AGRONOMY FACTS

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THE SEED TAG

State and federal seed laws set forth the conditions under which seed may be sold. One of the first requirements is that certain information concerning the seed be displayed on or attached to the container. The label, together with the reputation of the seedsman, is the buyer's best assurance of getting good quality seed.

John Doe Seed Co. — Urbana, Illinois

Variety or type	Kind	Lot No.
Kansas Common	Alfalfa	101

Pure Seed	99.5 %	Germination	82 %
Weed Seed	.05 %	Hard Seed	10 %
Inert Matter	.35 %	Total Germination & Hard Seed	92 %
Other Crop Seed	.10 %	Date Tested	9/15/57

Origin Kansas

In selecting good-quality seed, it is extremely important for the buyer to know what each item on the tag means. He should therefore study it carefully. The seller is responsible for the accuracy of the information that appears on the tag. The Illinois seed law requires that the germination test for seed must have been made within nine months of the date of sale (excluding month in which test was made).

Lot number. The lot number is used to identify a particular bag of seed as being representative of a specific and uniform parcel of seed.

Variety, type, and kind. The tag must list either the kind of seed (alfalfa, medium red clover, spring oats, etc.) or the variety (Ranger alfalfa, Kenland red clover, Clintland oats, etc.). Uncertified seed usually lists kind instead of variety; the seller will seldom risk guaranteeing variety unless seed is certified.

Certified seed carries an official tag showing the word Certified. This tag is usually blue, although it may be one of several other colors. It may include information on germination and analysis, but not necessarily. Some growers of certified seed prefer to use two tags, in which case germination and analysis are given separately from other data.

Certified seed is produced, processed, and marketed in such a way as to guard and maintain varietal purity. (See Fact Sheet M-18 and the Official Handbook of the Illinois Crop Improvement Association.) The best way to be sure of varietal purity is to buy certified seed.

Pure seed. Seed purity refers directly to mechanical purity and indirectly to varietal purity (if variety is named). For example, the statement 99% pure on a 100-pound bag of alfalfa seed indicates that the bag contains 99 pounds of whole alfalfa seed; the remaining 1% is inert material (dirt, sticks, broken seed, etc.), weed seeds, and seed of other crops. But if this bag is labeled Ranger alfalfa, then 99% pure should also mean that the bag contains 99% of whole seed of this variety. In such crops as alfalfa, where it is impossible to identify variety by seed characters alone, the only way to be sure of varietal purity is to buy certified seed.

Other crop seed. Other crop seed includes seeds other than those named on the tag. If variety is named, it would include seed of different varieties of the same crop as well as seed of other crops. It is not necessary to name these other crops unless the proportion exceeds 5% of the total. If it does exceed 5%, then the lot becomes a mixture and germination and analysis must be given for all components of the mixture.

The presence of other crop seed may or may not be important to the buyer. For instance, a high proportion of winter rye in winter wheat is extremely objectionable. On the other hand, the presence of spring oats in winter wheat is not so objectionable. One of the most objectionable crops in alfalfa is sweet clover. Presence of an excessive amount of an objectionable crop may be the reason for a low price tag. The buyer should check this point carefully.

Weed seed. The tag must also show the percentage, by weight, of all weed seeds. Most states prohibit the sale of seed containing the seed of any primary noxious weed. In Illinois Canada thistle, perennial sow thistle, field bindweed, leafy spurge, Russian knapweed, and hoary cress are classed as primary noxious weeds.

Illinois law does not require the listing of any kind of weed seed except secondary noxious weeds (curled dock, wild garlic, dodders, bullnettle, buckhorn, quackgrass, wild mustard, Johnsongrass, ox-eye daisy, and wild carrot), and then only when it exceeds certain amounts. "Clear tag" seed is seed that does not contain enough secondary noxious weed seed to require listing them on the tag.

Illinois law also prohibits the sale of crop seed or mixtures thereof containing secondary noxious weed seeds either singly or collectively in proportions larger than 1 to 1,000 crop seeds, or a total of all weed seeds in excess of 2% of total crop seeds.

Germination. Germination must be listed exclusively of hard seed. Some crops germinate readily and strongly, while others have a smaller proportion of viable seed. For instance, a total germination (germination plus hard seed) of 85 to 90% is normal for sweet clover, while 75% is normal for bluegrass and 80% for bromegrass.

One of the most misunderstood items on the seed tag is hard seed in legumes. Hard seeds are perfectly normal, viable seeds, but they were impervious to water at the time the germination test was made and therefore remained dormant. Most of these hard seeds will germinate when planted in the field. Some, of course, may remain dormant for a long time, as is shown by the frequent volunteering of sweet clover long after this crop has been planted in a particular field.

In some cases hard seeds may actually benefit the farmer because the seeds that germinate readily may die out quickly as seedlings, especially if dry weather occurs after seeding. The hard seeds that were slow to germinate may actually provide a practical stand when moisture increases later.

Origin (place of production). A statement of origin is required by law for alfalfa, red clover, and field corn (except hybrid corn). If the origin is not known, that fact should be stated on the tag. Information concerning the origin of these three crops is extremely important.

It is a well-known fact that common alfalfa seed produced in warm regions is not winterhardy. On the other hand, alfalfa seed produced in the central and northern plains and the mountain states is winterhardy. Origin therefore is a guide to winterhardiness of alfalfa. Origin of red clover is also important to the Illinois farmer. Red clover seed produced in Indiana, Iowa, and Kansas is generally adapted to Illinois.

Under the rules and standards of certification, both alfalfa and red clover may be produced outside the area of adaptation without changing their inherent adaptation to a particular area. Consequently, certified Ranger alfalfa produced in California is equally as well adapted to Illinois conditions as certified Ranger alfalfa produced in Montana. But uncertified Ranger alfalfa produced in California may or may not retain its winterhardy characteristics.

The relation of germination and analysis to seed quality will be discussed in a later fact sheet.

W. O. Scott
11-11-57

AGRONOMY FACTS

SEED QUALITY

All of the information carried on the seed tag is important in determining quality. However, kind or variety, pure seed content, and germination are major factors of quality.

Varietal purity is often overlooked as a seed quality factor. It is true that it usually has little influence on germination, mechanical purity, and appearance of the seed. However, varietal purity can not be overlooked in determining what makes good seed. Resistance to lodging, resistance to disease, and even tolerance to certain weather conditions are inherent in variety. In other words, no amount of cleaning will make a non-hardy variety of alfalfa winterhardy, nor a rust-susceptible variety of oats resistant to rust. Therefore, the first and most important thing to consider in buying seed is variety. The best way to be assured of varietal purity is to buy certified seed.

Pure seed content and germination will tell much of what you need to know about a particular lot of seed. However, other crop seed and weed seed content must also be taken into account. Pure seed content times germination gives the actual pure live seed in a given lot. In other words, if a bag of seed contains 99.5% of whole seed and has a germination of 80%, this bag of seed actually contains only 79.6% (99.5 x 80 = 79.6) of seed that will grow. Pure live seed is an excellent measure of quality, but of course this information must be tempered by information concerning the other crop seed content and weed seed content.

Pure live seed can often be used to compare the value of different seed lots. For instance, if one lot of alfalfa contains 99.5% of pure seed and has a germination of 90% and retails for 36¢ a pound, the actual cost of the pure live seed in the bag is about 40¢ a pound (36¢ ÷ 99.5 x 90 = 40¢). On the other hand, a lot of seed with the same purity, 99.5%, but with a germination of 80% retailing at the same 36¢ a pound, would actually cost about 45¢ per pound of pure live seed (36¢ ÷ 99.5 x 80 = 45¢).

Pure live seed can also be used to calculate seeding rate based on seed quality. The normal seeding rate for alfalfa is about 12 pounds of seed per acre. If we assume that this seeding rate is based on a normal minimum pure seed content of 99.0% and germination of 90.0%, then we can calculate the seeding rate of lower or higher quality seed in reference to the normal in the following way:

$$\frac{\text{Seed Lot A, "Normal" Pure seed } 99.0\% \times \text{ Germination } 90.0\% \times 12 \text{ lb./A}}{\text{Seed Lot B, "Below Normal" Pure seed } 99.0\% \times \text{ Germination } 60.0\%} = 14 \text{ lb. (of the lower quality seed needed)}$$

or

$$\frac{99.0\% \times 90.0\% \times 12}{99.0\% \times 60.0\%} = 14 \text{ lb.}$$

Several research workers have compared the field germination of certain crop seeds with laboratory germination. Their findings further support the advisability of buying high-quality seed. Laboratory germination is an indication of field germination, but field germination is usually lower than laboratory germination.

(over)

This difference between laboratory germination and field germination widens as seed quality goes down. When the laboratory germination of alfalfa and red clover is above 80%, the field germination may be expected to average about 52% of the laboratory germination. However, the average that may be expected in the field drops to about 33% when laboratory germination is between 60 and 80%.

It is difficult to assign a monetary value to the importance of a low weed seed content in agricultural seed. The purchaser can expect certain crops, like corn, to be entirely free of weed seeds. Other crops, like bromegrass may be expected to contain as much as 1.0% of weed seed under certain conditions. The purchaser should compare different lots of seed on the basis of weed seed content as well as on the basis of pure live seed. The cost of controlling weeds is already high on most farms. It isn't logical that a person would increase this cost by using crop seed with a high weed seed content.

The Illinois seed law helps to protect the purchaser from getting noxious and certain other weeds in crop seed. The seed law prohibits the sale of agricultural seed that contains noxious weed seed and requires that certain objectionable weeds, which the law calls secondary noxious, be named on the label if present in certain amounts. The purchaser should avoid seed that contains any secondary noxious weed seed. The primary and secondary noxious weeds are named in Fact Sheet M-24.

As indicated below, the germination that is considered normal by the seed trade and seed analysts will vary from crop to crop. The ease of obtaining a high degree of mechanical purity also varies from crop to crop. It is much harder to remove inert matter and weed seeds from bromegrass than from alfalfa. Consequently, one can readily find alfalfa seed with a purity of 99% but will seldom find bromegrass with a purity much higher than 90%.

The minimum purity and germination that a purchaser should strive for in buying seed varies by crops, and in certain instances even from one season to another. Following are normal minimums for purity and germination of certain crops that may be used as a guide in buying seed:

Crop	Pure seed minimum	Germination including hard seed minimum
	percent	percent
Alfalfa	99	90
Alsike clover	98	90
Red clover	98 to 99	90
Sweet clover	99	85
Birdsfoot trefoil	96	85
Bromegrass	90	85
Ryegrass	99	90
Redtop	92	90
Reed canarygrass	99	65
Orchardgrass	85	85
Kentucky bluegrass	85	80
Tall fescue	99	90
Barley	99	90
Corn	99	90
Oats	99	90
Sorghum	98	85
Sudangrass	98	85
Soybeans	98	85
Wheat	98.5	90

W. O. Scott
11-18-57

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ROGUES IN COMMERCIAL HYBRID SORGHUM

The frequent occurrence of off-type plants, or rogues, in commercial fields of hybrid sorghum has become a disturbing problem to farmers and sorghum seed producers. The rogues are of several types and origins. They include (1) mutations, or sudden hereditary changes in genes and chromosome number; and (2) hybrids between the male-sterile grain sorghum parent and other sorghums, such as Sudangrass and Johnsongrass.

In most sorghums the genes occur in pairs. The combine grain sorghums are pure for at least one pair of genes for dwarfness. This condition is symbolized by the expression "dd". The gene "d" is rather unstable and sometimes changes to a new form "D", which causes tallness. Thus, in a field of sorghum, perhaps one out of every thousand or two thousand plants will be tall and genetically "Dd". Except for their height, these tall rogues are quite similar to the standard plant of the hybrid involved.

Grain sorghums normally have 20 chromosomes associated in 10 pairs (10 II's). As individual plants mature, they produce male sex cells (pollen) and female sex cells (eggs), each with 10 single chromosomes (10 I's). The chromosome content of 10 II's is re-established in the offspring of a cross by a combining of unlike sex cells following pollination as illustrated below:

Sorghum plant with 20 chromosomes (10 II's)

Production of sex cells

Pollen (10 I's) — Eggs (10 I's)

Pollination

Offspring (10 II's)

Sometimes an egg with 10 I's produces a mature sorghum plant without having been fertilized. Such a plant has only 10 chromosomes and is small, weak, and sterile. It is known as a haploid. On the other hand, sometimes eggs are formed that have 20 chromosomes (10 II's). If these become fertilized, they produce sorghum plants with 30 chromosomes in 10 groups of three each (10 III's). This plant is a triploid. It is as vigorous and tall as the standard type of the variety or hybrid but is almost as sterile as a haploid. Unlike tall mutants, haploids and triploids are not readily detected. They occur rarely and are unlikely to cause problems for the sorghum grower.

Rogues resulting from out-crosses with other sorghum varieties or types reveal themselves most readily by an increase in height, number of stems, or both. They can usually be distinguished from tall mutants because they differ from the standard in several characters other than height. All such crosses are a nuisance in harvesting and give the field an unattractive, ragged appearance. However, the most serious out-cross is probably that involving Johnsongrass as the male parent.

Johnsongrass is a sorghum (*sorghum halepense*) and thus a relative of the grain sorghums. It has 40 chromosomes and usually does not cross with the 20-chromosome type. However, in crossing blocks used for hybrid seed production the male-sterile parent is particularly susceptible to being fertilized by Johnsongrass pollen from plants in neighboring fields and fencerows. Consequently, where seed is produced in a Johnsongrass area, hybrid sorghum seed is more likely to contain Johnsongrass hybrids than is seed from male-fertile varieties.

Hybrids between 20-chromosome sorghum, such as the grain types and Johnsongrass, are of two general types. One has 30 chromosomes and is highly sterile, rhizomatous, vigorous, and similar to Johnsongrass in appearance. The other has 40 chromosomes and is weakly rhizomatous, vigorous, and much coarser than Johnsongrass. Both types are taller than combine sorghums. The 40-chromosome type is rather fertile unless the female parent carried the genes and cytoplasm for male sterility, in which case the hybrid is also male-sterile. The origin of these types of hybrids is shown below:

Grain sorghum (male-sterile line) — Johnsongrass

Egg (10 II's) — Eggs (10 I's) — Pollen (20 chromosomes)

40-chromosome hybrid — 30-chromosome hybrid

How serious are these hybrids in introducing Johnsongrass-like weeds? Results of detailed studies are not yet available. However, no first-generation hybrids have been observed that are as rhizomatous as Johnsongrass. The 30-chromosome hybrids may overwinter in the warmer areas of the Johnsongrass belt. It is not likely that the 40-chromosome type will be very successful even in most of these areas, since its rhizomes are short and near the surface of the soil.

A recent study of 54 hybrids between grain sorghums and Johnsongrass showed the following information:

Female parent	Number of Johnsongrass hybrids with 30 chrcmosomes	40 chromosomes
Male-fertile (artificially emasculated)	24	2
Genetic male-sterile	4	12
Cytoplasmic male-sterile	3	9
Total	31	23

The 12 40-chromosome hybrids from genetic male steriles were all highly self-fertile. The 9 from cytoplasmic male steriles were all highly male-sterile but were female-fertile. This study indicates that this is the type of hybrid to be expected in commercial hybrid sorghum fields. All 30 of the 30-chromosome hybrids were highly sterile on both the male and the female side.

In spite of their sterility expressions, both 30- and 40-chromosome hybrids could be possible sources of troublesome seedlings. This is particularly true of the 40-chromosome hybrids if Johnsongrass is near by to act as a pollen parent. Controlled crosses between male-sterile 40-chromosome hybrids and Johnsongrass have produced seed. Such seed conceivably could be the source of rhizomatous offspring or volunteer annual plants with "hard seeds." At present, tests are being conducted in several areas to determine the seriousness of Johnsongrass hybrids in regions along the northern boundary of the Johnsongrass belt. In the meantime, producers of hybrid sorghum seed should exercise every effort to prevent crosses with Johnsongrass.

Henry H. Hadley
11/25/57

AGRONOMY FACTS

SEED TRADE TERMS

Seed terms. Several types or kinds of seed are sold on the market. Because farmers are often confused about which is the best type to buy, this fact sheet has been prepared to try to point out some of the differences.

The bulk of the seed that is sold can be classed as "brand" seed. For example, a company might sell "S" brand alfalfa, red clover, or other seed. This company depends on its reputation to encourage buyers to return again and again for "S" brand seed. In other words, a "brand" is used as a symbol of the reputation of the seed company. As additional assurance of quality, a company may point out that the seed it sells is certified, affidavit, or verified-origin seed.

Certified seed. Certified seed is seed that is produced, processed, and marketed according to a plan that protects its genetic identity and purity. Certification usually implies that the variety is recommended in the state in which the certification is completed. In many states only varieties that are recommended by the agricultural experiment stations are eligible to be certified. However, some states do certify nonrecommended varieties.

Sometimes a consuming state will ask another state to produce certified seed of a variety that is not recommended in the producing state. In this instance the certification is carried on under an interagency plan. The producing state carries out the field inspection (maybe even doing the germination and analysis work), but certification is actually completed in the consuming state where the variety is recommended.

In addition to meeting certain standards for genetic purity, certified seed must meet certain standards for mechanical purity, germination, freedom from crop seeds, and freedom from weed seeds.

Briefly, certified seed is produced in the following way:

First, the producer must start with certified seed. He may use breeder's seed, foundation seed, registered seed, or certified seed. Some states have a limited generation program. In such states, the producer must start with breeder's, foundation, or registered seed, and certified seed cannot be recertified. To eliminate danger of contamination by volunteer plants, the field selected to produce the certified seed must not have grown the same crop in the preceding year. For some crops the period will be more than one year. To eliminate danger of contamination by cross pollinization, cross-pollinated crops are isolated from like crops by a distance sufficient to eliminate this danger.

The grower of certified seed usually rogues the field to remove off-type plants, plants of other crops, and objectionable weeds. A trained inspector checks the field for the presence of off-type plants and weeds against standards set up for the various classifications. He also checks the field for proper isolation. Time and number of field inspections depend on the crop. For example, it is not unusual to make two inspections of soybeans (one at flowering time and one just before harvesting). As many as eight to ten inspections may be made in fields producing hybrid corn.

After harvest and cleaning, a trained inspector takes a representative sample of the seed as it is to be offered for sale. He submits this sample to a laboratory for germination and analysis. The seed must meet certain standards for mechanical purity, germination, and freedom from other crop seeds and weed seed. In addition, if varietal purity can be determined by seed character, the laboratory also makes a varietal purity determination.

If the seed meets all laboratory requirements, certification is completed. In most cases certified seed can be sold only in bags that are tagged with an official certification tag and sealed with an official certification seal. In other words, seed moving in bulk lots or broken bags cannot be called certified seed.

It is not uncommon to find that the bulk of the certified seed of a particular crop or variety is produced outside its "area of adaptation." This is the case with the improved alfalfa and red clover varieties. For instance, most of the seed of Buffalo, Ranger, and Vernal, which are alfalfa varieties developed by plant breeders for the corn belt, is now produced in the irrigated sections of the western and southwestern United States. If there is no change in the genetic make-up of a variety, there will be no change in its adaptation to an area. Therefore, it is possible through certification to produce seed of alfalfa varieties, such as Buffalo, Ranger, and Vernal, in the western and southwestern United States without fear of loss of adaptation to the corn belt.

