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1. Corn plant population recommendations

The Kansas Corn Production Handbook has been revised, and includes a discussion of recommended plant populations. The optimal corn population for any situation will depend on the anticipated environment and how the hybrid responds to that environment (see article #2 below for an example of this). If there are a number of barren plants, the populations may be too high. If the number of kernels per ear is much below 400 to 500, the population may be too high. If there are more than 600 kernels per plant, the population may be too low.

Don't be concerned if a half-inch or so of the ear tip has no kernels. If kernels have formed to the tip of the ear, there may have been room in that field for more plants with additional ears.

Always keep the current environment in mind. Will the conditions (rainfall amount and distribution, temperatures) experienced last year likely be repeated this year? Does the field you have in mind have more or less soil water storage capacity than average? Does the previous crop tend to deplete stored soil water more than most crops (e.g. sunflower). Will I have as much irrigation water available as in the past? When will I be able to apply it? How many seeds do I typically get to emerge and establish plants in my cropping system and with my planting equipment?

The recommended planting rates in the following table attempt to factor in these types of questions for the typical corn growing environments found in Kansas. Adjust within the recommended ranges depending on the specific conditions you expect to face.

Recommend planting rates from the revised corn production handbook.

Suggested Dryland Corn Final Populations and Seeding Rates			
Area	Environment	Final Plant Population (plants per acre)	Seeding Rate*
Northeast	100-150 bu/a potential	22,000-25,000	26,000-29,500
	150+ potential	24,000-28,000	28,000-33,000
Southeast	Short-season, upland, shallow soils	20,000-22,000	23,500-26,000
	Full-season bottomground	24,000-26,000	28,000-30,500
Northcentral	All dryland environments	20,000-22,500	23,500-26,500
Southcentral	All dryland environments	18,000-22,000	21,000-26,000
Northwest	All dryland environments	16,000-20,000	19,000-23,500
Southwest	All dryland environments	14,000-20,000	16,500-23,500

Suggested Irrigated Corn Final Populations and Seeding Rates			
Environment	Hybrid Maturity	Final Plant Population (plants per acre)	Seeding Rate*
Full irrigation	Full-season	28,000-34,000	33,000-40,000
	Shorter-season	30,000-36,000	35,000-42,500
Limited irrigation	All	24,000-28,000	28,000-33,000

* Assumes high germination and that 85 percent of seeds produce plants. Seeding rates can be reduced if field germination is expected to be more than 85%.

Optimal seeding rates may need to be adjusted for irrigated corn if fertilizer or irrigation rates are sharply increased or decreased. For example, research at the Irrigation Experiment Field near Scandia has shown that if fertilizer rates are increased, seeding rates also have to be increased to realize the maximum yield benefit. Consult seed company recommendations to determine if seeding rates for specific hybrids should be at the lower or upper end of the recommended ranges for a given environment.

Should seeding rates be adjusted depending on planting dates? Recent studies conducted at Manhattan provide evidence that seeding rate adjustments are not always necessary as long as planting is not delayed too far beyond the typical window for an area. We planted three hybrids of differing maturities (98, 106, 112 RM) at multiple planting dates. Each hybrid x planting date combination was planted at three populations (18,000, 22,000, 26,000 plants per acre). Hybrid maturity influenced yield differently depending on planting date and year (data not shown). In this study, hybrids of all maturities responded similarly to plant population. Yields continued to increase with each increase in plant population, although yield increases were less at later planting dates. Both 2006 and 2007 had favorable rainfall distribution for corn production at Manhattan, so results may be different under conditions of greater stress.

Average yields of three hybrids at three populations and four planting dates, Manhattan, 2006-2007.

	Planting Date				
Final Plant Population	Mid-March	Early April	Mid-April	Mid-May	Average
(plants per acre)	(bushels/acre)				
18,000	115	130	124	99	117
22,000	120	135	128	103	122
26,000	130	140	130	105	126
Average	122	135	127	102	

