crops (1991 edition), AG-BU-3157, Minnesota Extension Service, University of Minnesota, St. Paul.

Printed on recycled paper with agribased inks

The Minnesota Extension Service is committed to the protection and preservation of our environment. This publication was printed on recycled paper containing 10% post-consumer waste, using agribased inks made from soybean, corn, and vegetable oils.