Verified-origin seed. Verified-origin seed is seed that is identified as to place of production or origin. No verification is made as to variety. Briefly, it is seed for which the grower signs a declaration stating that it was produced in a certain county of a certain state. The seed is then identified by various declarations, invoices, blending records, shipping records, etc., in its movement through the seed trade.

The Seed Branch of the Grain Division, Agricultural Marketing Service, U. S. Department of Agriculture, is the clearing house and the watch dog for these records. Each lot can be traced from grower to final vendor by the records submitted to the U. S. Department of Agriculture by the various handlers.

Verification of origin of a given lot of alfalfa, for example, gives the vendor and the purchaser information as to where the seed was produced and supposedly, therefore, some idea of the winter-hardiness. In other words, if we know definitely that a certain lot of alfalfa seed was produced in Nebraska, we can assume that the climate of Nebraska was sufficiently severe to eliminate nonhardy types of alfalfa. This is generally true, and for all practical purposes the verification of origin gives some idea of the degree of winter-hardiness. However, verified-origin seed is checked only for place of production or origin. No one investigates whether the seed has been produced from hardy parent stock or from nonhardy stocks that might have lived through a mild winter.

The verified-origin service was started in 1927 and gave rise to the common terms of Northern Common, Central Common, and Southwestern or Southern nonhardy alfalfa. Northern Common comes from the section bounded on the south by the southern boundaries of Oregon, Idaho, Wyoming, and Nebraska and extending eastward along the 40th parallel. The Central Common alfalfas are produced in the area just to the south of the one described for Northern Common, which is bounded on the south by the southern boundaries of Nevada, Utah, Kansas, Missouri, Kentucky, and Virginia. The Southern Commons, or the nonhardy group, are those produced south of the area designated as the Central Common area.

Within these three general areas are recognized a few special districts. Special districts are assigned to areas where the normal winter temperatures are much more severe or less severe than in the rest of the state. For instance, the origin of alfalfa seed produced in certain counties in northwestern Texas can be given as "Northwestern Texas" to distinguish it from seed produced elsewhere in the state. The winters in northwestern Texas are relatively severe.

It should be pointed out that Kansas Common, Dakota Common, etc., are not variety names. These are descriptive terms applied by the seedsmen to alfalfa seed produced in the particular state.

Oklahoma-approved alfalfa. Oklahoma falls in the group of states comprising the southern region of non-winter-hardy seed-producing areas. Since Oklahoma produces a great deal of alfalfa seed that is comparable with Kansas Common in winter-hardiness, it has developed a plan of identifying seed produced in certain sections of the state as winter-hardy. This seed is called Oklahoma-approved.

The certification agency, the Oklahoma Crop Improvement Association, supervises the production of Oklahoma-approved alfalfa. All of this seed is grown in the western and northwestern sections of the state. This organization keeps adequate records to identify Oklahoma-approved seed as having been produced from hardy parent stocks of Oklahoma Common alfalfa. In addition, it inspects fields for the presence of weeds, particularly Johnson grass, dodder, and bindweed.

Oklahoma-approved seed differs from certified seed in the fact that it does not meet any standard for varietal purity. Certified seed must meet a standard for varietal purity. Oklahoma-approved seed differs from verified-origin seed in the fact that, in addition to being identified as having been produced in a certain section of Oklahoma, the seed is also known to have been produced from winter-hardy parent stocks.

Affidavit seed. Affidavit seed is seed for which the producer signs a statement or affidavit concerning either origin, variety, or both. It differs from verified-origin seed in the fact that no service or agency checks into the authenticity of this statement. Consequently, the value of the affidavit is no better than the integrity of the grower.

Affidavits are used by the seed trade in the merchandising of a number of crops in which it is difficult, if not impossible, to distinguish between varieties by seed characteristics alone. Each year a considerable amount of affidavit seed of the improved alfalfa varieties, such as Buffalo and Ranger, is sold. Affidavits as to varietal identity of Buffalo or Ranger alfalfa are of questionable value. Alfalfa is a cross-pollinated crop. Consequently, to state that a certain lot of seed is Buffalo or Ranger because it is only one or two generations removed from certified Buffalo or Ranger, means very little. If the alfalfa is improperly isolated or carelessly handled in harvesting and processing, even alfalfa seed only one generation removed from certification may vary tremendously from the original variety. Most of the affidavit alfalfa seed sold in Illinois is produced in Kansas, Nebraska, or another of the central or northern states. In most cases this seed is at least one generation removed from certification, and it may or may not be the true variety.

W. O. Scott
3-3-58

AGRONOMY FACTS

GIBBERELLIC ACID

Gibberellic acid is the newest plant growth-regulating chemical to receive the attention of scientists and publicists. Much has been written about its remarkable capacity to stimulate growth of many plant species and about its potential usefulness in agriculture. Present knowledge of this material and of the responses of crops to it is summarized in the questions and answers below.

What is it? Gibberellic acid is a metabolic product of a fungus that is pathogenic on rice and other crops and is closely related to the organisms causing ear and stalk rot in corn. Chemically, its formula is $C_{19}H_{22}O_6$. There are at least three closely related active materials: gibberellic acid, gibberellin A, and gibberellin A_2.

What does it do? It causes a temporary increase in the rate of elongation of stems. In some species there is no increase in root growth; in others the effect on root growth is less or lasts a shorter time than the effect on stem growth; and in some instances root growth is retarded. The growth stimulation is due mainly to increased cell elongation, although there may also be more cell division. An increase in dry weight has been observed in some cases. Gibberellic acid probably affects growth mechanisms other than those affected by auxin.

How do crops respond? More rapid germination of treated seed has been observed in Kentucky bluegrass, tomatoes, corn, cotton, soybeans, and other crops. This response probably depends partly on temperature, the effect being more pronounced in cool soil. Lodging tendency may be greater when foliage is sprayed in midseason. Corn grows faster and taller, both root and shoot growth being stimulated. Ten percent more bolls were observed on cotton in Texas, but no clear-cut yield increases. Despite faster germination, stands of cotton and soybeans were poorer after seed treatment.

What crops benefit? Most promising are the effects on horticultural and floral crops. Favorable results have been noted in grapes, tomatoes, and strawberries. Field crops have not shown yield increases, but other responses, such as faster emergence and more rapid early growth, may prove beneficial in soybeans, small grains, cotton, and other crops. Forage crops have given higher yields at the first cutting after treatment, but lower yields at subsequent cuttings.

How and when do you use it? Gibberellic acid has been applied to seed in "slurry" treatments or to foliage as a spray. Concentrations of 1000 ppm in "slurry" treatments or 50 or 100 ppm or more in foliage treatments can be used; for maximum effect, concentrations may need to be higher. If used as a spray, a wetting agent (most household detergents are suitable in a concentration of 0.1%, but some may burn the foliage) should be used to aid in wetting the leaves. Young plants are more responsive than old, but soybeans respond by faster growth to spray treatment as late as July 20. Other types of treatment, such as soil treatment, are yet to be investigated extensively.

Is there danger of injuring plants or animals? There is little or no danger. No report of injury to plants or animals has come to our attention, and so far the Federal Food and Drug Administration has shown no concern. One experimental aerosol preparation contained a material that severely burned the leaves of several species. Although the injurious material has been eliminated in that case, such products should be used cautiously until it is known that they are safe.

Can you use repeated treatments? Yes. In fact, indications are that repeated treatments will be required, since in most cases untreated checks seem to catch up with treated plants after a few weeks.

How does it affect weeds? It has been commonly observed that 2,4-D is most effective when weeds are growing rapidly. Since gibberellic acid promotes plant growth, it was thought that it might enhance 2,4-D effectiveness. Gibberellic acid was therefore applied in various concentrations to smartweed and pigweed one week before 2,4-D applications. The treated weeds were growing more rapidly than untreated at the time the 2,4-D was applied, but 2,4-D was no more effective on these plots than on plots where 2,4-D was used alone. When gibberellic acid was applied at the same time as 2,4-D, the reaction was the same as that from 2,4-D treatment alone. (F.W. Slife)

How much does it cost? A 12-ounce aerosol preparation costs about $3.00. It contains about 20 mg. of gibberellic acid--enough to treat a lot of house plants, but a negligible amount for treating a field. Present cost figures are not realistic because the material has been produced mainly on an experimental basis. Price will be closely related to production volume. Until more is known about which crops will respond to gibberellic acid and how much may be used, manufacturers can not estimate price very closely. However, they say that, if an important crop response is observed, the price will probably be low enough to make use of gibberellic acid profitable.

What form does it come in? Gibberellic acid is being produced as a soluble salt, as a wettable powder, in solution that forms an emulsion with water, and in aerosol bombs. Other formulations are being produced experimentally and will be available if they prove desirable.

Are different forms equally effective? This question has not been carefully investigated. Presumably when equal amounts of gibberellic acid are used, the different forms will be equally effective, but different formulations must be tested before this point is established.

What are the prospects for commercial use of gibberellic acid? No immediate large-scale commercial use on field crops is indicated by the results to date. However, present information is generally based on limited concentrations, a few arbitrarily selected treatment dates, and a single formulation. Grapes are reported to have responded favorably in California, and commercial use on that crop is a possibility. Improvements in quality in peas have been observed from certain treatment combinations. These results will probably stimulate further work on other crops. Supplies of gibberellic acid for experimental use have been good, and 1958 will probably see further extensive studies of its usefulness. For the present, however, judgment on the place of gibberellic acid for use on agronomic crops must be reserved.

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Agricultural Research Service
U. S. Department of Agriculture
3/17/58

CORN AND CLIMATE

Corn is grown practically the world over. One reason is that there are many different types that will grow in varying climates. Some strains grow only two feet tall, have fewer than 10 leaves, and mature in 60 days; others grow 20 feet tall, have over 40 leaves, and require almost a year to mature.

The flint type is the one grown principally in the northern or drier regions of the corn-producing areas. The hard seeds of the flint varieties make them able to stand more adverse soil temperature and moisture after planting than dent corn. The flint varieties generally mature more rapidly and the grain is injured less by unfavorable fall weather. Sometimes flint varieties are also found growing in tropical climates. Again, the harder seeds offer more resistance to the more numerous insects and diseases prevalent in warm climates.

Temperature

Corn is a warm-weather plant. In general, it is grown only in regions where the mean summer temperature is above 66° F. or where the average night temperature during the three summer months remains above 55° F. The region where most of the corn is produced in the United States has a mean summer temperature of 70° to 80° F., a mean night temperature exceeding 58° F., and a frost-free growing season of over 140 days. Corn is grown at almost all latitudes except where it is too cold or where the growing season is too short.

The average temperature at the time corn planting begins is about 55° F. Most of the planting is done when the soil temperature is about 60° F. Soil temperatures closely follow air temperatures.

In other words, the soil accumulates little heat in the early spring. For corn to emerge quickly, daily heating must occur during the period. A hot spell during one week does not mean that the soil will stay warm during two or three more cloudy, cool days. Before germination can take place, the corn seed must take in water and swell. If the soil is completely saturated with water, germination is retarded or even prevented by lack of oxygen.

Under greenhouse conditions, corn can emerge easily in three to four days. Generally in the field, with an average temperature of 70° F., emergence will require five or six days. At 60° to 65° F., emergence will require 8 to 10 days; at 50° to 55° F., it will often take 18 to 20 days. Low soil temperatures (45° F.) also predispose the seed to attack by various soil organisms. Present-day hybrid seed comes to the farmer with fungicides on each kernel that help to reduce stand damage in cold, wet soil.

Young corn plants can withstand low temperatures very well. It generally requires a temperature as low as 31° F. to kill the leaves, and even then the plant will often recover rapidly. Research at Illinois has shown that temperatures as low as 25° F. will not kill some inbreds and hybrids. The length of time the chilling lasts is important, and plants are also damaged more in moderately wet soil than in moderately dry soil.

How much a plant grows in a day depends primarily on temperature. Workers in

Nebraska reported that corn grew an average of 2.5 inches in 24 hours. Iowa workers found that growth averaged 3.2 inches a day (24 hours) at a temperature of 65° F. and 5.4 inches at a temperature of 78° F. Dr. Dungan found that under ideal conditions corn in Illinois would grow as much as 6 inches in 24 hours.

Temperature can have a very important effect on corn in the period from planting to tasseling. Iowa research showed that a 115-day variety took 74 days to tassel when the temperature averaged 68° F. but only 54 days when it averaged 70° F. Temperature does not seem to be so important in the period between silking and maturity (33 percent moisture in the grain). Iowa weather researchers reported this over-all period to be 51 days with little variation from year to year. Leng in Illinois found that about 26 days were required from planting until the tassel began development (when the corn is about knee high) and another 40 days to pollination.

Although corn grows best in warm weather, extremely high temperatures may also be injurious. Plants are most susceptible to high temperatures at tasseling time. In 1954, a 113° F. temperature and hot winds killed the top leaves and tassels in many fields in south-central Illinois. Certain hybrids in the variety trials at Brownstown that year showed no heat damage, while others produced very little grain. Plant breeders in the dry areas of the West have bred heat tolerance into their hybrids.

Rainfall

Corn is grown in areas that differ widely in rainfall as well as temperature. It is found growing in areas that receive as little as 10 inches of rain annually and in other areas that receive over 200 inches. It thrives in areas where the native grasses are tall like the bluestems, whereas its growth is generally limited in areas where the native grasses are short, like buffalo grass.

Soon after emerging, the corn plant no longer depends on stored food but becomes self-sufficient. The plant needs only a relatively small amount of water in the seedling stage. In fact, if the soil is somewhat dry during this period, the corn roots will penetrate deeper into the soil and the plants are better able to withstand later dry periods than if they had had an abundant supply of water when small.

Correlation studies between grain yield and rainfall in Ohio during 10-day growth periods of a corn plant have showed the closest relation between yield and rainfall to occur during the 10 days following tasseling. Recent studies by Runge and Odell in Illinois (see Agronomy Fact Sheet C-19) indicate that corn yields are influenced more by precipitation and maximum temperatures immediately before and during the full tassel stage of corn development than at any other time. Lack of moisture during tasseling and silking may delay silking in relation to tasseling, causing poor seed set and even barren stalks.

Day Length

Corn responds to changes in day length. The period from emergence to flowering is reduced by short days and increased by long days. This means that varieties grown in the South, when planted in Illinois, will generally grow taller and require a longer period to pollinate than they would in their own region. On the other hand, an early variety from northern Wisconsin will grow shorter and be earlier when planted in Illinois than in Wisconsin. One researcher described the difference in this way, "As we go north or south of a given latitude, a given variety becomes one day later or earlier for each 10 miles of travel if the latitude remains the same."

When Is Corn Mature?

Corn reaches physiological maturity (that is, the grain reaches its maximum dry weight) when the moisture in the grain reaches about 33 percent. This figure can vary between 30 and 35 percent according to season and variety.

What Is Ideal Weather for Corn?

Perhaps the best way to answer this question would be to see what the weather was in central Illinois in a year (1956) when corn yields were among the highest on record and the general quality of the crop was excellent. The following table shows rainfall and temperatures during the growing season of 1956 alongside long-time averages (the data are from Urbana).

It is evident that the 1956 growing season was characterized by below-normal rainfall during May and June, a total of more than three inches of above-normal rainfall during July and August, and very little rainfall during the fall months. A comparison of temperatures with the long-time average shows that 1956 had a fairly warm spring and warmer weather than usual in the late fall.

	1956 Data		Long-time average	
Month	Temperature Deg. F.	Rainfall in.	Temperature Deg. F.	Rainfall in.
May	64	2.92	62	4.18
June	74	1.89	73	4.52
July	73	5.82	77	3.29
August	73	3.79	74	3.15
September	66	1.25	67	3.20
October	62	.39	57	3.17

J. W. Pendleton
12/9/57

EFFECT OF SUMMER PRECIPITATION AND TEMPERATURE ON CORN YIELDS

Weather conditions immediately before and during full-tassel stage have a marked effect on corn yields. This conclusion was reached from a study of yields of first-year corn from 1903 through 1956 in a corn, corn, oats, and red clover rotation on the Agronomy South Farm at Urbana, Illinois. The soil treatments applied since 1903 have been rock phosphates and residues from the previous crop, plus limestone applied in 1946. The weather data were taken from official records of the Urbana, Illinois, weather station, located adjacent to the Morrow Plots.

The objectives of this study were:

(1) To determine the relation between corn yields and weather factors, such as precipitation and maximum daily temperatures, during the growing season.

(2) To study, for each of these weather factors, the effectiveness of different types of mathematical functions and different over-all lengths and subdivisions of periods during the growing season, in explaining corn yield variability. The purpose was to determine the simplest mathematical function and the optimum set of precipitation and temperature data, with regard to over-all length and subdivision of periods during the growing season, that would most efficiently explain variations in corn yields from one year to another.

In the crop rotation studied, open-pollinated corn was grown from 1903 through 1939 and hybrid corn was grown from 1940 through 1956. To study yields during this entire period, it was necessary to convert yields of the two kinds of corn to a comparable basis. This was done by (a) determining the relation between yields of open-pollinated and hybrid corn in central Illinois corn performance tests and then (b) using this relation to convert open-pollinated yields to their hybrid equivalent. The least squares equation, $Y = 11.14 + 1.059X$ with $r^2 = 96.7\%$, was used to make this adjustment. The hybrid equivalent yields were used from 1903 through 1939, and actual hybrid corn yields from 1940 through 1956.

There was a significant upward trend in yield of first-year corn during the period from 1903 through 1956. This upward trend may have been due to one or several causes, such as improved varieties of open-pollinated and hybrid corn, improvement in cultural practices from 1903 to 1956, addition of limestone in 1946, and possibly weather cycles.

The relationships between corn yields, precipitation, and maximum temperature were studied for different periods ranging from 8 to 112 days, during the growing season, within a fixed calendar period each year (i.e., May 12 through August 31), and a variable period (i.e., a specific number of days before and after full-tassel stage). Polynomials from the first to the fourth degrees were also studied.

With the fixed calendar period for each year, use of the period from May 20 through August 23 (12 eight-day periods) and a two-degree multiple correlation explained more of the yield variability due to precipitation and maximum temperature than any other fixed period or degree of polynomial studied. On this basis differences in precipitation and maximum temperature during the 96-day period were responsible for 58.0 percent of the yield variability. Figures 1a and 1b show the relationships between the mean of daily maximum temperatures and yield and between precipitation and yield, respectively.

The assumptions made in this method are (a) that an inch of precipitation or a degree of maximum temperature has the same effect on corn yield whether the precipitation total or mean of the maximum temperature, respectively, for each eight-day period is above or below average, and (b) that the total effect is directly proportional to the inches of precipitation or number of degrees of maximum temperature above or below average. For example, in Figure 1b, one inch of precipitation above average at the average anthesis (full tassel) date would increase corn yields about 2.8 bushels per acre. Two inches of precipitation above average during corn tasseling would increase yields about 5.6 bushels per acre.

The variable calendar period was more closely related to the stage of development of the corn than the fixed period, because it included the same number of days before and after tasseling. However, a method was needed for calculating the tasseling date from the planting dates, since only the planting dates, which varied from May 1 to June 8, were recorded.