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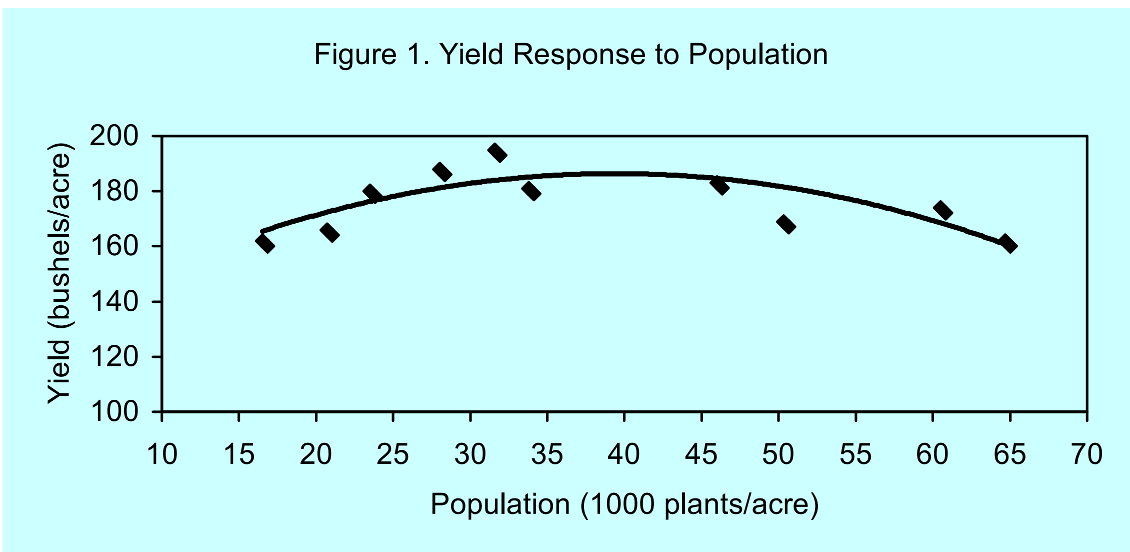
2. How corn plants respond to changes in plant populations

A recent, "accidental" study illustrates some interesting responses of the corn plant to changes in population. On April 23, 2007, we planted a patch of a 110 RM corn hybrid for a fungicide study at the Agronomy North Farm near Manhattan. Unfortunately, the planter settings were incorrect, so we dropped close to three times the intended number of seeds. We were able to thin it down to our desired stand for the fungicide study, so it was still useable for that purpose. Fortunately, we had planted about twice as much ground as we actually needed, so we used the rest of the area for a population experiment. We thinned plots down to stands ranging from 16,500 to 65,000 plants per acre. The experiment was located on a bottomland site with deep soil. Rainfall was abundant in 2007, so this was essentially a high-yield, rain-fed site, nearly equivalent to irrigated conditions.

Monthly weather information for Manhattan, 2007.

	Precipitation		Average Temperature		Growing Degree Units	
Month	2007	Normal	2007	Normal	2007	Normal
	inches		degrees F		GDU F	
April	3.7	2.6	54	53	277	237
May	11.9	4.5	68	64	559	441
June	5.9	5.1	74	73	705	685
July	4.7	4.0	79	79	829	823
August	2.3	3.5	84	78	887	801
September	2.0	3.8	72	70	617	587

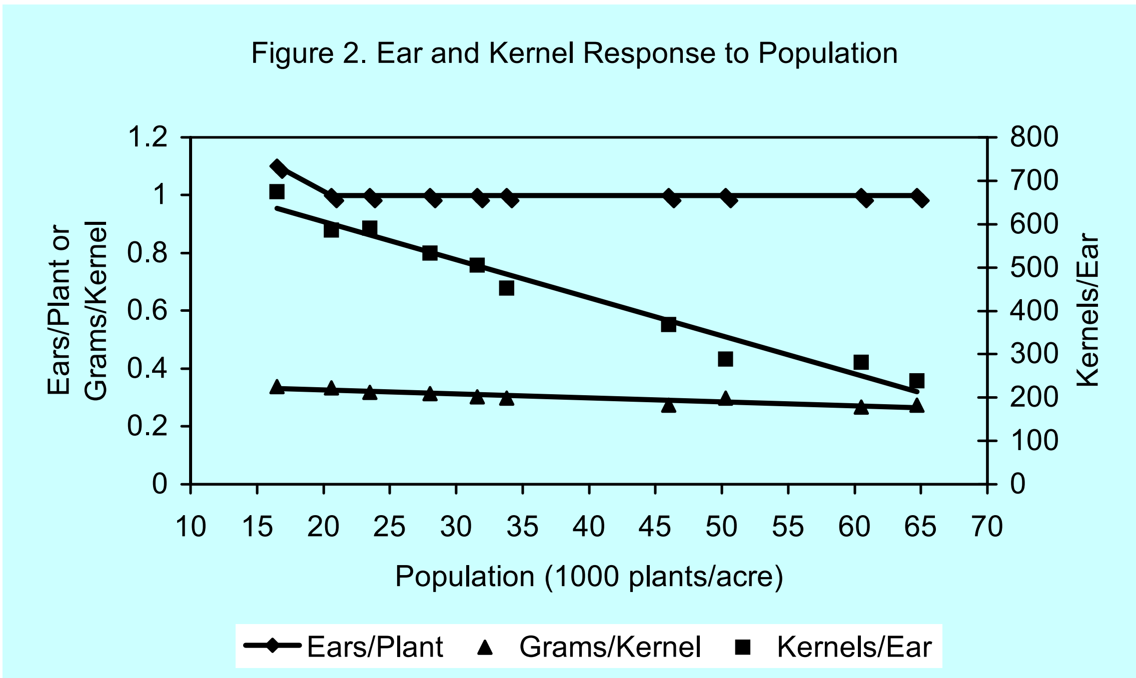
Yield increased with population until it reached a maximum of 195 bushels/acre at just over 30,000 plants/acre, and then gradually dropped off (Figure 1). Incredibly, yields for 65,000 plants/acre were equal to those for 16,500 plants/acre at 162 bushels per acre.