During studies of tassel development in corn, Dr. E. R. Leng found that the period up to tassel initiation (when the tassel can be observed with a microscope by dissecting the corn plant) was more variable than the period from tassel initiation to full tassel. The period from planting to tassel initiation was closely related to degree days, an indication of the amount of heat during the period, whereas the period from tassel initiation to anthesis was nearly a constant number of days. This difference may be due to the fact that temperatures from tassel initiation to anthesis are more constant than temperatures from planting to tassel initiation.

On the basis of Leng's findings and degree days, tasseling dates were calculated from the planting dates recorded in this experiment. Corn yields were then studied in relation to precipitation and maximum temperatures during specific numbers of days before and after tasseling. Precipitation and maximum daily temperatures (Figures 2a and 2b) during the period 50 days before and 14 days after full tassel, 8 eight-day periods, and a two-degree polynomial explained 66.9 percent of the corn yield variability. When the upward trend in yields was included in this analysis, approximately 75 percent of the corn yield variability was explained.

Figure 2a indicates that one degree of maximum daily temperature above normal near the full-tassel stage of development in corn is associated with a yield reduction of .05 bushel per acre. Likewise, one inch of rainfall above normal a week before full tassel will usually increase yields about four bushels per acre (Figure 2b). Since above normal precipitation is especially beneficial about one month before and during full tassel, the frequency and magnitude of moisture deficiencies during this period should be studied as a basis for determining the economics of supplemental irrigation for corn.

E. C. A. Runge and R. T. Odell
12-16-57

FIGURE 1a -EFFECT OF A DEGREE OF TEMPERATURE ABOVE THE AVERAGE DAILY MAXIMUM TEMPERATURE ON CORN YIELD ON THE AGRONOMY SOUTH FARM, NORTH-CENTRAL ROTATION, AT THE MEAN PRECIPITATION FOR EACH EIGHT-DAY PERIOD, MAY 20 THROUGH AUGUST 23

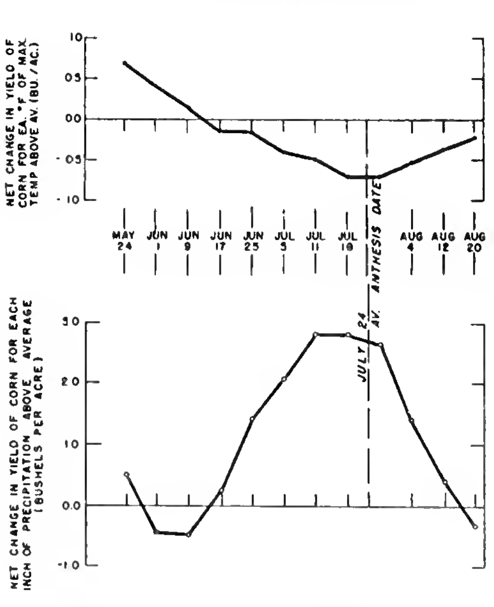

FIGURE 1b -EFFECT OF AN INCH OF PRECIPITATION ABOVE THE AVERAGE DAILY PRECIPITATION ON CORN YIELD ON THE AGRONOMY SOUTH FARM, NORTH-CENTRAL ROTATION, AT THE MEAN MAXIMUM TEMPERATURE FOR EACH EIGHT-DAY PERIOD, MAY 20 THROUGH AUGUST 23

FIGURE 2a -EFFECT OF A DEGREE OF TEMPERATURE ABOVE THE AVERAGE MAXIMUM DAILY TEMPERATURE ON CORN YIELD ON THE AGRONOMY SOUTH FARM, NORTH-CENTRAL ROTATION, AT THE MEAN PRECIPITATION FOR EACH EIGHT-DAY PERIOD, WITH 50 DAYS BEFORE ANTHESIS AND 14 DAYS AFTER ANTHESIS

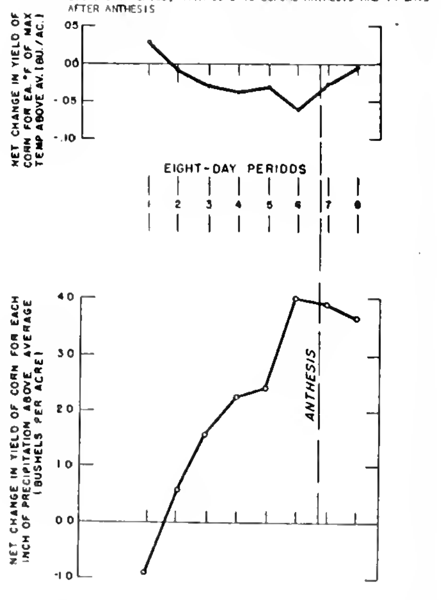

FIGURE 2b -EFFECT OF AN INCH OF PRECIPITATION ABOVE THE AVERAGE DAILY PRECIPITATION ON CORN YIELD ON THE AGRONOMY SOUTH FARM, NORTH-CENTRAL ROTATION, AT THE MEAN MAXIMUM TEMPERATURE FOR EACH EIGHT-DAY PERIOD, WITH 50 DAYS BEFORE ANTHESIS AND 14 DAYS AFTER ANTHESIS

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AGRONOMY FACTS

C-20

MOISTURE CHANGES IN EAR CORN DURING CRIB STORAGE

Ear corn goes into farm cribs at a fairly high moisture content except in occasional seasons that are favorable for field drying. Sometimes the moisture is so high as to give farmers great concern, but always there is the question about loss of weight or shrinkage in the crib. The Department of Agronomy in cooperation with the Department of Agricultural Engineering has made extensive studies on corn shrinkage. Ten lots of corn in slatted cribs 6 feet wide and 8 feet long and holding approximately 250 bushels each were used in these experiments.

The average moisture content of the grain at the time of storage in November was 21.3 percent, and that of the cob was 29.9 percent. By the end of each month throughout the year, beginning with December, the moisture in the kernels was 19.1, 18.4, 17.6, 16.0, 14.3, 12.5, 12.0, 11.1, 11.7, 12.1, 12.4, and 13.3 percent, respectively. That of the cobs month by month was 23.9, 23.1, 18.9, 16.3, 13.2, 11.0, 10.4, 9.4, 10.1, 10.5, 10.8, and 12.2 percent, respectively. These data are presented in graphic form on the accompanying chart (Fig. 1). These results show that the grain and cob attain approximately the same moisture content at the 16.0 percent level. With further drying, the cob drops below the grain but holds its moisture content parallel with that of the grain.

Shrinkage tests showed that after the minimum moisture level had been reached in July or August the moisture content of both grain and cobs rose gradually. To see what happens in corn stored for two years, these same lots of corn were continued in the experiment and weight determinations were made every week. The percentage shrink in weight is charted in Figure 2. The results show that in January and February of the second year of storage the loss in weight was 8.8 percent, whereas in the previous July the loss in weight had increased to 12.4 percent. The progressive weight loss from month to month, beginning in December of the first year of storage and continuing until the end of November of the second year, is as follows: 2.6, 3.5, 5.0, 6.9, 9.1, 11.0, 11.6, 12.4, 11.9, 11.5, 11.1, 10.1, 9.3, 8.7, 8.8, 9.3, 10.3, 11.4, 11.7, 12.5, 12.1, 11.6, 11.3, and 10.5 percent. These percentages are based on the original weight of the corn as it went into storage. They represent averages of data from ten cribs and a range of kernel moistures at the time of storage from a low of 17.8 to a high of 26.1 percent.

That corn absorbs moisture from the atmosphere is not understood generally. In 1926 Dr. H. W. Alberts published a paper in the Journal of American Society of Agronomy reporting the results of his experiments on exposing corn grain to atmosphere maintained at different relative humidities. Here is a summary of his findings:

Approximate Moisture Content of Corn at Different Relative Humidities

Relative humidity perct.	Moisture in corn perct.
10	7.0
20	8.0
30	9.0
40	10.0
50	11.5
60	13.0
70	15.0
80	17.0
90	20.0

In a season when corn carries high moisture, people are deeply interested in information that will enable them to know whether their corn will store safely. In other words, they want to know the critical moisture level for safe storage. The shrinkage experiments were not set up specifically to give information on this point, but it is possible to get some data for use in answering this question. For this purpose a few cribs containing corn at different moisture contents have been selected. The data on these are presented in the following table:

Outcome of Corn Ears Stored at Different Moisture Contents

Moisture content of kernels at time ears went into storage	Maximum shrinkage: Amount in per-cent	Maximum shrinkage: Month when maximum shrinkage occurred	Type of internal venti-lator used	Date corn was put into crib	Amount of corn in crib	Amount of damaged corn	Moisture in corn at end of 1st week in March
perct.	perct.				bu.	perct.	perct.
16.0	3.7	August	None	11-12-34	215.5	0.0	16.3
18.0	8.2	July	None	11-11-30	281.3	0.0	16.3
20.8	14.0	July	None	11-15-24	285.5	0.0	16.2
22.2	12.3	June	None	11-10-28	270.2	0.0	16.4
24.6	16.7	November	None	1-25-28	213.3	0.0	17.8
25.5	18.2	July	None	12-4-26	229.2	0.0	18.5
27.6	18.2	September	None	12-14-26	256.2	3.9	20.0
34.9	36.8	July	A-frame	12-13-24	250.7	42.8	23.5
33.5	31.5	September	None	12-13-24	22.7	71.2	35.1

The last column in the above table shows the calculated amount of moisture in the kernels as of the first week in March. This value was figured from the amount of shrinkage on this date and represents an approximation rather than a precisely accurate figure. The highest moisture in March associated with no kernel damage was 18.5 percent. When the moisture content of the grain was 20.0 percent, the damage averaged 3.9 percent. This was in a crib of corn that went into storage in the fall at 27.6 percent kernel moisture.

The benefit of an A-frame structure in a crib of wet corn is shown by comparing the amount of damage and the rate of drying of the last two cribs shown in the table. The A-frame reduced the amount of commercially damaged corn by about 28 percent and hastened drying very materially. The crib without a ventilator actually increased in moisture from the date of storage until the end of the first week in March. This may have been due to moisture leaving the cob and to the excessive rate of respiration.

The high shrinkage shown for the last two cribs is due to the loss of weight resulting from the rot damage that took place. Not only did the ears lose moisture, but dry matter was consumed by the fungi and bacteria associated with the deterioration of this corn.

These experiments also included studies on artificial drying of ear corn. Unheated air and heated air were used, and records were kept of energy and operational costs. Because prices were much lower than they are now, no mention will be made of these records. The tests showed that heated air was more economical as a drying agent than unheated air. The rate of drying of natural air was so slow that the long time required to operate the fan ran the cost up high. High temperatures were more efficient than low. It was at this point that we ran into trouble. Too high drying temperatures cause changes in the starches in the corn grain, and millers of corn by the wet process had difficulty in separating the starch from the protein fraction.

Research at the Northern Regional Research and Development Division, U. S. Department of Agriculture, Peoria, Illinois, has shown that the changes in corn kernels that cause difficulty in industrial processing begin to take place at a drying temperature of 130 degrees. This finding is in general agreement with industry experience, and Corn Industries Research Foundation, Inc., strongly recommends that drying temperatures be held down. Recent findings indicate that viability is a good index of processing quality of artificially dried corn. If corn will germinate, it will process nicely.

G. H. Dungan
3-24-58

SHRINKAGE OF EAR CORN DURING TWO YEARS IN STORAGE

10 YR. AVERAGE

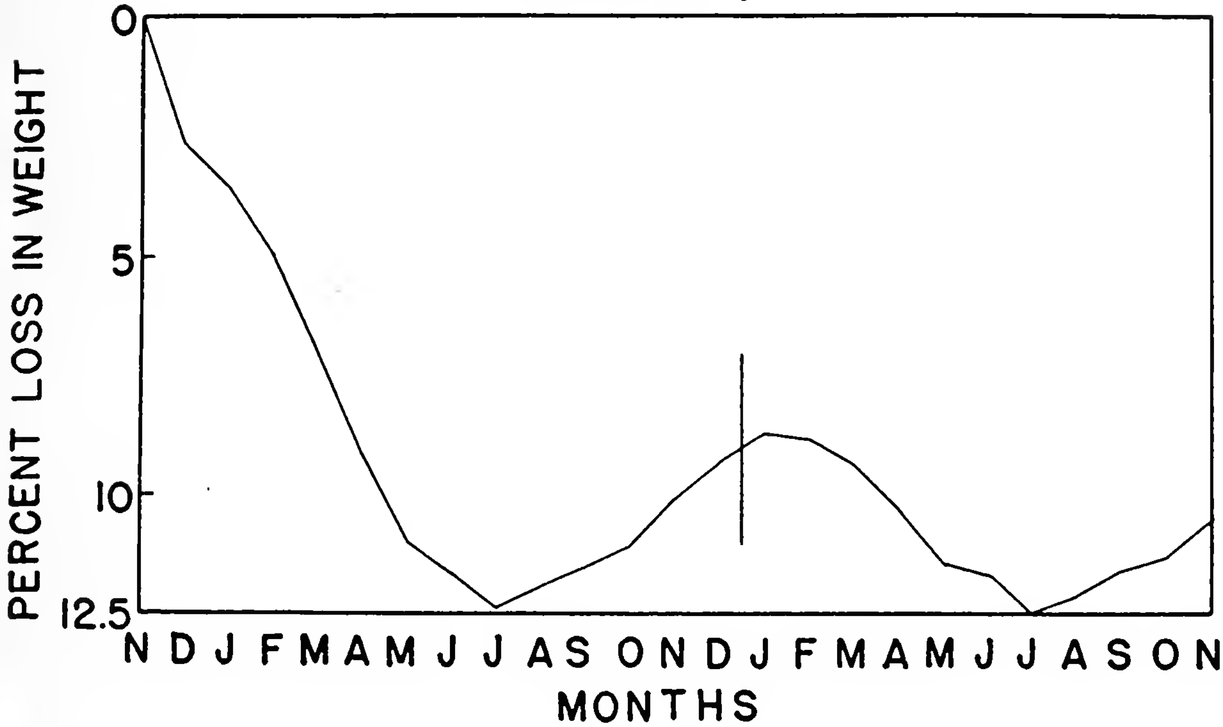
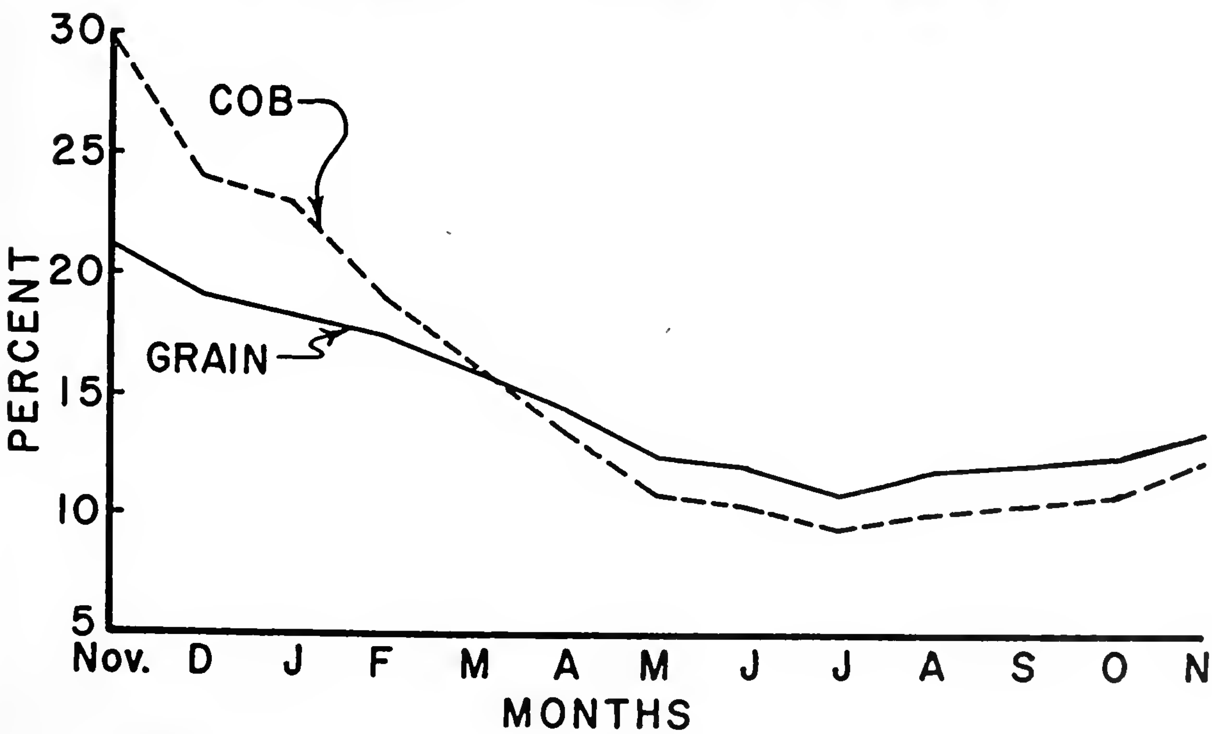


Figure 1

COB AND GRAIN MOISTURE DURING STORAGE - 10 YR. AVERAGE



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AGRONOMY FACTS

F-27

IDENTIFICATION OF GRASSES BY THEIR FLORAL CHARACTERS

There are about 8,000 species of grasses in the world. About 1,500 of these occur in the United States. These grasses can be assigned to various tribes on the basis of a few simple floral characters. The following definitions and key should be helpful in identifying the grasses:

Spikelet - the characteristic unit defined via outer glumes of the inflorescence of a grass.

Floret - a lemma and palea with the inclosed flower.

Glumes - the two bracts at the base of a typical spikelet.

Lemma - the lower of the two bracts inclosing a flower.

Palea - the upper of the two bracts inclosing a flower.

Spike - A form of inflorescence with the spikelets sessile along a common axis.

Raceme - a simple inflorescence of pediceled flowers on a common axis.

Panicle - a compound inflorescence with pedicellate flowers.

Monoecious - bearing male and female flowers in different inflorescences on the same plant.

To help further in the use of the following key, the species below are oriented in their respective tribes:

Agrostideae - timothy, redtop, the bentgrasses, the needlegrasses, the poverty grasses, nimble will.

Andropogoneae - the sorghums, Johnson grass, sudangrass, Indian grass, the bluestems.

Aveneae - oats, tall oatgrass, velvetgrass, June grass.

Chlorideae - Bermuda grass, goosegrass, sloughgrass, the grama grasses.

Festuceae - the fescues, the bromegrasses, orchardgrass, the lovegrasses, false redtop.

Hordeae - annual and perennial rye grass, rye, barley, wheat, wild barley, wheat grasses, quackgrass, Canada and Virginia wild rye.

Maydeae - corn, teosinte, gama grass.

Oryzeae - rice and rice cutgrass.

Paniceae - the foxtails, barnyard grass, crabgrass, Dallis grass, sandbur, tumblegrass, the panic grasses, switchgrass.

Phalarideae - reed canary grass, sweet vernal grass, ribbon grass, canary grass.

Reference: Further information on grass identification can be obtained in "Manual of the Grasses of the United States" by A. S. Hitchcock, which can be purchased from the Superintendent of Documents, Washington, D. C., for $3.00.

(See Key on Reverse Side)

KEY* TO THE TRIBES

- 1a Spikelets, 1 - many-flowered
  - 2a Glumes present
    - 3a Spikelets, 3-flowered, incomplete florets below perfect ones (Phalarideae - canary grass tribe)
    - 3b Spikelet, 1 - many-flowered; no incomplete florets below the perfect ones
      - 4a Inflorescence - spike or raceme
        - 5a Spike (Hordeae - barley tribe)
        - 5b Raceme (Chlorideae - grama grass tribe)
      - 4b Inflorescence - panicle
        - 5a Spikelets, 1-flowered (Agrostideae - timothy tribe)
        - 5b Spikelets, 2 - many flowered
          - 6a Glumes shorter than the lowermost floret (Festuceae - fescue tribe)
          - 6b Glumes as long as or longer than the lowermost floret (Aveneae - oat tribe)
  - 2b Glumes obsolete
    - 3a Flowers perfect (Oryzeae - rice tribe)
    - 3b Flowers imperfect (Zizanieae - Indian rice tribe)
- 1b Spikelets, 2-flowered
  - 2a Spikelets not in pairs (Paniceae - millet tribe)
  - 2b Spikelets in pairs
    - 3a Flowers not monoecious (Andropogoneae - sorghum tribe)
    - 3b Flowers monoecious (Maydeae - corn tribe)

*This key is greatly simplified. There are a few exceptions to its general use, but for practical field use it will help to identify some grasses by their floral characters. It should be remembered that two other families look like grass plants, viz., the Juncaceae and Cyperaceae, the rushes and sedges (see F-16).

A. W. Burger
11-4-57

BAND SEEDING OF FORAGE LEGUMES

Throughout the years Illinois farmers have probably experienced more failures in getting stands of forage legumes than of any other crop. The importance of forage legumes in our agriculture is evident from the fact that farmers continue to raise them in spite of numerous failures. There are three main reasons why these seeding failures occur:

1. The seed fails to germinate.
2. The germinated seed fails to grow.
3. Seedlings die following establishment.

The farmer has only limited economical control over weather, disease, and insects. But he can reduce the number of seeding failures by:

1. Using properly inoculated seed having a high germination percentage.
2. Shallow planting of seed at a depth of $\frac{1}{4}$ to $\frac{1}{2}$ inch in a fine, firm seedbed.
3. Building up and maintaining proper lime and fertility levels.
4. Controlling competition from companion crop, weeds, and other species in the seeding mixture.
5. Using herbicides and fertilizers in such a way as to avoid chemical injury.
6. Using adapted winter-hardy varieties.
7. Allowing seedings to build up enough food reserves in their roots to carry them through the winter. (Clipping or grazing new seedings too late in the season or making late summer seedings after September 1 often leads to winterkilling because of low root reserves).

The underlying purpose of the practices outlined above is to produce fast-growing, vigorous seedlings that are better able to withstand unfavorable conditions, such as drought and low winter temperatures.

In the past few years another practice has been much discussed in farm magazines and newspapers and has become a popular subject among farmers. It is band seeding. What is band seeding? Is it the cure-all for seeding failures? What place does it have on Illinois farms?

What is band seeding?

In band seeding the legume seed is sown near the surface of the soil at a depth of $\frac{1}{4}$ to $\frac{1}{2}$ inch in bands or rows about an inch wide directly over bands of phosphate fertilizer placed $1\frac{1}{2}$ inches deep. The idea is that concentrating the fertilizer in a band underneath the row of forage seed will make more of the phosphorus provided by the fertilizer available to the young seedlings and thus enable them to get off to a faster, more vigorous start. Mixed fertilizers or nitrogen or potash fertilizers should not be used in band seeding because of the danger that the fertilizer may injure the seed.

A grain drill with a forage seeder attachment can be adapted for use in band seeding. A flexible tube (such as a piece of garden hose) is attached to each of the outlets of the forage seed box, extended 14 inches to the rear of the disc, and held by a rigid brace about two inches above the surface of the soil so that the forage seed falls in a narrow band behind each of the fertilizer tubes and discs. Special kits for this adaptation are commercially available.

<u>Without this modification the seed will fall in front of the discs and be buried too deep.</u> The drag chains behind each disc should be removed because they also will cause the seed to be buried too deep. The fertilizer is applied through the fertilizer tubes and is placed in a band $1\frac{1}{2}$ inches below the forage seed. If a companion crop is used, the grain is sown $1\frac{1}{2}$ inches deep along with the fertilizer.

Band seeding is not a cure-all

Band seeding is only one method of applying phosphate fertilizer and planting forage seed at the proper depth. It is not a substitute for good seed, proper seedbed preparation, an adequate fertility program, and the other practices outlined previously. Band seeding without using other sound practices is likely to result in seeding failure rather than in the prevention of failures.

Band seeding in Illinois

Most of the reported successes obtained by band seeding have been with late summer and spring seedings with no companion crop. In southern Illinois, where high midsummer temperatures are harmful to spring seedings, many legume seedings are made in August with no companion crop. However, most Illinois farmers prefer to make their spring seedings with a companion crop, either in winter wheat sown the previous fall or oats.

To find out whether band seeding would be a beneficial practice under such situations, a series of experiments were started several years ago by the Agronomy Department. This research is still in progress, but several conclusions can be drawn from the results to date.

Band seeding in the spring with an oat companion crop has neither improved stands nor increased yields. Putting the forage plants into the same row with the companion crop seems to overcome any advantage obtained by putting the forage plants over the banded fertilizer.

The results of late summer seedings with no companion crop are somewhat different, however. The risk of dry weather or drought is considerably greater following a late summer seeding than following a spring seeding. The fertilizer used in band seeding has a starter effect on the young seedlings. It gets them off to a faster, more vigorous growth following germination. Under unfavorable conditions this may mean the difference between their survival and death. Thus band seeding might be considered an insurance practice in late summer seedings.

When sufficient moisture is available to produce a good stand, band seeding apparently does not further increase stand or yield. However, if there is a period of insufficient moisture after the seedlings have started to grow, band seeding may give a better stand and higher yields the next year. Band seeding seems to allow the young seedlings to make better use of the water that is available, but there still must be enough moisture to germinate the seed and start growth.

Farmers who have no trouble in obtaining good stands without using band seeding should not be encouraged to use it. However, those who have experienced a number of seeding failures or poor stands with late summer seedings may find band seeding helpful in obtaining better stands.

A look to the future

Although at present band seeding apparently is limited to late summer seedings in Illinois, continued research may bring about more uses for it. Studies are under way to determine whether band seeding is beneficial when the legume seed and fertilizer are put in bands between the rows of companion crop in spring seedings. Also, there is the possibility that at some future date the use of herbicides may replace companion crops as a means of reducing weed competition. Under these circumstances, band seeding may assume a more prominent role. But even then, as now, it would pay each farmer to keep in mind the points mentioned at the beginning of this article.

S. G. Carmer and J. A. Jackobs
1/13/58

ALFALFA MANAGEMENT IN NORTHERN ILLINOIS

Numerous management studies before 1940 in the Midwest showed that cutting alfalfa before bloom stage, especially first cutting, frequent cutting, and cutting between September 1 and October 20, were very detrimental to productivity and longevity. Bacterial wilt, a root disease of alfalfa, probably affected the results of these trials, because these early studies were made with wilt-susceptible varieties and it is known that anything that reduces the vigor of alfalfa hastens the onset of bacterial wilt.

Wilt-resistant varieties, Ranger, Buffalo, and Vernal, are now available. New management studies are now under way in Illinois to determine whether it is safe to use less conservative management with these varieties than with the old wilt-susceptible varieties.

One such study with Ranger alfalfa was completed at the Northern Illinois Experiment Field at Shabbona in 1957. An excellent stand of Ranger alfalfa was established in 1954 in a companion crop of oats. During the winter of 1954-55, the alfalfa was damaged by heaving. The soil was saturated with water from heavy rains in October 1954, and the plants were lifted out of the ground during periods of freezing and thawing. When the different cutting schedules were started in 1955, the plants were weakened because of this injury.

Twelve cutting schedules were followed in 1955 and 1956. In 1957 all plots were cut on the same schedule, and the differences in yield were considered to be due to the influence of previous management on the vigor of the alfalfa. The cutting schedules were so arranged that it was possible to determine the effect of (1) clipping in early spring to delay maturity of the first cutting; (2) cutting three times instead of two, since early Wisconsin studies had indicated that only a two-cutting schedule should be followed; (3) taking the first cutting at prebloom stage instead of half-bloom stage, because if the crop is used for silage it is desirable to take it early to get better quality feed; and (4) cutting in late September, which is considered a critical time for the plant because it is accumulating reserves for winter.

Data were taken on yield at each cutting; weeds in the hay on August 29, 1956, and June 13, 1957; and relative vigor of the stand on May 3, 1957 (0 = no growth, 9 = 10-inch growth). The effect of spring clipping was as follows:

	Seasonal yield, T/A		
	1955	1956	1957
Spring-clipped	2.44	3.14	4.47
Not spring-clipped	3.42	3.78	4.52

	Vigor	% of weeds	
	5/3/57	8/29/56	6/13/57
Spring-clipped	4.8	47.0	23.3
Not spring-clipped	5.3	23.0	15.8

Spring clipping reduced seasonal yields .98 and .64 ton per acre in years when it was practiced. It apparently had little effect on plant vigor the following spring, because in 1957 there was little difference in yield between plots that had and had not been spring-clipped in 1955 and 1956. However, there were more weeds in the first cutting in 1957. Spring clipping allowed more weeds to grow in the alfalfa in 1956 also, but quality was not greatly affected because the weeds were mostly annual grasses that were readily eaten by livestock.

Performance with the two- and three-cut schedules was as follows:

	Seasonal yield, T/A		
	1955	1956	1957
2 cuts, 1st cut ½ bloom	3.06	3.48	4.93
3 cuts, 1st cut ½ bloom	3.22	3.72	4.36

	Vigor	% of weeds	
	5/3/57	8/29/56	6/13/57
2 cuts, 1st cut ½ bloom	7.2	12.2	16.9
3 cuts, 1st cut ½ bloom	5.0	24.2	22.5

These data show that a two-cut schedule is not practical in northern Illinois, even though the result is fewer weeds and a more vigorous stand. The reason is that seasonal yield is smaller and quality of both cuttings is very low (not shown by these data). The alfalfa becomes too mature before it is cut; by the time it is cut on the two-cut schedule, a high proportion of the leaves have dropped off.

The performance when the alfalfa was cut at prebloom stage and at half-bloom stage was as follows:

	Seasonal yield, T/A		
	1955	1956	1957
3 cuts, 1st cut prebloom	2.53	3.18	4.20
3 cuts, 1st cut ½ bloom	3.22	3.72	4.36

	Vigor	% of weeds	
	5/3/57	8/29/56	6/13/57
3 cuts, 1st cut prebloom	3.7	68.5	19.4
3 cuts, 1st cut ½ bloom	5.0	24.2	22.5

Making the first cutting at prebloom stage instead of at half-bloom reduced yield .69 and .54 ton per acre in 1955 and 1956. It was apparent in 1957 that vigor was reduced. The effect on weed growth in subsequent cuttings was similar to that of spring clipping--it increased weeds in a cutting taken later the same year, but it had little effect on weeds the following year.

The effect of fall clipping on performance was as follows:

	Seasonal yield, T/A		
	1955	1956	1957
Fall-clipped	3.03	3.46	4.24
Not fall-clipped	2.84	3.46	4.76

	Vigor	% of weeds	
	5/3/57	8/29/56	6/13/57
Fall-clipped	4.2	36.0	22.1
Not fall-clipped	6.4	34.0	17.1

The increase in seasonal production in 1955 was due to yield of the fall clipping added to the other cuttings. In 1956 the fall clipping yield apparently just made up the decrease in yield of the cuttings due to clipping the previous fall. The 1957 data indicate that fall clipping slightly reduced plant vigor, but it had little effect on weeds the following year. These data suggest that the critical period may occur later in the season than September into October, as clipping in late September did not seriously reduce the vigor of the alfalfa.

The results of this experiment justify the following conclusions: (1) A two-cutting schedule is not practical in northern Illinois because seasonal yield and quality of the hay are lower than if a three-cutting schedule is followed. (2) Cutting alfalfa any time before first bloom increases the likelihood of weeds in subsequent cuttings that year, and seasonal yield is reduced. The increase in quality of the first cutting, however, may justify cutting in the prebloom stage. (3) Clipping in the spring does not appear to be a practical way to delay maturity of the first cutting.

The effect of fall clipping on subsequent vigor must be studied further before the latest safe cutting date can be determined. Results to date do not warrant recommending cutting later than September 1.

Current Reccmmendations for
Northern Illinois

The following cutting schedule will give a high yield and a good quality of hay and will maintain a vigorous stand of alfalfa:

1. Make the first cutting at an early-bloom stage.
2. Make the second cutting midway between the date of the first cutting and September 1.
3. Make the third cutting as close to September 1 as possible.
4. If there is rank growth on the field by November 1, graze the field enough to keep the alfalfa from being smothered, but leave enough stubble to hold snow through the winter.

J. A. Jackobs
1-20-58

REED CANARYGRASS (PHALARIS ARUNDINACEA)

Reed canarygrass is a warm-weather perennial with wide, smooth, light green leaves and a heavy creeping root system. The seed head is a dense panicle on a seed stem that often reaches a height of five feet. The seed is medium sized, gray-brown, smooth, and shiny.

Because canarygrass is a warm-weather plant, it grows vigorously throughout the warm summer months and recovers rapidly after grazing or mowing; therefore it produces a high yield of forage. It is also winter-hardy and long-lived.

<u>Adaptation</u>. Reed canarygrass is native to the northern corn-belt states and is especially adapted to areas that are too wet for more desirable plants. However, it will also make excellent growth on upland soils that are dry in the summer. Deep-ponded water usually does not injure the plants during the dormant season, but it may kill them if it stays on for long periods during the growing season. Established stands will survive moving overflow water for long periods and heavy deposits of silt.

<u>Use for Pasture, Hay or Silage</u>. This grass can be pastured during the entire grazing season. If properly managed, it will produce a large quantity of succulent, palatable forage during July and August, when most of our cool-weather grasses are dormant. Proper management includes (1) fertilizing annually with nitrogen, plus phosphorus, potash, and lime as needed; (2) keeping growth down to 12 inches or less; and (3) leaving about 10 inches of top growth for the winter.

An example of animal gains on canarygrass pastures is the results of grazing trials on well-drained organic soil in Michigan[1/] from 1953 to 1955, where lambs and ewes grazing on canarygrass gained an average of 267 pounds per acre per year over the three-year period.

Reed canarygrass hay has a feeding value similar to that of timothy. It should be cut in the leafy stage before the seeds form. On upland soils it can be grown with alfalfa and will usually be up even with, or taller than, the alfalfa at each cutting.

A three-year study[2/] was conducted on upland soils at five locations in Indiana in which the forage production of several grass species (brome, timothy, tall fescue, Kentucky bluegrass, and reed canarygrass) grown in association with alfalfa was measured. Results showed that, when two or three cuttings were made, reed canarygrass in nearly all cases excelled the other grasses in yield of forage per acre.

This study also showed that canarygrass made a good companion crop for alfalfa when cut for hay on upland soils. On low, wet soils one-half pound of ladino clover per acre may be seeded with canarygrass. Combining it with a legume or applying nitrogen annually will help to improve the quality of the hay and its protein content.

Canarygrass can also be ensiled successfully. Time of cutting is the same as for hay production. If allowed to wilt one or two hours after cutting, it will

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1/ Michigan State University. Quarterly Bulletin. Vol. 3[illegible], No. [illegible]. November 19[illegible], p. 23[illegible]-23[illegible].

2/ Purdue Agr. Exp. Sta. Circular 34[illegible], "Bromegrass Strains in Indiana." by J. J. Pierre and G. O. Mott.

usually contain the proper amount of moisture (60-70%) to be ensiled.

Special Conservation Uses. Reed canarygrass can be used to control some gullies at a minimum cost. It can also be used as a heavy-duty grass in waterways, along streambanks to prevent landslides and to control weeds, and at the waterline of a pond to prevent erosion damage from wave action.

Variety. Ioreed, a variety that was developed at the Iowa Agricultural Experiment Station, is apparently well adapted throughout the corn belt. Seed obtained from local productive fields has also given good results.

Establishment. Reed canarygrass may be established from seed, small sod pieces or rhizomes, or by using green hay.

Seeding. To seed successfully, prepare a good firm seedbed; use about 8 pounds of new viable seed. Seed shallow ($\frac{1}{4}$-$\frac{1}{2}$") and fertilize as needed in late August or early in spring. Add $\frac{1}{2}$ pound of ladino clover seed per acre on wet land or 8 pounds of alfalfa per acre on upland. Without a companion crop, late August is usually the best date to seed canarygrass. Use of newly harvested seed is recommended because it usually germinates faster and produces a better stand than old seed. For heavy-duty areas, such as grass waterways, double the amount of canarygrass seed and delete the legumes. If weeds compete with the new seedlings, mow them. In a pure stand of canarygrass (no legumes) broadleaved weeds can be controlled by spraying with 2,4-D.

Sprigging. If using rhizomes, cut them into small pieces, cover lightly, about 2 inches, and firm by cultipacking. To do this, (1) plow an established stand shallow, (2) cut with a disk, (3) load with a manure scoop, (4) spread on the new site with a manure spreader, and then (5) disk and pack.

Green Hay Method. Cut green hay when it is $1\frac{1}{2}$ to 2 feet tall and well jointed. The best time is when the soil is too wet for field work and when the site to be established will remain wet for three weeks. Tramp or poke the hay into the mud as soon as possible after it is cut. A large pickup load of hay will treat 500 feet of gully bottom five feet wide. It is not necessary to cover the entire stem; as long as a few nodes are under water or in moist soil at a depth of about 2 inches, new growth will develop.

Seed Production. As a general rule, the seed must be harvested within about 3 or 4 days in late June or loss of seed from shattering may be tremendous. The seed ripens from the top of the head downward. Therefore, combining or harvesting with a header should start as soon as the seed at the top of the head begins to shatter. Using a combine with a high-lift attachment allows fewer leaves to pass through with the seed. Since some seeds will be rather immature, the combine-run material should be dried with a dryer or spread about 4 inches deep on a clean floor or canvas and stirred every 4 to 5 hours until the seed is dry enough not to heat.

Other methods of harvesting can be used. One is to cut with a binder, shock, and thresh when dry. Another is to use a header made from an old binder by building a large hopper on the platform and elevating the sickle bar on the front of the hopper until it is high enough to clip off the seed heads. The heads are carried into the hopper by the reel equipped with belting flaps. When a header is used, seed will finish ripening as it dries in the head, and thus more seed will be saved.

If the seed heads are dried on a tight floor, they can be easily threshed with a thresher or a stationary combine.

Best seed yields (averaging about 150 pounds per acre at the Soil Conservation

Service Plant Material Centers at Ames, Iowa, and Elsberry, Missouri) were obtained when canarygrass was grown in 38-inch cultivated rows. However, broadcast plantings can also be used for seed production.

Annual early spring applications of nitrogen are needed for good seed yields. In 38-inch rows, on good soils, 50 pounds of elemental nitrogen has proved satisfactory. Slightly higher rates are better on broadcast fields.