How was yield maintained at such extremes of population? Corn plants respond to changes in population (or to different environmental conditions) by adjusting three things: ear number, ear size, and kernel size. These three items plus the number of plants per acre determine yield and are often referred to as *Yield Components*.

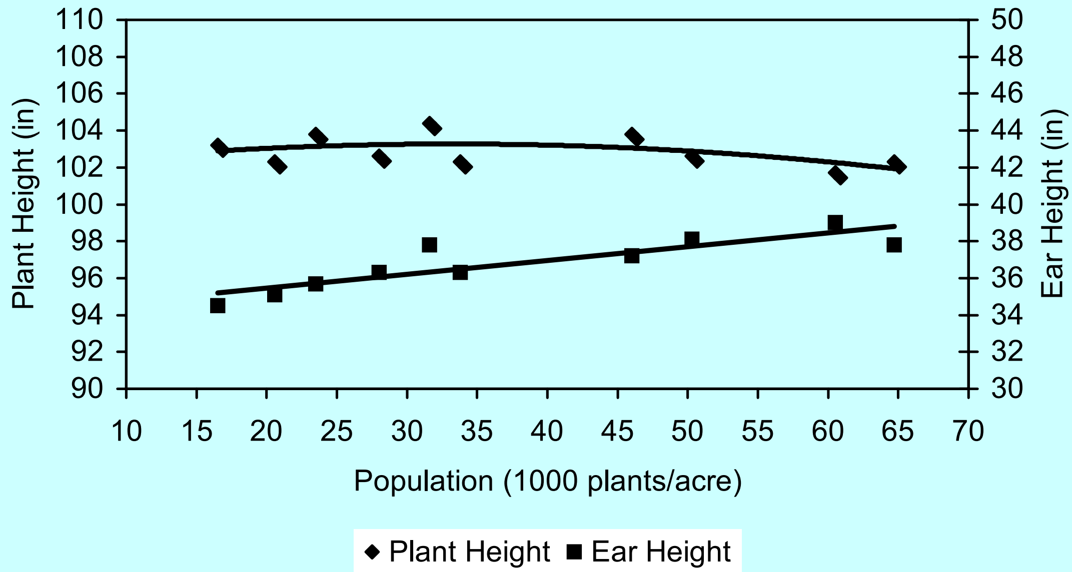
$$Yield = \frac{plants}{acre} \times \frac{ears}{plant} \times \frac{seeds}{ear} \times \frac{mass}{seed}$$

Figure 2 shows that at the lowest population, some plants set additional ears (1.1 ears/plant on average). As population increased, favorable rainfall and large amounts of stored soil moisture resulted in very few barren plants, so ear number did not drop below one ear per plant. The primary mechanism used by this hybrid to respond to changes in population in this environment was by adjusting ear size. Each ear had nearly 700 kernels at the lowest population, but only about 240 kernels at the highest population, a change of nearly three-fold. Kernel weight was affected as well. It is hard to see in the chart, but kernel weight was actually 20% less at the high populations compared to the lowest population (0.268 g/kernel vs. 0.338 g/kernel).