Seed Cleaning. The seed weighs 44 to 48 pounds per bushel, and it is easy to clean with the common seed cleaners, such as a fanning mill.

J. J. Pierre
Soil Conservation Service
1-27-58

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS

F-31

SERICEA LESPEDEZA

Plants, like soils, have varying capabilities. Sericea has earned a special place as a soil-building and -conserving crop because it will grow on land that is too poor for other agricultural crops.

Sericea, a legume, differs from the common or Korean lespedeza in several ways. First, it is a perennial, making new growth each spring from crown buds in a way similar to alfalfa. New growth later in the summer sprouts from stem buds, as in sweet clover.

Sericea makes its first spring growth later than alfalfa and the clovers. Sericea top growth is upright and often reaches a height of five feet or more. At plant maturity the upright stems are heavy and woody but carry many very leafy short side branches. The roots are the deep, branching, tap-root type and are more fibrous than those of most other legumes.

Uses. In Illinois Sericea is adapted primarily to use as a soil-building crop on poor soils south of Route 50. It tolerates acid soils and will grow on soils that are low in nutrients. Some of the best stands at the Dixon Springs Experiment Station have been established on soils too poor to grow weeds. This does not mean that, once established, Sericea will not respond to lime and fertilizers but, rather, that as a seedling it does not compete strongly with other plants.

Like all legumes Sericea, when properly inoculated, can draw nitrogen from the air and return it to the soil in organic matter. Its deep root system opens up the soil for water to penetrate, and the fibrous roots serve as an excellent soil-holder.

Sericea also holds soil and water and builds up the soil in another way by laying down a heavy leaf mulch. In four years a field of Sericea lespedeza at Dixon Springs, when used only as a seed crop, laid down over 15 tons of oven-dry mulch per acre.

As a hay crop. Sericea has not been widely accepted as a hay crop. Most studies indicate that it is less digestible than alfalfa and is lower in protein and minerals (except phosphorus). Also, it has a high tannin content, making the forage less palatable to livestock. However, proper mowing will improve its quality for feed. Both tannin and crude fiber increase rapidly as the plant grows. Mowing when the plant is 10 to 12 inches high will make the hay finer stemmed and more palatable.

In tests at Dixon Springs Sericea, when cut at the proper stage, produced as much gain on steer calves as did second-cutting alfalfa. Also, high-quality Sericea hay fed to lambing ewes this winter (1957-58) is doing as good a job as alfalfa, Korean lespedeza, or mixed clover hay.

Sericea is more easily cured than most other hays. It is not uncommon to mow and rake the hay in the morning and bale it in the late afternoon. Two or three cuttings can be expected each year. Yields from two cuttings of limed and fertilized Sericea will make 3 to 3 1/2 tons of hay per acre.

As pasture. To give the best yields as pasture forage, Sericea must be managed in such a way that it will not become rank, coarse, and bitter. This will mean periodic clipping if stocking does not keep growth down. Southern experiment stations report that grazing animals will readily consume Sericea clippings.

As a seed crop. Yields of clean seed from fertilized Sericea may be expected to run from 200 to 400 pounds per acre. Yields will be highest when Sericea is grown only as a seed crop and is not mowed or grazed during the year the seed is harvested. Managing it in this fashion, however, makes combining more difficult.

A more acceptable way is to remove one crop for hay and take the second crop for seed, combining the standing plant after a hard frost. This system demands that the first crop be cut early to allow enough time for seed from the new growth to mature. Sericea should be mowed two to three inches above the crowns to leave enough old stem for the new growth to bud.

Seeding. Best stands are obtained on a well-prepared seedbed, such as would be prepared for alfalfa. Broadcast seedings in small grain or on sod are rarely successful. The seedbed can be prepared in April or as soon as danger of frost is past. Broadcast 30 to 40 pounds of scarified seed per acre on a firm seedbed, and cover by pressing with a roller or by harrowing lightly.

Erosion may be severe when a seedbed is worked as finely as is needed for Sericea. On long slopes or in other places where erosion losses may be high, contour strips may be used. Seed one strip one year and another the following year.

The crop should not be grazed or mowed the first year unless it is necessary to clip overtopping weeds. If clipping must be done, clip high to leave enough stem buds for new growth.

Sericea will usually be more successful if seeded by itself than if seeded in mixtures. The reason is that as a seedling it is not able to compete with other grasses, legumes, or weeds. However, once established, it is a persistent, long-lived plant, resisting not only other plant competition, but also insects and diseases. If a grass is to be grown with Sericea, the grass seed can be drilled in the fall or winter after Sericea has been established in the spring.

Fertilizing. As a general rule, do not fertilize the soil before seeding Sericea. Doing so will promote weed growth. Limestone and rock phosphate can, however, be applied ahead of seeding without causing undue competition from weeds. Once established, Sericea will produce higher forage and seed yields if fertilized. Soil tests should serve as a basis for liming and fertilizing. In general, Sericea responds more to phosphorus than to other mineral elements.

Cover crop. Because Sericea lives longer than other common legumes, builds up the soil, resists insects and diseases, and requires little management, it should be an excellent cover crop for land that is taken out of crop production. A mixture of Sericea and fescue should therefore be good to use on land put into the soil bank program in southern Illinois.

H. A. Cate
Dixon Springs
Experiment Station
2-3-58

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS

GRAINS

G-19

LODGING IN SMALL GRAINS

Lodging is the leaning or falling over of the small-grain plant. Varieties that will resist lodging have been the goal of plant breeders for centuries. A variety must stand well to meet the needs of the present-day farmer with his modern harvesting machinery. Some breeding programs put even more emphasis on lodging and disease resistance than on yield itself, because improvement of these two characteristics will in turn stabilize yields.

In one type of lodging the straw breaks a few inches above the ground or sometimes higher. This type occurs most often after the plants are ripe. If it occurs before maturity, while the green leaf sheath is still enveloping the stem, the break or bend occurs below the node. Later, as the plant ripens and the leaf sheath withers and becomes loose around the stem, the break generally occurs above the node. In the second type of lodging the stems lean or bend when the plants are still green. This is the most common type in Illinois and it frequently occurs during a heavy rainstorm. The bending usually starts at the ground.

Ironically, lodging is a rich-soil problem. It is most likely to occur where nitrogen levels are high. Under such conditions the plant produces a relatively small root system in proportion to its top. High soil moisture also increases lodging, and it is more likely to occur in warm, rainy, cloudy seasons.

Cultural practices that increase lodging are high seeding rates and, in spring grains, late seeding dates. When seeding is heavy, the plant stems are smaller in diameter, generally have less internal strengthening tissue, and contain relatively less dry matter per unit of length. This results, indirectly, from a low carbohydrate-nitrogen ratio and directly from the competition for light. Late-seeded spring grains tend to lodge more than early-seeded grains. The higher temperatures during the seedling stage favor top growth but not root formation. The crown internodes elongate rapidly, and such fast growth often causes the plants to be spindly. In Illinois, late planting also favors diseases, which in turn increase lodging and yield loss. In 1957 at Urbana, crown-rust-susceptible oat varieties seeded on May 2 lodged completely and yielded only 24 percent as much as the same varieties seeded on March 29.

Many studies have been made to determine what characteristics a variety needs in order to give it lodging resistance. Stiff straw is not the only cure for lodging; anchorage or root system of the individual plant is also important. The bending often occurs at ground level because the root hold is weak. Varieties with the greatest lodging resistance are often found to have large, widely spreading, rigid roots at the basal nodes. Canadian studies have shown a correlation between root type and stem diameter; i.e., varieties with large stems were found to have large, heavy root systems. Short straw will help small grain varieties to stand, but it may not be genetically linked with lodging resistance. Sometimes tall varieties stand better than short ones. Saline wheat is an example.

Three variety characters most often mentioned by research workers as being helpful in improving standability are large diameter, heavy root development, and disease resistance. There has been disagreement on the association of the following factors and lodging: amount of tillering, height of straw, yield of grain, length of internodes, erectness of leaf, depth of seeding, number of vascular bundles, percent lignin, and percent silicon.

How much can lodging affect yield and quality

Several years ago spring oats were artificially lodged at Urbana to study the effect of time and severity of lodging on yield and test weight. The method used was simply to stretch two-inch mesh wire about 18 inches above the ground and let the oat plant grow through the wire. On the selected lodging date, the wire was gently moved in a horizontal direction until the desired degree of lodging was reached, and then it was refastened. The results are given in the following table:

Table 1.--Yield and Test Weight of Spring Oats Artificially Lodged at Urbana, Illinois, 1952 and 1953

Lodging treatment	Acre yield		Test weight	
	2-yr. average	Compared with erect	2-yr. average	Compared with erect
	bu.	percent	bu.	percent
Erect - no lodging	68.2	100	27.0	100
Lodged 90°, 4 days after heading	43.1	63	21.4	79
Lodged 45°, 4 days after heading	58.8	86	25.6	95
Lodged 90°, 20 days after heading (hard dough stage)	56.3	83	25.7	95
Lodged 45°, 20 days after heading (hard dough stage)	66.1	97	26.4	98

It is apparent from these data that lodging affects both yield and quality of grain. It should also be pointed out that these plots were hand-harvested; if a combine had been used, the differences would probably have been even greater. The earlier the lodging occurred and the greater the degree of severity, the greater was the reduction in yield and test weight.

Such lodging data are also helpful in explaining why oat varieties that differ in maturity sometimes perform differently from one year to the next and also why varieties may rank one way in one test and differently in another test the same year. A farmer may plant a new oat variety that has a good performance record and yet, because of lodging caused by a thunderstorm, be very much disappointed in its yield and test weight.

How to minimize lodging

1. Seed a disease-resistant variety that has stood well in performance trials.

2. Use a lighter than normal seeding rate on highly fertile soils.

3. Seed spring grains early.

4. Go easy on nitrogen. Fertilizing with nitrogen will be profitable on many soils, but be reasonable with the rate.

5. On fertile soils, grazing or clipping will retard plant growth, reduce height, and thereby reduce lodging. Generally, clip 3 or 4 inches above the ground, and do it when the grain is about 9 or 10 inches high. Prolonged grazing or a delay in clipping is likely to reduce yields; extent of the reduction will depend on subsequent weather. Cool weather will encourage growth of tillers and minimize yield reduction.

In conclusion, lodging is the result of tremendous physical forces on the small grain plant. It is not difficult to imagine how we ourselves would fare in a June thunderstorm if one-third to one-half of our total weight were located above our shoulders and we were standing on one leg.

J. W. Pendleton
3-31-58

SOIL FERTILITY AND TESTING

AGRONOMY FACTS

SF-50

FIXATION OF AMMONIUM IN SOILS

When potassium is added to the soil, part of it goes into the interior of the clay particles and is no longer immediately exchangeable. This potassium is called the storehouse form because it is only removed slowly by plants.

The ammonium ion (NH_4^+) is positively charged and reacts with clay minerals in much the same way as the potassium ion (K^+). Both are fixed by clay minerals because they become trapped in the voids (pits) making up the skeletal framework of the clay. Other cations in the soil, such as Na^+, Ca^{++}, and Mg^{++}, are not fixed because they are either too large to fit into the voids or they are so small that they move freely in and out of them. Potassium and ammonium fit snugly and are therefore not readily exchangeable.

With the increased use of ammonium fertilizers, more information about ammonium fixation is needed. The questions that need to be answered are (1) how much naturally occurring fixed ammonium soils contain, (2) how much of the nitrogen in ammonium fertilizers becomes fixed by clay minerals, and (3) how available the fixed ammonium is to plants.

Naturally Occurring Fixed Ammonium

The available forms of nitrogen in soils are ammonium and nitrate. Ammonium is produced in soil as a by-product of the decomposition of soil humus by microorganisms. Under ordinary conditions the nitrifying organisms convert the ammonium to the nitrate form.

Part of the ammonium produced from organic matter becomes fixed by the clay minerals. A recent study has shown that nearly all of the soils in Illinois contain some naturally occurring fixed ammonium. The amounts vary from zero to 250 pounds per acre. About 5 percent of the nitrogen in surface soil and as much as 50 percent of the nitrogen in subsoil occurs as fixed ammonium. The level of naturally occurring fixed ammonium in any given soil remains fairly constant from year to year, indicating that as it is utilized by plants a similar amount becomes fixed from ammonium produced through the decay of organic matter.

Ammonium-Fixing Capacity of Soils

The clay minerals that are primarily responsible for fixing ammonium are illite, vermiculite, and montmorillonite. The amount of ammonium fixed by soil depends on the relative amounts of these minerals that are present. Soils that contain predominantly vermiculite clay minerals fix considerable amounts of ammonium, whereas soils that contain predominantly illite clay minerals fix moderate amounts. When the main clay mineral is montmorillonite or kaolinite, the soil fixes only small amounts of ammonium.

The ammonium-fixing capacity of the soil also depends upon the amount of potassium that is present. If the soil contains a high amount of potassium, the fixing capacity will have already been satisfied by potassium. This means that very little ammonium will be fixed by a soil that has recently received a heavy application of potassium.

The ammonium-fixing capacity of Illinois soils vary widely from only a few pounds to several hundred pounds per acre, depending on the type and amount of clay minerals that are present and on the levels of storehouse and exchangeable potassium. For a single application of an ammonium-containing fertilizer, high values for fixation are not generally obtained. But some accumulation may occur through repeated additions. This nitrogen cannot be regarded as lost to the plant because most of it will become available eventually.

The fixation of ammonium by clay minerals must be considered a favorable effect. Fixation prevents nitrogen from being lost through leaching or denitrification. The possibility that significant amounts of fertilizer ammonium would be permanently lost for plant growth through fixation is extremely remote.

Availability of Fixed Ammonium to Plants

Information on the availability of fixed ammonium to plants under field conditions is extremely sparse. Present evidence is that most of it becomes available during the first growing season.

Potassium acts as a lock on the clay minerals and prevents the release of fixed ammonium to nitrifying organisms and plants. This means that, if potassium is added to the soil immediately after an ammonium-containing fertilizer is applied, any ammonium that is fixed would be temporarily unavailable to the plant. Many of our soils have such low ammonium-fixing capacities that this reaction has no practical significance. However, a number of soils in the state, such as the Harpster, are suspected of having high ammonium-fixing capacities, and some tie-up of ammonium is possible.

The blocking effect of potassium on the uptake of fixed ammonium by plants may prove to be desirable. It may be possible to increase the efficiency of ammonium fertilizers on some Illinois soils by following the application of an ammonium-containing fertilizer with a dressing of potassium. The potassium would prevent some of the ammonium from being lost through leaching or denitrification, and yet the nitrogen would become slowly available as the plant used the potassium.

Research is now under way in an attempt to evaluate the importance of ammonium fixation to Illinois agriculture. Work that has been done so far indicates that this process may be of considerable importance in some soils. The results have also shown that there is no need to be alarmed about the use of ammonium-containing fertilizers on Illinois soils. As indicated earlier, the fixation of ammonium should be considered a positive effect.

Only through a complete understanding of the reactions of nitrogen in soils will it be possible to formulate a sound program of nitrogen fertilization. Research can provide the answers.

F. J. Stevenson
12/30/57

AGRONOMY FACTS

SF-51

CHLORIDES IN STARTER FERTILIZER

There appears to be growing concern about the use of chlorides in starter fertilizer for corn. The chloride is added as KCl, or muriate of potash—the cheapest and most widely used potassium fertilizer. The high concentration of chloride in the band of starter fertilizer is believed to cause a rapid uptake of chloride by the young roots, with a concomitant diminution in the uptake of other anions, particularly phosphate. This impaired phosphate uptake may reduce both growth and yield. Concern about this possibility is sufficiently great that serious consideration is being given to the use of the more expensive sulfate salt as a potassium carrier, or to elimination of potassium from row fertilization.

In this country fertilizer experiments with chloride salts go back to the first part of this century, but few definite conclusions can be drawn from them. In terms of yield, most crop plants seem not to be affected by moderate chloride fertilization, a few seem to be adversely affected, and some others (notably root crops like sugar beets) show increases in yield. In general, however, grain crops are not affected or show small yield increases.

Chloride has the general effect of increasing the succulence or "wateriness" of plant tissue, and in moderately high quantities it is reported to alter the carbohydrate metabolism of some crops. Low chloride fertilizers are usually recommended for tobacco and potatoes because of quality considerations based on water, carbohydrate, and organic acid content.

Generally speaking, agronomists consider that normal broadcast applications of KCl will not produce high chloride concentrations in the soil. Very little chloride is bound to soil constituents and the ion tends to leach through the profile. The amount of chloride in productive soils varies widely—between 50 and 400 pounds per acre-foot. Precipitation adds from 5 to 30 pounds of chloride per acre each year. This addition results from the fact that the hygroscopic nuclei on which atmospheric moisture condenses to form raindrops are largely sea salt.

The soil must have a small amount of chloride to produce plant growth. Broyer and co-workers in California have established that chloride is an essential element. However, chloride proves to be a micronutrient, and no areas of soil deficiency are known.

Most crop plants will contain chloride in excess of the minimum requirements. The physiological and biochemical role of the ion is not yet established.

Chloride is rapidly accumulated by plant roots. If the external concentration is high, large amounts of the ion will be found in the tissue. Different crop plants, however, exhibit different capacities for accumulation; tobacco, for example, has been noted to accumulate large amounts, while corn in comparison takes up little. Such differences in relative ion uptake are quite common and apply to all the nutrient ions. Plants have only limited control over ion accumulation, however, and most ions that are present in high concentration will be rapidly absorbed.