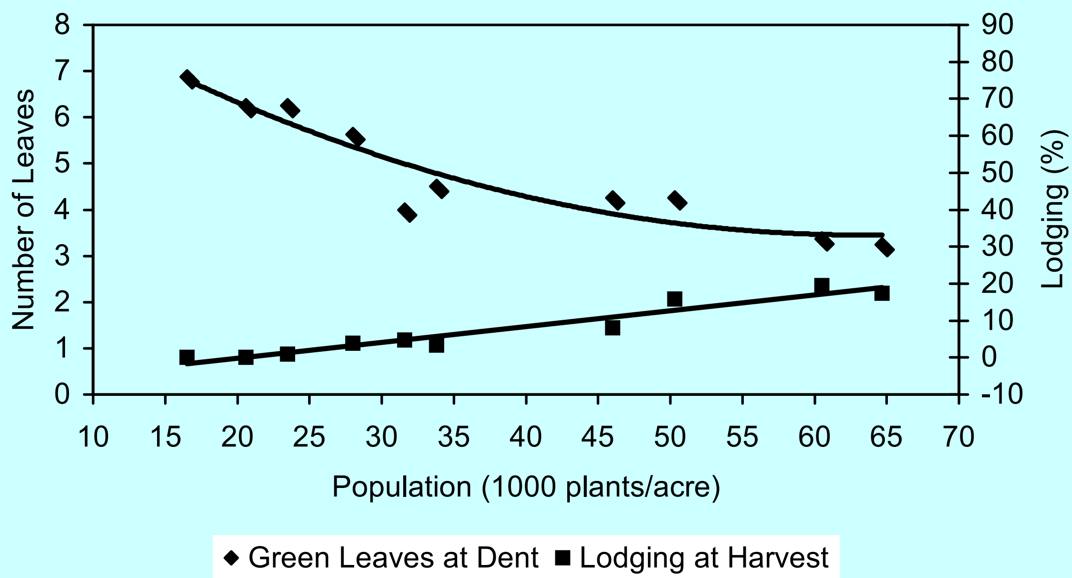
Corn plants are affected by plant density in other ways. Figure 3 shows that plant height was maintained, or perhaps increased, up to a population of 30,000 plants per acre. Plant height was reduced slightly at the highest populations. Ear height responded more dramatically by increasing by 0.5 inches for each additional 6,700 plants per acre on average.

Figure 3. Plant and Ear Height Response to Population



Two measures of the increasing stress imposed at greater plant densities are how rapidly the plant senesces (dries down and loses leaves) and stalk strength. The number of green leaves remaining at R5 (dent stage) and the number of lodged stalks at harvest can serve as proxies for these indicators of plant stress (Figure 4). The number of green leaves remaining at R5 dropped steadily as plant population increased to roughly 30,000 plants per acre and then continued to decrease more gradually. Lodging did not occur at the two lowest populations, but steadily increased thereafter to a maximum of close to 20% at the highest two populations.

Figure 4. Senescence and Lodging Response to Population



Not all hybrids will respond to different populations the way this hybrid did, and different environments will also result in different responses. But this study does illustrate a typical response of corn to different population levels.

Seed companies claim that some hybrids have a greater ability to adjust ear size (flex ear) or to adjust ear number (prolific) than others. (The supplier of this particular hybrid makes no claims either way about these traits for their hybrids). The most likely reason that this hybrid responded as it did relates to weather conditions in late July and August compared to May, June, and early July.

Corn plants determine ear size fairly early, and the favorable early environment had a major impact on yield in this study – even at the lower populations. The number of kernel rows is determined by V12 and the potential length of the ear is set by V17, just before tasselling. With the high rainfall and average temperatures received in May, June, and early July, plants in the low populations could produce larger ears.

Favorable early-season environments can cause corn plants to “over-react” somewhat, too. For example, in this study a number of plants in the low and medium populations had set additional ears at silking, but few of these ears actually set viable seed, except in the lowest populations. Kernels on those secondary ears that may have pollinated effectively were aborted as the weather turned dry and temperatures increased in late July and August. As the kernels were filling during August, relatively low rainfall caused earlier senescence at the higher populations, shortening grain fill and reducing kernel size, especially on plots with plant populations greater than 30,000.

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3. Starter fertilizer rates and placement for corn

Many producers in Kansas could benefit by using starter fertilizer when planting corn. Starter fertilizer is simply the placement of some fertilizer, usually nitrogen (N) and phosphorus (P), near the seed -- which "jump starts" growth in the spring. It is very unusual for a farmer not to see an early season growth response to starter fertilizer application. But whether that carries on to an economic yield response is not a sure thing in Kansas. How the crop responds to starter fertilizer depends on soil fertility levels, tillage system, and N placement method.