The bulk of the accumulated chloride is to be found in the cell sap, or vacuole (see Figure 1). The vacuole is separated from the living substance (cytoplasm) of the cell by a membrane. In addition to inorganic ions, the cell sap contains sugars and other organic compounds. For each negatively charged ion (anion), such as chloride, in the sap, there is a

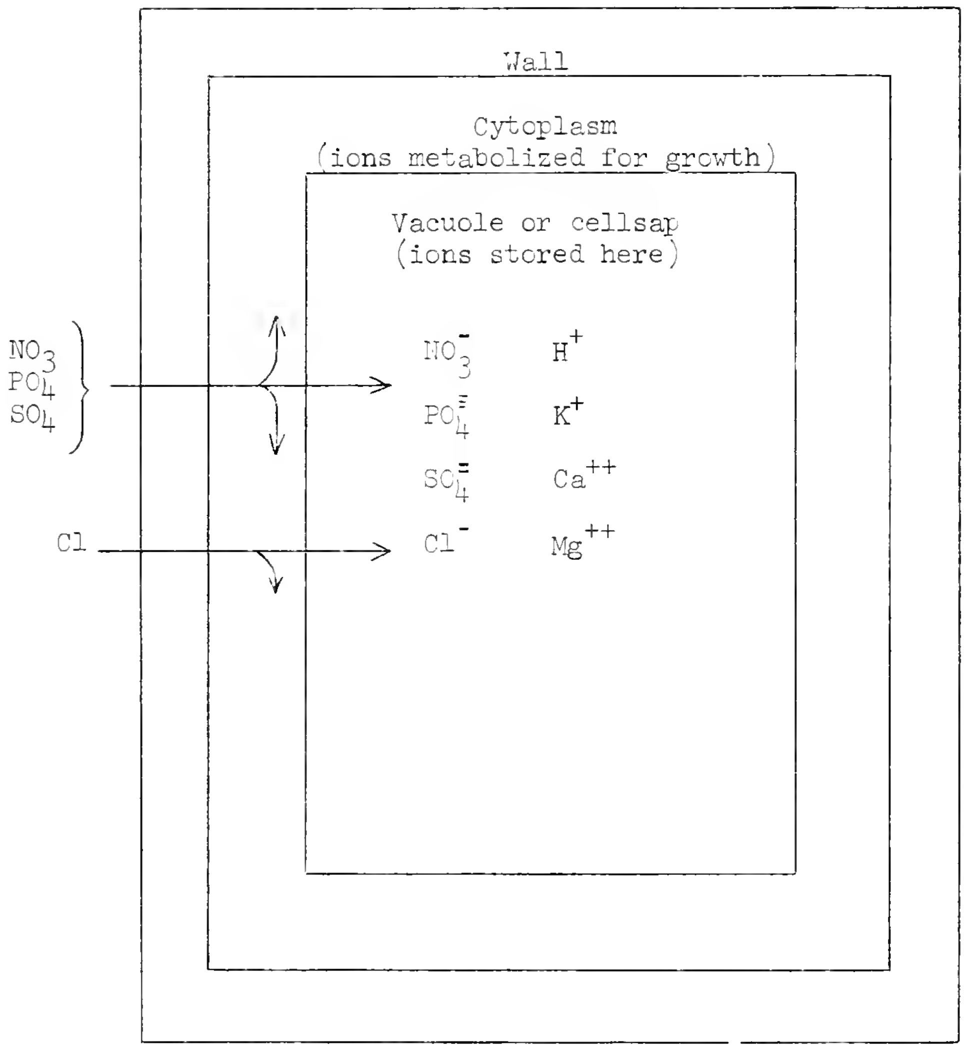

Figure 1. Diagram of Plant Cell

positively charged ion (cation) to maintain electrical neutrality. When excess cations accumulate, the cell maintains neutrality by secreting organic acids in the sap. Conversely, when an anion like chloride is rapidly taken up, the balance is maintained with the hydrogen ion (H^+). The increase in hydrogen ion makes the sap more acid. Increasing the concentration of chloride in the soil nearly always makes the plant sap more acid.

The fact that chloride can be accumulated in high concentrations has many times brought up the question of the effect of the excess ion on plant growth. Is the excess metabolically inert, or does it exert a toxic effect? The chloride ion in itself is not known to be toxic to plants. It does not specifically block or inhibit enzymatic reactions as does the related fluoride ion. On the contrary, as previously mentioned, small amounts of chloride are necessary for plant metabolism. Excess amounts in the cell sap seem to be inocuous. Only when the concentration of chloride salts in the soil solution reaches salinity levels are there deleterious effects on growth (see Figure 2).

An extremely high soil concentration of any salt has two effects on the plant: soil moisture is made less available because of increases in osmotic pressure,

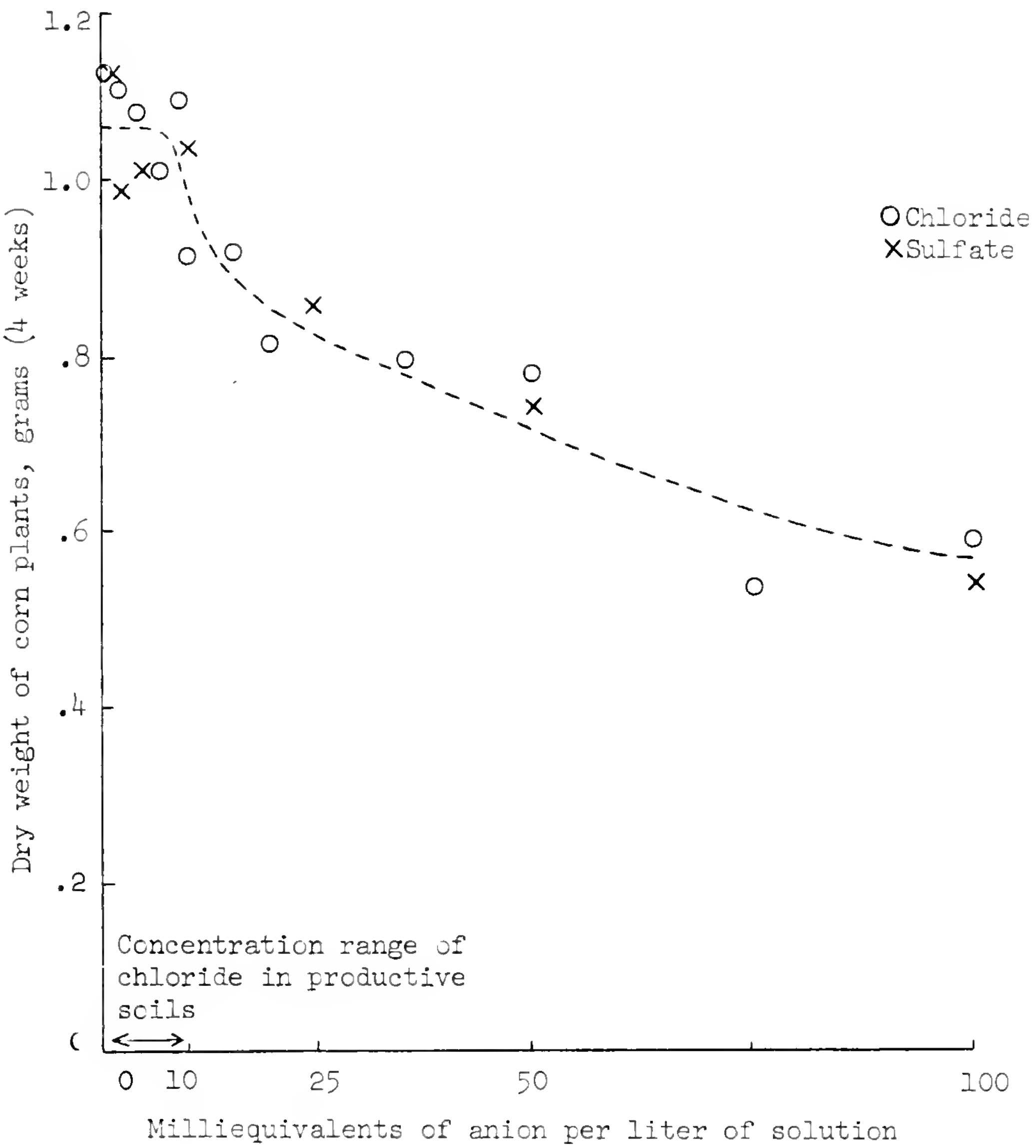

Figure 2. Growth Response of Corn Plants to Increasing Chloride and Sulfate

and the cytoplasmic colloids tend to be adversely altered. It should be emphasized, however, that this phenomenon is general for all salts. Inasmuch as chlorides are more soluble in most soil solutions and are more rapidly accumulated than sulfates, the chlorides may be somewhat more deleterious, but the difference is not great.

Localized saline conditions are produced in the soil when large amounts of soluble starter fertilizer are concentrated in a band. If young roots are forced to grow directly into areas of high salt concentration, growth will be retarded. Because of their high solubility, chloride salts can contribute heavily to this type of damage. Ideally, starter fertilizer should be placed 1 1/2 to 2 inches to the side and below the seed so that the emerging roots will not grow directly into the fertilizer band, but will contact areas adjacent to the fertilizer salts where the concentration is favorable.

Attempting to supply the entire nutrient needs of a crop by starter fertilization is an unrealistic practice. A wide and deep root system is required for good water economy, and this will be best secured if the growing roots continually contact new supplies of needed nutrient ions. While it is true that the plant can internally redistribute ions absorbed in a favorable root zone to the roots growing in a less favorable zone, the root growth will not be vigorous in these infertile zones. Hence, while starter fertilizer provides a zone of high nutrient concentration for vigorous early growth, too great dependence upon this method of fertilization may lead to difficulties.

Investigations of the effect of chloride on phosphate accumulation have given conflicting results. In general, analyses of the cell sap or leaf tissue tests that depend largely on sap concentrations show that chloride depresses phosphate uptake. On the contrary, almost all analyses of leaf tissue show that chloride has had no effect on total phosphate concentration. It is believed that this discrepancy can be resolved by referring again to Figure 1. The major nutrient anions (nitrate, phosphate, and sulfate), upon entering the cell, are immediately subject to metabolism in the cytoplasm. They are rapidly incorporated into the organic compounds of the cell. The rate at which they are incorporated is a function of external concentration, not the internal concentration of the cell sap.

To be sure, part of the entering nutrient anions are secreted into the sap; and when other variables are constant, the sap concentration will reflect the external concentration. When large amounts of chloride are accumulated, however, the nutrients must compete for occupancy of the vacuole, and the sap concentration of phosphate will be reduced. Sap analyses will then show less phosphate. This reduction will not appreciably affect the metabolism of phosphate in the cytoplasm, however, because the chloride ion does not accumulate in the cytoplasm. Since tissue phosphate is largely organic, total phosphate analyses will show little effect of high chloride accumulation in the sap.

It might be well to point out here that the potassium ion in muriate of potash can itself cause difficulties. Potassium is the most rapidly accumulated of any nutrient cation. In addition, it possesses a reciprocal relationship with the divalent ions calcium and magnesium. If the root accumulates excess potassium because of high soil concentrations, the uptake of calcium and magnesium will fall correspondingly. With high K/Ca ratios in the plant, vegetative growth of corn is vigorous and succulent, but yield may sometimes be reduced. This problem has not yet been adequately explored and few soils are so high in potassium as to make the difficulty widespread, but it is well to remember that the chloride in heavily banded muriate of potash is not the only potential source of trouble.

With respect to practical recommendations, some generalizations can be made. If a soil is quite deficient in potassium and large amounts of potash are needed, the KCl should be broadcast. High concentrations of any soluble salt too near young seeds can lead to nutrient imbalance and salinity effects. Maintenance levels of K can be partly applied as starter fertilizer with good effect. Judging from most reports, it will make no difference whether chloride or sulfate of potash is applied so long as the rates do not exceed the equivalent of 40 pounds of K_2O per acre. With proper equipment for banding the fertilizer to the side and below the seed, up to 80 pounds per acre could be applied. Some reports indicate that at these high rates the less soluble sulfate salt might be slightly preferable, but the difference in yield is small.

J. B. Hanson
2-19-58

AGRONOMY FACTS

SF-52

INOCULATION OF LEGUMINOUS CROPS

In general, nodule bacteria isolated from a plant in a particular group, such as the Alfalfa Group, will form nodules on the plants within that group but will not form nodules on plants in the Red Clover Group. There are some exceptions to this general statement because some strains (selections) in one group will produce nodules on plants in another group, at least under controlled greenhouse conditions.

Another important condition is effectiveness in nitrogen fixation. Strains of nodule bacteria differ greatly in their ability to fix nitrogen in association with a particular leguminous crop. Some strains are highly effective, whereas others are ineffective. Fortunately, most producers of commercial legume inoculants sell only the effective strains.

The effectiveness of strains of the nodule bacteria varies with the crop species in the group with which it is used. For example, some strains of "clover bacteria" may work efficiently with red and white clover but not with crimson clover.

The value of inoculating leguminous crops depends upon several conditions. One condition is the use of suitable inoculants. There are several different kinds of nodule bacteria, classified according to the plants which they nodulate. Erdman of the United States Department of Agriculture in Farmers' Bulletin 2003 classifies the nodule bacteria on the basis of their nodule-forming function as follows:

ALFALFA GROUP

Common name	Scientific name	Common name	Scientific name
Alfalfa	Medicago sativa	Tifton bur-clover	M. rigidula
Buttonclover	M. orbicularis	Yellow alfalfa	M. falcata
California bur-clover	M. denticulata	White sweetclover	Melilotus alba
Spotted bur-clover	M. arabica	Hubam sweetclover	M. alba annua
Black medic	M. lupulina	Yellow sweetclover	M. officinalis
Snail bur-clover	M. scutellata	Bitterclover (sour-clover)	M. indica
Tubercle bur-clover	M. tuberculata	Fenugreek	Trigonella foenumgraecum
Little bur-clover	M. mimina		

CLOVER GROUP

Alsike clover	Trifolium hybridum	Zigzag clover	T. medium
		Ball clover	T. nigrescens
Crimson clover	T. incarnatum	Seaside clover	T. willdenovii
Field hop clover	T. agrarium	Lappa clover	T. lappaceum
Small hop clover	T. dubium	(No common name)	T. michelianum
Rabbitfoot clover	T. arvense	Puff clover	T. fucatum
Red clover	T. pratense	Large hop clover	T. procumbens
White clover	T. repens	Persian clover	T. resupinatum
Sub clover	T. subterraneum	Carolina clover	T. carolinianum
Strawberry clover	T. fragiferum	Rose clover	T. hirtum
Berseem clover	T. alexandrinum	Buffalo clover	T. reflexum
Cluster clover	T. glomeratum	Hungarian clover	T. pannonicum

SOYBEAN GROUP

Common name	Scientific name	Common name	Scientific name
All varieties of soybeans	Glycine max (Soja max)		

PEA AND VETCH GROUP

Common name	Scientific name	Common name	Scientific name
Field pea	Pisum arvense	Purple vetch	V. atropurpurea
Garden pea	P. sativum	Monantha vetch	V. articulata
Austrian Winter	P. sativum (var. arvense)	Sweet pea	Lathyrus odoratus
Common vetch	Vicia sativa	Rough pea	L. hirsutus
Hairy vetch	V. villosa	Tangier pea	L. tingitanus
Horsebean	V. faba	Flat pea	L. sylvestris
Narrowleaf vetch	V. angustifolia	Lentil	Lens culinaris (esculenta)

COWPEA GROUP

Common name	Scientific name	Common name	Scientific name
Cowpea	Vigna sinensis	Pigeonpea	Cajanus cajan (indicus)
Asparagus-bean	V. sesquipedalis		
Common lespedeza	Lespedeza striata	Guar	Cyamopsis tetragonoloba
Korean lespedeza	L. stipulacea		
Sericea lespedeza	L. cuneata	Jackbean	Canavalia ensiformis
Slender bushclover	L. virginica		
Striped crotalaria	Crotalaria mucronata	Peanut	Arachis hypogaea
		Velvetbean	Stizolobium deeringianum
Sunn crotalaria	C. juncea		
Winged crotalaria	C. sagittalis	Lima bean	Phaseolus lunatus (macrocarpus)
Mat bean	Phaseolus aconitifolius		
		Adzuki bean	P. angularis
Florida beggarweed	Desmodium tortucsum	Mung bean	P. aureus
		Tepary bean	P. acutifolius var. latifolius
Tick trefoil	D. illinoense		
Hoary tickclover	D. canescens	Partridge-pea	Chamaecrista fasciculata
Kudzu	Pueraria thunbergiana		
		Acacia	Acacia linifolia
Alyceclover	Alysicarpus vaginalis	Kangarro-thorn	A. armata
		Wild-indigo	Baptisia tinctoria
(No common name)	Erythrina indica	Hairy indigo	Indigofura hirsuta

BEAN GROUP

Common name	Scientific name	Common name	Scientific name
Garden beans, kidney bean, Navy bean, pinto bean	Phaseolus vulgaris	Scarlet Runner bean	P. coccineus (nultiflorus)

LUPINE GROUP

Common name	Scientific name	Common name	Scientific name
Blue lupine	Lupinus angustifolius	Sundial	L. perennis
Yellow lupine	L. luteus	(No common name)	L. diffusus
White lupine	L. albus	(No common name)	L. villosus
Washington lupine	L. polyphyllus	Serradella	Ornithopus sativus

In addition to these seven groups, the following leguminous crops appear to require specific strains of bacteria for effective nodulation:

Birdsfoot trefoil	Lotus corniculatus	Hemp sesbanis	Sesbania exaltata
Big trefoil	L. uliginosus	Sanfoin	Onobrychis vulgaris (sativus)
Foxtail dalea	Dalea alopecuroides	Crown vetch	Coronilla varia
Black locust	Robinia pseudoacacia	Siberian pea-shrub	Caragana arborescens
Trailing wild bean	Strophostyles helvola	Garbanzo	Cicer arietinum
		Leadplant	Amorpha canescens

The benefits to be obtained from inoculation are greatest where good leguminous seeds are planted, efficient cultures of the right group of bacteria are used, and soil conditions are favorable for growth of the leguminous crop.

O. H. Sears
4/7/58

IMPORTANCE OF NODULATION

The main purpose in inoculating leguminous crops is to insure nodule formation with an efficient strain of bacteria. Several benefits can be derived from good nodulation. Foremost among them, from the farmer's viewpoint, is an increase in yield and profits. A second benefit is that nodulation enables the crop to obtain part of its nitrogen supply from the air and thus contributes to the nitrogen resources of the soil. A third benefit is that it increases the protein content of both hay and seed.

Previous investigations with soybeans had shown that inoculation (with nodulation) increased yield, where the nodule bacteria were not present already, from a few percent up to 300 percent or more, depending on the nitrogen fertility of the soil. While these investigations indicated the importance of inoculation, they did not show conclusively how much the nodule bacteria contributed to yield because, under field conditions, even uninoculated beans bear some nodules. It was only recently that a new tool was found that made it possible to evaluate more accurately the efficiency of nitrogen fixation by the soybean nodule bacteria and their host plant. We are indebted to Dr. L. F. Williams, formerly of the United States Regional Soybean Laboratory, for this tool.

In his breeding studies Doctor Williams selected two sister strains from a cross between Lincoln x (Lincoln x Richland). One of these selections, designated here as a nodulating selection, is abundantly nodulated under favorable conditions; whereas the other, designated as a non-nodulating selection, is completely void of nodules under the same conditions.

When supplied with a source of available soil nitrogen, these selections have equal yielding ability and are similar in all respects except in susceptibility to infection by nodule bacteria. Thus, through the use of these two selections, it was possible to get exact information on the benefits derived from association of the soybean nodule bacteria with the host plant.

Method of Study

The two selections were inoculated with the same strain of nodule bacteria and then seeded in alternate rows on five blocks of soil that differed mainly in their nitrogen fertility level. (They had all been limed and phosphated and, by soil test, were well supplied with potassium.)

The differences in nitrogen-supplying power were shown by the differences in color of the plants as well as by yields of the two selections.

The treatments on these soils which produced differences in the nitrogen fertility level are given in Table 1.

Table 1. Soil Treatment Practices

Block	Previous treatment	Additional treatment
I	Birdsfoot trefoil green manure crop	NH_4NO_3 300 lb. per acre
II	Same as Block I	None
III	Grass sod fertilized with $(NH_4)_2SO_4$	None
IV	Grass sod--no nitrogen fertilizer	None
V	Same as Block IV	5 tons oat straw mulch

The NH_4NO_3 was applied in order to be sure that nitrogen was not a limiting factor in the growth of the non-nodulating selection. It was necessary to establish the fact that, if given sufficient available nitrogen, the two selections would have the same yielding ability.

The straw mulch was used in order to lower the available nitrogen supply in Block V. Previous experiments had shown that soluble organic matter of straw was leached into the soil during rains and that this soluble organic matter stimulated nitrate-assimilating microorganisms which decreased the supply of available nitrogen. Nearly two inches of rain fell on these plots soon after mulching.

When the beans started to develop yellow leaves about the middle of September, some of the beans, including the roots, were harvested for chemical analyses. Others were permitted to ripen and were harvested for seed.

Results. The yields of the two soybean selections are given in Table 2.

Table 2. Yields of Soybeans on Soils of Different Nitrogen Fertility Levels

Block	Soybean selection		Gain for nodule bacteria
	Nodulating	Non-nodulating	
	bu./A	bu./A	bu./A
I	38.6	38.3	0.3
II	36.2	33.0	3.2
III	36.6	33.1	3.5
IV	36.0	29.2	6.8
V	35.5	20.9	14.6

In inspecting these data, one should remember that, even though both selections were inoculated, the non-nodulating strain bore no nodules, whereas the nodulating strain was nodulated, and that, as the nitrogen fertility level of the soil decreased, the extent of nodulation increased.

The consistency of the yields of the nodulated selection is apparent and suggests that under the conditions of this experiment the bacteria were able to take care of the nitrogen needs of the crop. Comparison of the yields on Block I, where nitrogen fertilizer, in addition to a leguminous green manure, was used indicates that the two selections have equal yielding ability where available nitrogen is present.

An inspection of the column giving the gains for the nodule bacteria indicates that, as the nitrogen fertility of soil declines, the value of the bacteria increases. Thus the greatest benefit is derived on soils with low nitrogen-supplying power, provided other plant nutrients are present. Also, it may be concluded that the use of nitrogen fertilizers may cancel the effect of nodulation. From a monetary standpoint, however, few farmers would wish to substitute nitrogen fertilizers for nodulation.

These data show only the value of the nodule bacteria and not the value of inoculation. The importance of inoculation depends not only on the nitrogen fertility of the soil, but also on the presence or absence of efficient bacteria in the soil.

Of even greater importance is the information obtained in this experiment on the proportion of nitrogen in the crop that is taken from the air. These data give an insight into the contribution to soil nitrogen balances that soybeans make under field conditions.

Present-day textbooks on soils and on crops state that two-thirds of the nitrogen of nodulated leguminous crops is secured from the air and one-third from the soil. This statement originated with Dr. C. G. Hopkins in 1902 in Illinois Bulletin 76 and has been repeated often. He arrived at this value by harvesting the tops of alfalfa and determining the nitrogen content of inoculated and uninoculated plants. Since that time many investigators have studied the amount of nitrogen fixed by nodulated leguminous crops with widely varying results.

The unique part of this soybean experiment is the comparison of an unnodulated leguminous crop with a similar nodulated selection under field conditions. The data for nitrogen fixation are presented in Table 3.

Table 3. Nitrogen Fixation by Soybean Nodule Bacteria in Association With the Host Plant

Block	Total nitrogen: Nodulating selection	Total nitrogen: Non-nodulating selection	Nitrogen from air
	lb./A	lb./A	perct.
III	199	158	21
IV	192	102	47
V	177	65	63

The results show that the proportion of nitrogen secured from the air by nodulated soybeans varies with soil conditions. On land that is low in available nitrogen, provided other available nutrients are present, about two-thirds of the nitrogen is air-derived. On the other hand, where available nitrogen is plentiful, only a small percentage of nitrogen is drawn from the air. Thus the soybean crop is capable of expressing its full hereditary possibilities even in soils that are low in nitrogen if it is nodulated by efficient nodule organisms and other limiting factors are removed.

Under what conditions may one expect soybeans to secure a large proportion of their nitrogen from the air? While it is impossible to pin-point the answer, a comparison of the amount of nitrogen secured from the soil by the non-nodulated beans with the amount in a corresponding corn crop may be of interest. This comparison is given in Table 4.

Table 4. Soil Nitrogen Removed by Non-nodulating Selection and Estimated Corn Crop Which Soil Would Produce

Block	Nitrogen removed by non-nodulating selection	Estimated corn yield
	lb./A	bu./A
III	158	105
IV	102	68
V	65	43

This estimate, and it is an estimate only, assumes that 1.5 pounds of available soil nitrogen will be sufficient to produce a bushel of corn and that the corn crop can secure the same amount of nitrogen from the soil as the non-nodulated soybean crop. If this assumption is reasonably accurate, one can conclude that, on land having a nitrogen fertility level adequate to grow about 40 bushels of corn an acre, nearly two-thirds of the nitrogen requirement of soybeans will be obtained from the air. On land having a nitrogen fertility level sufficient to grow 100 bushels of corn, only one-fifth of the nitrogen in the nodulated soybean crop will be air-derived.

It is not unreasonable to project these values in estimating the effectiveness of other legumes and their associated nodule bacteria in fixing nitrogen. These data suggest that the amount of nitrogen taken from the air will depend upon the available nitrogen-supplying power of the soil as well as the kinds of legume, the method of use, and the nitrogen-fixing efficiency of the particular nodule bacteria.

Thus it would appear that natural processes set a ceiling on nitrogen accumulation for each environment and that, as the nitrogen content of the soil approaches this ceiling, it becomes more difficult for nodulated legumes to add nitrogen to the soil.

O. H. Sears
4-21-58

AGRONOMY FACTS

SM-19

DEEP TILLAGE AND DEEP FERTILIZATION OF CLAYPAN SOILS

Results and general conclusions from some experiments on deep tillage are given in Agronomy Facts SM-11 (1953). Our purpose here is to report on two studies of deep tillage and deep fertilization started in recent years on two southern Illinois claypan soils.

The first experiment was started in September 1953 on Cisne silt loam, a claypan soil developed under prairie vegetation, at the Brownstown soil experiment field.

Two depths of tillage were used, 18 inches (deep) and 6 to 8 inches (regular). All deep plots were mixed to 18 inches in 1953. Since then the deep plots have been plowed 18 inches ahead of each corn crop.

Original soil treatment (1953) of 12 tons of limestone and 2 tons of rock phosphate was mixed to the 18- and the 6- to 8-inch depths.

Since 1953, 165 pounds of 0-0-60 per acre have been applied ahead of each corn and each wheat crop. Superphosphate (0-20-0) has been drilled at the rate of 200 pounds per acre with each wheat crop.

The rotation on the plots is corn, soybeans, wheat, and mixed hay.

As shown in the following table of yields, there are no pronounced differences between regular (6 to 8 inches) plowing and fertilization and deep (18 inches) plowing and fertilization to date.

Crop Yields Each Year (Average of Three Replications)

Year	Corn		Soybeans		Wheat		Hay	
	Regular	Deep	Regular	Deep	Regular	Deep	Regular	Deep
	bu.	bu.	bu.	bu.	bu.	bu.	T.	T.
1955	46.7	43.3	23.7	23.5	49.9	48.[illegible]	2.28	2.19
1956	100.3	95.2	32.0	31.0	65.[illegible]	68.3	2.65	2.62
1957	Wet*	Wet*	26.2	24.5	3[illegible].2	30.7	2.84	2.70

*Crop failure because of excess rainfall.

The second experiment was started in August 1955 on Weir silt loam, a claypan soil developed under forest vegetation, at the Southern Illinois Cooperative Agronomy Research Center at Carbondale. The Illinois Agricultural Experiment Station and Southern Illinois University cooperated in this study.

Four depths, 9, 18, 27, and 36, inches, of tillage or mixing were used. The soil was thoroughly mixed to these depths and not merely stirred. The Caterpillar Tractor Co., Peoria, Illinois, furnished the equipment and manpower for the mixing operations under the supervision of Mr. Jack Diamond. Mixing to the 9-inch depth was done with an ordinary plow and disk; to the 18-inch depth, with a disk plow; and to the 27- and 36-inch depths, with heavy road-working machinery. At the 27- and 36-inch depths, the soil was entirely removed, fertilized, and thoroughly mixed, and then returned to its original place.

Four rates of treatment were established. The lowest rate (F1), consisting of 9 tons of limestone, 3,630 pounds of 0-20-0, and 1,452 pounds of 0-0-60 per acre, represents the treatment needed according to soil tests for the total 36 inches of soil. The F2, F3, and F4 rates are two, three, and four times the F1 rate respectively. Check plots (F0) receiving no fertilizer or lime and mixed only to 9 inches were also set up. The check plots, like all other plots, did receive nitrogen at the rate of 200 pounds of N per acre as plow-down in the spring of 1956 and 1957.

Studies of clay content, bulk densities, and moisture-holding and moisture-storage capacities of the mixed zones indicated that reasonably good mixing was obtained. Mixing of some of the clay from the claypan or subsoil with the silty surface soil increased the moisture-holding capacity, but it also increased the amount of moisture held too tightly for plants to use. Thus it left the available moisture-storage capacity about the same as that of the natural, unmixed soil.

U. S. 13 Hybrid corn was grown on all plots in 1956 and 1957, and yields in bushels per acre are given in the table below.

Corn Yields for 1956 and 1957 in Bushels per Acre

Mixing depths	Fertilizer rates F0 1956	F0 1957	F1 1956	F1 1957	F2 1956	F2 1957	F3 1956	F3 1957	F4 1956	F4 1957
9 inches	57	61	106	92	93	81	89	49	77	36
18 "	78 1/	84 1/	109	106	102	86	91	63	86	70
27 "	35 2/	82 2/	93	100	114	96	105	85	101	82
36 "	51 3/	90 3/	109	101	109	102	104	100	108	101

1/ On this plot the F2 rate was all applied to the surface 9 inches.
2/ " " " " F3 " " " " " " " " "
3/ " " " " F4 " " " " " " " " "

With only two years' results nothing definite can be concluded, but to date it can be said that depth of mixing of the soil had no significant effect irrespective of fertilizer treatment. At the F1 rate, depth of placement of fertilizer had no apparent significant effect. At the F3 and F4 rates, there were significant decreases in corn yields in 1956 where all of the materials were applied in the surface 9 inches of plots mixed to depths greater than 9 inches. Similar decreases did not occur in 1957 on these same plots.

Yields tended to decrease with increased rate of fertilization at mixing depths of 9 and 18 inches in 1956 and at mixing depths of 9, 18, and 27 inches in 1957. This trend in 1956 may have been related to salt effect, because rainfall distribution was nearly ideal. But with less than 5 inches of rainfall in June, July, and August in 1957, the effect may have been partly related to moisture supply. Fertilizer at the F1 rate, including limestone, increased corn yields [illegible] 40 bushels per acre for the two years over those obtained with no fertilizers or lime.

Root development of the corn was studied on selected plots in 1956. Tillage or mixing alone had little effect on maximum root penetration. Fertilization increased root growth and penetration, especially where the fertilizer was placed throughout the entire mixed zone. The F3 and F4 rates, when placed only in the upper 9 inches of 27- and 36-inch mixed plots reduced yields, stalk growth, and root penetration. This effect may have been temporary, because yields were not reduced on these same plots in 1957.

On the plots with stunted stalk growth and reduced yields, corn roots penetrated to [illegible] and 36 inches. On the check plot (F0) they penetrated to 42 inches, and on all other plots studied they penetrated to depths ranging between 48 and 64 inches.

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2-17-58

AGRONOMY FACTS

SM-20

MANAGEMENT PRACTICES AND CROPS ADAPTED TO ORGANIC SOILS

The farming of peat and muck organic soils is a hazardous occupation for the unexperienced. Problems of drainage, cultivation, erosion, and shrinkage differ from those of mineral soils. Also, the kinds of crops that may be grown successfully, together with their care, fertilization, and harvesting, require special knowledge as well as special equipment.

Organic soils need drainage if they are to be used to produce crops. Many areas may be pastured if not covered with water, but undrained areas are normally too wet for satisfactory production of farm crops, including most forage crops.

Drainage can be provided most economically by open ditches. The system must be carefully planned and maintained, however, if it is to prove satisfactory. If tile are used, they should not be placed directly in deep organic material or in any loose underlying sand without a stable base. Such a base is sometimes provided by laying the tile lines on boards or planks. A good drainage outlet is necessary but is often difficult to locate. Most organic soils occur in low areas or depressions, and the cost of providing an adequate outlet should be carefully studied for each area.

Overdrainage should be avoided. Tile lines are most efficient when placed three or four feet deep; open ditches need to be somewhat deeper. However, in peat and muck soils the groundwater level should be maintained at an average depth of about two feet. Capillary moisture will tend to move to the surface from that depth, not only providing adequate moisture for shallow-rooting crops, but preventing excessive drying.

Overdrained organic soils become excessively dry and do not then readily moisten or conduct capillary moisture. Dry organic material becomes loose and fluffy, especially when cultivated, and is easily removed by the wind. It catches fire easily and may burn down to the water table. Also, overdrained peat soils shrink rapidly, and the surface may soon subside to a level below which drainage is no longer feasible. Or the peat may disintegrate so completely as to bring undesirable underlying materials within crop-rooting depth or even within plow depth.

To maintain the water table at a desired level means that some provision must be made to reduce water-flow in tile or ditches or to halt it completely as the need arises. For this purpose special gates or locks may be used in the drainage system. Supplemental irrigation may be used to attain the same results, but the value of the crops must be high to pay for its installation and maintenance.

All known areas of organic soils in Illinois but two are neutral to alkaline in reaction. Adding limestone to correct acidity is of little or no value. Calcium is not likely to be deficient. In fact, in the alkaline areas it is already present in excessive amounts. Magnesium, a constituent of dolomite, may be deficient or out of balance for certain crops, particularly in the alkaline areas, but is best applied to the crop as a magnesium sulfate spray.

Well-drained organic soils usually contain enough nitrogen for crops. However, proper water control may increase the need for nitrogen, particularly for corn and many of the leafy vegetables.

Both phosphorus and potassium are deficient for most crops. Potash fertilizer is especially important, and it is usually more effective when combined with some phosphate.

Minor elements, such as copper, manganese, boron, zinc, and sodium, are often deficient for specific crops. Where needed they should be applied in small amounts to correct the deficiency for the particular crop. Large amounts are often toxic. Small amounts are best applied as a side-dressing or in a spray. Some may already be contained in certain fungicides, whereas others may be added to insect or disease spray mixture for application.

Sulfur is seldom deficient as a plant nutrient, but it is sometimes used on alkaline soils to help manganese become more available. Over a period of years, the use of sulfur may be more economical to overcome manganese deficiency than small yearly applications of a manganese compound.

Plowing organic soils is difficult. Extension rims on the tractor wheels are needed to prevent miring. A track-laying tractor is suitable. The initial plowing should be deep to effectively bury all plant growth. Other plowings are not needed except where heavy crop residues or weed growth interferes with tillage. Surface tillage is usually sufficient to prepare a good seedbed and frequently improves crop growth. Also, shallow cultivation usually produces more satisfactory crop yields than deep cultivation.

Of the farm crops, corn is one of the best to grow on peat and muck soils in Illinois. Stalks are often tall and leafy but barren if phosphorus and potassium are deficient or are out of balance with nitrogen. But with adapted hybrids and a balanced fertility program, high yields of corn can be obtained. Corn is excellent as a silage crop in organic soils.

Alsike and White (Dutch) clovers are the best adapted legumes for use on such soils. Timothy and reed canary grass are dependable hay crops, while bluegrass produces good pasture on areas that are not too wet.

Many vegetable crops also do well on peat and muck soils. With good seed and proper fertilization, planting, disease and insect control, and harvesting, these vegetables are adapted to production on organic soils: asparagus, beets, cabbage, carrots, cauliflower, celery, lettuce, onions, peppers, rhubarb, spinach, Swiss chard, and tomatoes. Mint may also be grown successfully.

Two excellent publications on the use, management, and adaptation of various crops to organic soils are "The Muck Soils of Michigan, Their Management and Uses," by Paul M. Harmer, Special Bul. 314 (1941), Michigan State University Agricultural Experiment Station, East Lansing, Michigan; and "Farming Muck and Peat in Wisconsin," by A. R. Albert and O. R. Zeasman, Circular 456 (1953), University of Wisconsin College of Agriculture, Extension Service, Madison, Wisconsin.

H. Wascher
3-10-58

POTENTIAL PRODUCTIVITY OF THE NORTHEASTERN TILL SOILS OF ILLINOIS
AREA I

POTENTIAL YIELDS ON SOILS IN AREA I

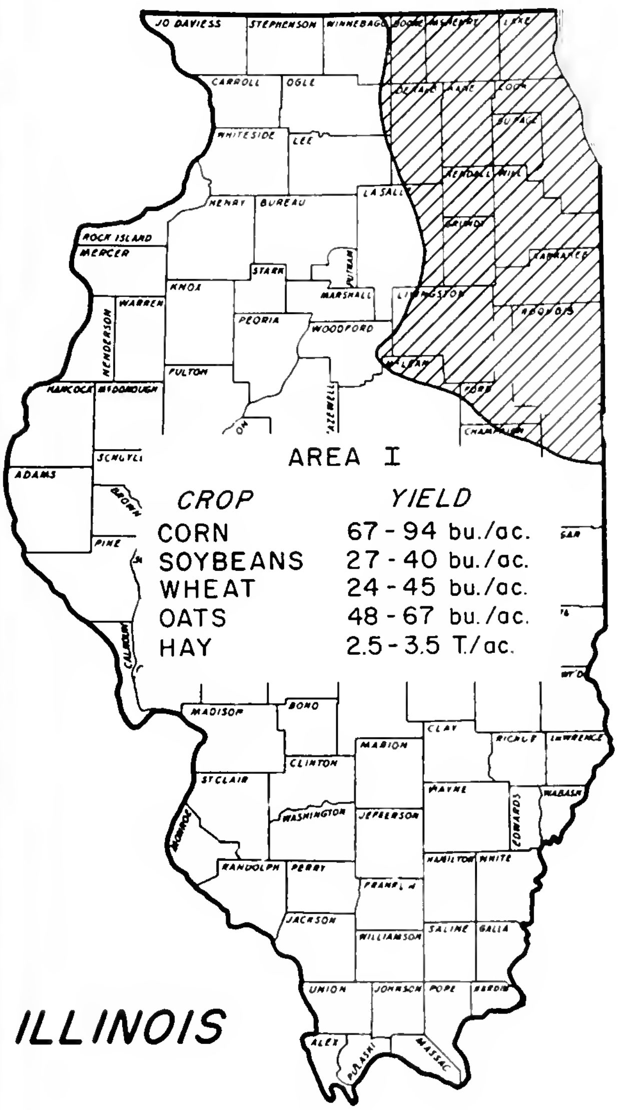


Figure 1

Farmers in northeastern Illinois can combat rising production costs by making most efficient use of the potential productivity of their soils. Figure 1 shows a broad area, called Area I,1/ in northeastern Illinois that includes soils formed primarily from glacial drift. It also indicates the crop yields that may be obtained under a high level of management1/ over a period of years.

Crop yields vary with kinds of soils, management, and climate. Figures 2 and 3 show the ranges in average yields that may be obtained under four levels of management on some major soils in the area. For example, in Area I, farmers on Saybrook soils may obtain yields that are above the average shown for the area in Figures 2 and 3; farmers on Elliott-Ashkum soils may obtain yields that are near the average; and farmers on the Alvin or Eylar soils may obtain yields that are below the average shown for the area.