* Soil fertility levels. The lower the fertility level, the greater the chance of economic responses to starter fertilizers. A routine soil test will reveal available P and potassium (K) levels. If soils test low or very low in P, below 20 ppm, there is a very good chance that producers will get an economic yield response to applying a starter fertilizer containing P, even in some low-yield environments. If the soil test shows a medium level of P, 20-30 ppm, it's still possible to get a yield response to P fertilizer. But the yield response will not occur as frequently, and may not be large enough to cover the full cost of the practice. The chances of an economic return at higher soil test levels are greatest when planting corn early in cold, wet soils. If the soil test is high, above 30 ppm, economic responses to starter P fertilizers are rare. In general, the same principles apply with K. If soil tests are low, below 130 ppm, the chances of a response to K in starter are good, and the lower the soil test level, the greater the odds of a response.

All of the recommended P and/or K does not need to be applied as starter. Generally, plants respond best to a combination of starter and broadcast applications. Banding the first 15-20 pounds of P or K as starter, and broadcasting the balance of the fertilizer seems to result in the best performance.

* Tillage system. No-till corn will almost always respond to a starter fertilizer that includes N – along with other needed nutrients – regardless of soil fertility levels or yield environment. This is especially so when preplant N is applied as deep-banded anhydrous ammonia or where most of the N is sidedressed in-season. That's because no-till soils are almost always colder and wetter at corn planting time than soils that have been tilled, and N mineralization from organic matter tends to be slower at the start of the season in no-till environments.

In general, no-till corn is less likely to respond to an N starter if more than 50 pounds of N was broadcast prior to or shortly after planting.

In reduced-till systems, the situation becomes less clear. The planting/germination zone in strip-till or ridge-till corn is typically not as cold and wet as no-till, despite the high levels of crop residue in the row middles. Still, N and P starter fertilizer is often beneficial for corn planted in reduced-till conditions, especially where soil test levels are very low, or low, and where the yield environment is high. As with no-till, reduced-till corn is also less likely to respond to an N starter if more than 50 pounds of N was broadcast prior to or shortly after planting.

Conventional- or clean-tilled corn is unlikely to give an economic response to an N and P starter unless the P soil test is low.

* Starter fertilizer placement method. Producers should be very cautious about applying starter fertilizer that includes N and/or K, or some micronutrients such as boron, in direct seed contact. It is best to have some soil separation between the starter fertilizer and the seed. The best, safest placement methods for starter fertilizer is either:

-- A deep-band application 2 to 3 inches to the side and 2 to 3 inches below the seed, or
-- A surface-band application to the side of the seed row at planting time, especially in conventional tillage or where farmers are using row cleaners or trash movers in no-till.

If producers apply starter fertilizer with the corn seed, they run an increased risk of seed injury when applying more than 6 to 8 pounds per acre of N and K combined in direct seed contact.

Work by Barney Gordon at the North Central Kansas Irrigation Experiment Field near Scandia illustrates some of these points. Gordon compared in-furrow, 2x2, and surface band placement of different starter fertilizer rates in a multi-year study on irrigated corn. Excellent responses from up to 30 pounds of N and 15 pounds of P were obtained with the both the 2x2 and surface-band placement (see chart below). In-furrow placement was not nearly as effective. This was due to stand reduction from salt injury to the germinating seedlings. Where no starter, or the 2x2 and surface band placement, was used, final stands were approximately 30-31,000 plants per acre. However, with the 5-15-5 in furrow treatment, the final stand was approximately 25,000. The final stand was just over 20,000 with the in-furrow 60-15-5 treatment.

Effect of Starter Fertilizer Placement on Corn Yield at North Central Irrigation Experiment Field			
Yield (bu/acre)			
Fertilizer Applied	In-Furrow Placement	2x2 Band Placement	Surface Band Placement
Check: 159 bu	--	--	--
5-15-5	172	194	190
15-15-5	177	197	198
30-15-5	174	216	212
45-15-5	171	215	213
60-15-15	163	214	213
Average	171	207	205

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4. Oat forage production

Several factors are causing producers with cattle to seek alternatives to more traditional hay and pasture this spring. Hay prices are high, especially for quality alfalfa hay. Annual forage hay quality is variable. The price of feed grains has resulted in cattle remaining on pasture for longer periods of time.

While much of Kansas received precipitation well above normal last spring and early summer, many areas received little precipitation during late summer and early fall. This resulted in variable winter annual cereal grass pastures (wheat and rye). Though much of western Kansas is dry, the central and eastern portions of the state have received significant amounts of winter precipitation, especially in December. This provides an opportunity for producers looking for emergency spring pasture, silage, hay, or high-quality hay for next fall/winter.

Spring oats provide an excellent option for producers in this situation. While traditionally produced for hay and silage, oats can provide high quality pasture in April and May. This can provide a bridge until other grazing options are ready. Properly stored, oat hay also provides a high quality feed source for next fall and winter. Oat pasture is also being used successfully in sheep production.

Oat pasture should be treated similar to winter wheat pasture when determining stocking rates and when to place cattle in terms of vegetative growth. Since grain production is not practical or recommended under grazing, the length of pasture production will be a function of stocking rate and weather. Studies at the South Central Experiment Field southwest of Hutchinson indicate hay yields on a dry weight basis of three to five tons per acre are typical under average weather conditions. The average yield across 20 varieties has been a little more than four tons per acre. Hay yield in these studies was determined at late milk/early dough stage with an average moisture of 60%. These yields were obtained with 75 lb/acre N applied preplant and an additional 50 lb/acre broadcast approximately six weeks after emergence.

Oats should be harvested for silage from late milk through early dough stages. Expect silage with a TDN of approximately 60%, and 9% protein on a dry weight basis. For hay, late boot to early heading is the optimal timing. Harvested at the dough stage, hay should have an approximate TDN of 56% with 10% protein, both on a dry basis. The quality of oat hay at the late boot to early heading stage will be similar. A nitrate test is recommended. Prussic acid should not be a concern.

Producers interested in planting oat pasture should secure seed as soon as possible since oat seed stocks are in short supply, especially of Kansas-produced seed. Often area seed dealers will have to have oat seed shipped into Kansas.

Cultural practices

Before planting oats, check the herbicide history of the desired field. Oats are especially sensitive to triazine herbicides.

The optimal planting date depends on location. In southeast Kansas, the optimal date ranges from Feb. 20 to March 15. In northwest Kansas, the optimal date is from the first week of March through the end of March. For most of the state, planting is recommended from late February through mid-March. After the optimal planting range, production will be limited most years. However, these planting date recommendations are made with grain as the end use, not forage. Planting as early as possible produces the most pasture, but oats may also be planted later than the recommended seeding dates and still produce adequate pasture, as long as grain isn't the goal.

A seeding rate of two bushels per acre is recommended. Under good soil moisture or irrigation, three bushels may be preferable for grazing. When grown for hay or silage, fertility recommendations are similar to those for grain production -- 75 to 125 lb/acre nitrogen. When planted for grazing, an additional 30 lb/acre nitrogen is recommended. As always, a soil test is recommended, especially with the price of nitrogen fertilizers.

Oats may be successfully planted no-till; however, growth and vigor are typically greater with pre-plant tillage. No-tillage is more successful in fields that have been under no-tillage for a period of years. It is riskier to try to no-till oats under "opportunistic no-tillage" conditions. In either case, a fine, firm seedbed is necessary for optimal production.

Under adequate soil moisture conditions, a seeding depth of ½ to 1 inch is preferable. Oats may be planted at depths greater than one inch under dry conditions. However, oat seedlings are less vigorous than wheat and may experience difficulties emerging at deeper planting depths. This is especially true on soils crusted from precipitation after planting. Also to facilitate planting and maximize forage production, winter annual weeds should be controlled either mechanically or chemically. Weed control is best achieved through a good stand with rapid growth. Herbicides are available, although many are not permitted under forage production. Before using any herbicides consult the label.

Oats in Kansas may be planted for grain with expected yields of 50 bushels per acre or more most years. However, typical growing conditions during grain fill normally result in low test weights, making the grain unsuitable for food use. Low-test-weight oats are acceptable for feed uses; however, a market should be identified prior to planting since few markets exist locally.

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These e-Updates are a regular weekly item from K-State Extension Agronomy and Steve Watson, Agronomy e-Update Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Steve Watson, 785-532-7105 swatson@ksu.edu, or Jim Shroyer, Research and Extension Crop Production Specialist and State Extension Agronomy Leader 785-532-0397 jshroyer@ksu.edu