Because of variations in temperature and rainfall, additional variations of plus and minus 20 percent may be expected from year to year on all soils in the area under all management levels. For example, on Saybrook soils under a high level of management, corn yields may range from 75 to 115 bushels an acre, depending on the weather, and occasionally will even fall outside that range. Climate also affects yields in other ways. For example, corn yields on most soils in Lake and Cook Counties are depressed somewhat because of the moderating influence of Lake Michigan on the climate.

Table 1 lists some of the major soils in northeastern Illinois in decreasing order

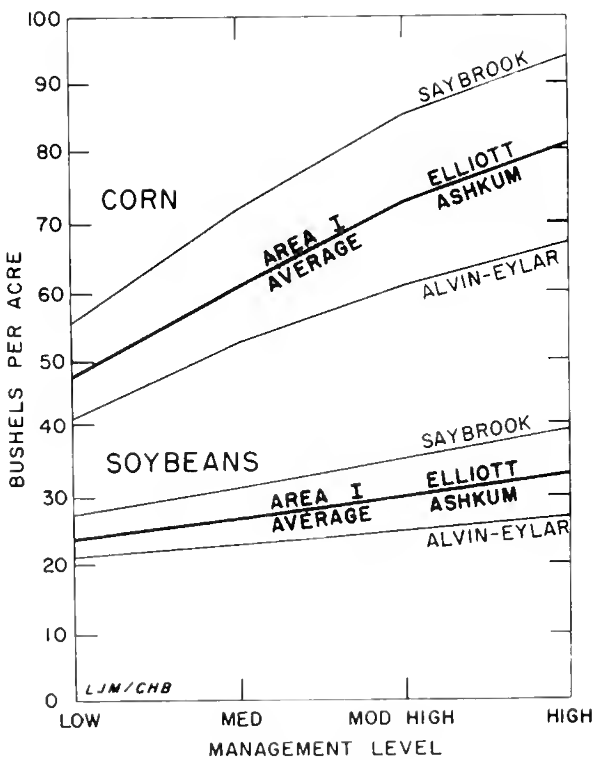
1/ Management levels and potential productivity areas of Illinois have been defined in SP-17, "Potential Productivity of Illinois Soils," published by the University of Illinois, March 21, 1957.

of potential productivity. For example, the Saybrook soils, which are potentially among the most productive in the area, as shown in Figures 2 and 3, are placed near the top of the list; while the Eylar soils, which are among the least productive are placed near the bottom.

Table 1 also shows the amount of water that can be stored, available for plants, in the upper 60 inches, and the estimated amount of water that is available in the normal rooting zone of corn growing in the various soils.2/3/ For example, the Elliott soils retain about 12 acre-inches of available water in the upper 60 inches, but only about 7 inches are available to corn plants. The reason is that the lower subsoil of Elliott soils is too compact for corn roots to penetrate. Tillage and fertility practices that tend to reduce the compact nature of Elliott subsoils could make more of the soil water available to plant roots and make the soils more resistant to drouth in dry years. On the other hand, the Brenton soils retain 12 inches of available water, all of which is available to corn roots. Brenton soils tend to be drouth resistant.

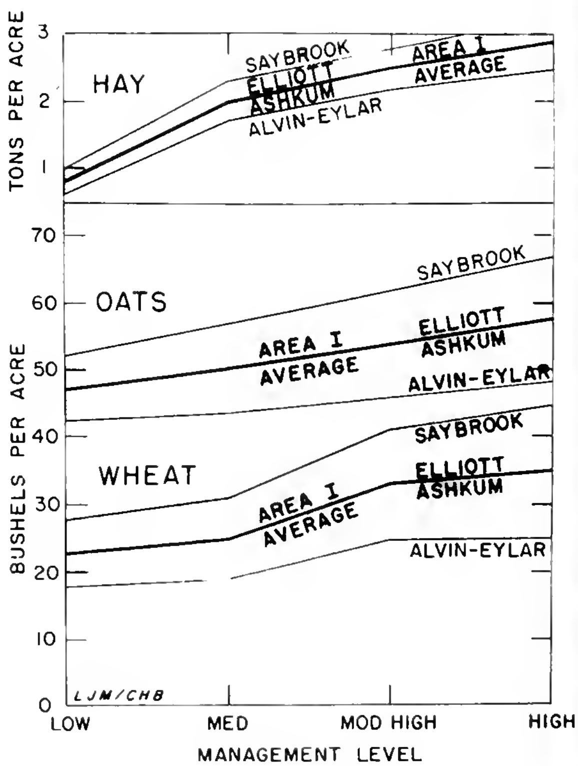
The last column in Table 1 lists the most important treatments that should be included in soil management programs by farmers who wish to develop their soils to the maximum productivity level.

The information given above is essential if farmers are to obtain either maximum productivity or optimum economic production from their soils. Those who use such knowledge should be able to produce crops more efficiently and thus increase their net incomes.



AREA I
POTENTIAL PRODUCTION OF
NORTHEAST ILLINOIS SOILS

Figure 2



AREA I
POTENTIAL PRODUCTIVITY OF
NORTHEAST ILLINOIS SOILS

Figure 3

2/ Unpublished data of D. B. Peters and L. J. Bartelli of the U. S. Department of Agriculture.

3/ R. T. Odell, "Available Water-Holding Capacity of Some Illinois Soils," University of Illinois Department of Agronomy, AG-1731.

Table 1.--Special Characteristics of the Soils of Area I

Soil	Available water in soil (acre-inches) in 60-inch depth	estimated* in corn root zone	Special treatments
Brenton	12	12	Use tile drainage where necessary. Maintain fertility.
Saybrook	11	10[4/]	Control erosion; maintain fertility.
Drummer	10	10	Tile drainage or surface drainage is necessary; maintain fertility.
Ringwood	9	7[4/]	Compact substratum limits root penetration.
Ashkum	13	9	Tile drainage or surface drainage is necessary; maintain fertility.
Elliott	12	7[4/]	Compact substratum limits root penetration.
Miami	9	8	On slopes, use erosion control practices.
Camden	14	10	Organic matter supply is low; improve fertility.
McHenry	8	7	Use erosion control practices; improve fertility.
Swygert	9	6	Compact subsoil limits root penetration; use erosion control practices on slopes.
Bryce	--	--	Use a surface drainage system.
Ridgeville	7	7	Sandy lenses hinder use of tile drains; improve fertility.
Warsaw	7	7	Use erosion control practices; maintain fertility.
Blount	10	6	Use erosion control practices. Use surface drainage where necessary.
Clarence	12	6[4/]	Use surface drains and erosion control practices. Compact subsoil limits root penetration.
Rowe	--	--	Surface drains should be used. Compact subsoil limits root penetration.

Table 1.--Special Characteristics of the Soils of Area I (Cont.)

Soil	Available water in soil (acre-inches) in 60-inch depth	Available water in soil (acre-inches) estimated* in corn root zone	Special treatments
Alvin	--	--	Use practices to combat drouthiness, control wind erosion, and improve fertility.
Eylar	11	5	Essential to control erosion. Compact subsoil limits root penetration. Grains not well adapted.
Hagener	--	--	Control wind erosion; improve fertility; combat drouthiness; grains not well adapted.
Plainfield	--	--	Control wind erosion; improve fertility; combat drouthiness; grains not well adapted.

*Estimated amounts except where Footnote 4 applies.

4/ J. B. Fehrenbacher et al, Soil Sci. 77 (No. 4), April, 1954; Agron. Jour. 47 (No. 10), October, 1955; Soil Sci. 82 (No. 5), November, 1956.

L. J. McKenzie
9-30-57

POTENTIAL PRODUCTIVITY OF THE SOILS OF NORTHWESTERN AND EAST-CENTRAL ILLINOIS AREA II

POTENTIAL YIELDS ON SOILS IN AREA II

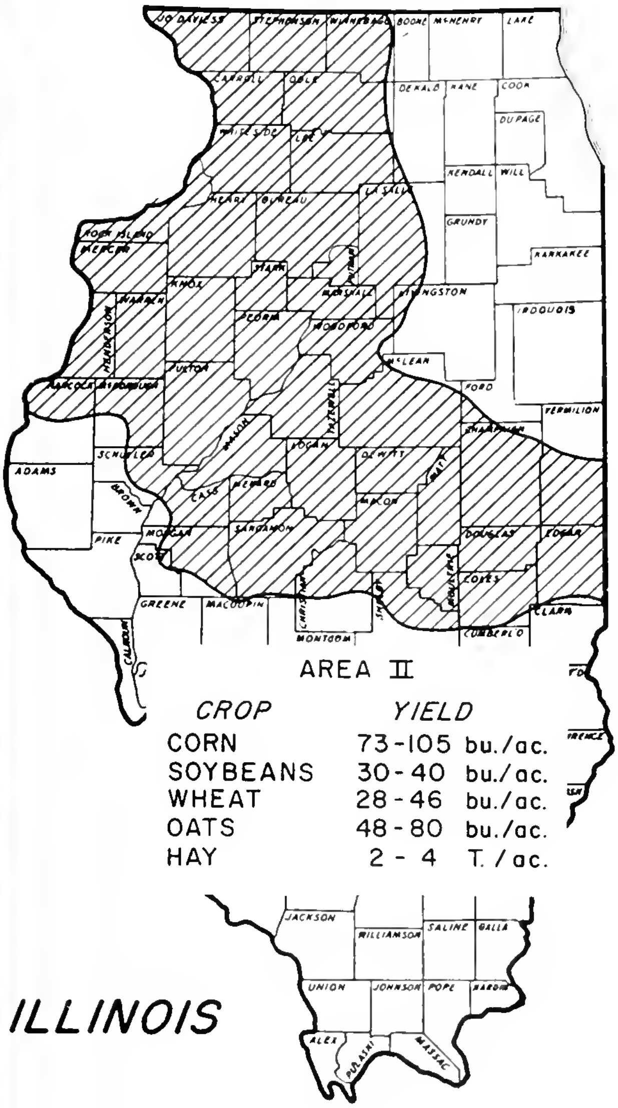


Figure 1

Farmers in northwestern and east-central Illinois can combat rising production costs by making most efficient use of the potential productivity of their soils. Figure 1 shows a broad area, called Area II, in northwestern and east-central Illinois[1] that includes soils formed primarily from deep loess or moderately deep loess. It also indicates the crop yields that may be obtained under a high level of management[1] over a period of years.

Crop yields vary with kinds of soils, management, and climate. Figures 2 and 3 show the ranges in average yields that may be obtained under four levels of management on some major soils in the area. For example, farmers on Muscatine soils may obtain yields that are higher than the average shown in Figures 2 and 3; farmers on Tama soils may obtain yields that are near the average; and farmers on the Alvin soils may obtain yields that are below the average shown for the area.

Because of variations in temperature and rainfall, additional variations of plus or minus 20 percent may be expected from year to year on all soils in the area under all management levels. For example, on Muscatine soils under a high level of management, corn yields may range from 85 to 125 bushels an acre, depending on the weather, and occasionally will even fall outside that range.

Table 1 lists some of the major soils in Area II in decreasing order of potential productivity. For example, the Flanagan

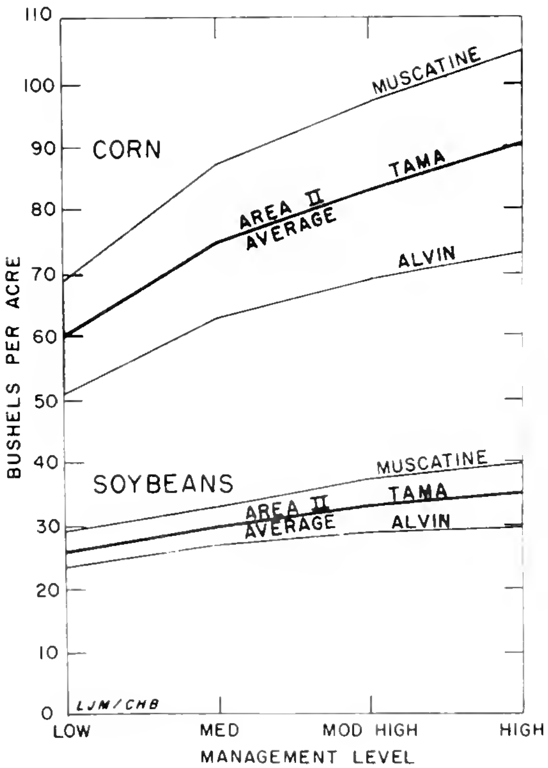
1/ Management levels and potential productivity areas have been defined in SP-17, "Potential Productivity of Illinois Soils," published by the University of Illinois, March 21, 1957.

soils, which are potentially among the most productive in the area, are placed near the top of the list; while the Plainfield soils, which are among the least productive for general farm crops, are placed near the bottom.

Table 1 also shows the amount of water that can be stored, available for plants, in the upper 60 inches of the soils in the list, and the estimated amount of water that is available in the normal rooting zone of corn growing in the various soils.[2/][3/] For example, the Muscatine soils retain about 13 acre-inches of available moisture in the upper 60 inches, and 14 acre-inches is used by corn plants. This means that corn roots are able to penetrate Muscatine subsoils and use all of the water available there. The corn roots also extend beyond 60 inches and obtain an additional supply of water. Muscatine soils are therefore quite drouth resistant. On the other hand, the Ridgeville soils have only 7 acre-inches of available water, and although all the water is available to corn plants, these soils tend to be somewhat "drouthy" in dry years.

The last column in Table 1 lists the most important treatments that should be included in soil management programs by farmers who wish to develop their soils to the optimum productivity level.

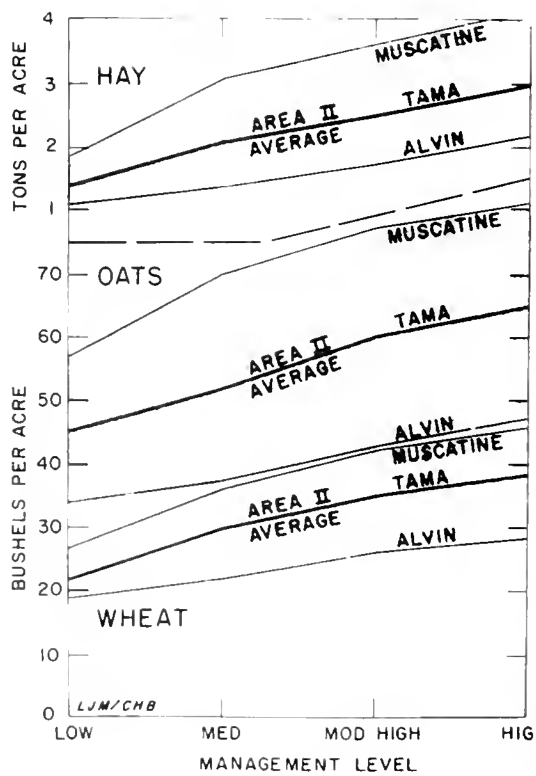
The information given above is essential if farmers are to obtain either maximum productivity or optimum economic productivity from their soils. Those who use such knowledge should be able to produce crops more efficiently and thus increase their net incomes.



AREA II

POTENTIAL PRODUCTIVITY OF NORTHWEST AND CENTRAL ILLINOIS SOILS

Figure 2



AREA II

POTENTIAL PRODUCTIVITY OF NORTHWEST AND CENTRAL ILLINOIS SOILS

Figure 3

2/ Unpublished data of D. B. Peters and L. J. Bartelli of the U. S. Department of Agriculture.

3/ R. T. Odell "Available Water-Holding Capacity of Some Illinois Soils," University of Illinois Department of Agronomy, AG-1731.

Table 1.--Special Characteristics of the Soils of Area II

Soil	Available water in soil (acre-inches) in 60-inch depth	Available water in soil (acre-inches) estimated* in corn root zone	Special treatments
Muscatine	13	14 4/	Use tile or surface drains where necessary.
Sable	10	10	Use tile or surface drainage.
Flanagan	13	12 4/	Use tile or surface drainage where necessary.
Drummer	10	10	Use tile or surface drainage.
Ipava	12	12	Use tile or surface drainage.
Tama	14	14	Erosion control practices should be used.
Illiopolis	9	9	Tile or surface drainage should be used.
Tonica	--	--	Use random tile or surface drains if necessary.
Fayette	14	14	Improve fertility; use erosion control practices.
Birkbeck	14	14	Use erosion control practices; improve fertility.
Ridgeville	7	7	Sand pockets interfere with tile. Improve fertility.
Dodgeville	--	--	Bedrock occurs at 20-36". Control erosion.
Alvin	--	--	To combat drouthiness, control wind erosion and improve fertility.
Dubuque	--	--	Bedrock occurs at 20-36". Control erosion and improve fertility.
Hagener	--	--	Control wind erosion; improve fertility; combat drouthiness; grains not well adapted.
Plainfield	--	--	Control wind erosion; improve fertility; combat drouthiness; grains not well adapted.

*Estimated amounts except where footnote 4/ applies.

4/ J. B. Fehrenbacher et al, Soil Sci. 77 (No. 4), April, 1954; Agron. Jour. 47 (No. 10), October, 1955; Soil Sci. 82 (No. 5), November, 1956.

L. J. McKenzie
10-7-57

DEEP TILLAGE AND DEEP FERTILIZATION RESEARCH IN ILLINOIS

Results and general conclusions from some experiments on deep tillage are given in Agronomy Facts SM-11 (1953) and SM-19 (1958). Our purpose here is to bring together research information obtained in several studies of deep tillage and deep fertilization. This Fact Sheet replaces SM-19 (1958), which presented early results from two studies on claypan soils in southern Illinois.

An experiment was started in September 1953 on Cisne silt loam, a claypan soil developed under prairie vegetation, at the Brownstown soil experiment field.

Two depths of tillage were used, 18 inches (deep) and 6 to 8 inches (regular). The soil in all deep plots was mixed to a depth of 18 inches in 1953. Since then the deep plots have been plowed to 18 inches ahead of each corn crop.

Original soil treatment (1953) of 12 tons of limestone and 2 tons of rock phosphate was mixed to the 18- and the 6- to 8-inch depths.

Since 1953, 165 pounds of 0-0-60 (100 lb. K_2O) per acre have been applied ahead of each corn and each wheat crop. Superphosphate (0-20-0) has been drilled at the rate of 200 pounds (40 lb. P_2O_5) per acre with each wheat crop.

The rotation on the plots is corn, soybeans, wheat, and mixed hay.

As shown in the following table of yields in the five-year period 1955 to 1959, there are no pronounced differences between regular (6 to 8 inches) and deep (18 inches) plowing fertilization.

Crop Yields (Average of Three Replications Each Year), 1955 to 1959

Year	Corn		Soybeans		Wheat		Hay	
	Regular	Deep	Regular	Deep	Regular	Deep	Regular	Deep
	bu.	bu.	bu.	bu.	bu.	bu.	T.	T.
1955	47	43	24	23	50	49	2.3	2.2
1956	100	95	32	31	65	68	2.7	2.6
1957	Wet1/	Wet1/	26	24	35	31	2.8	2.7
1958	79	72	29	27	36	40	2.5	2.4
1959	115	119	30	26	33	27	2.3	2.5
Av.	85 2/	82 2/	28	26	47	43	2.5	2.5

1/ Crop failure because of excess rainfall.
2/ 4-year average.

The second experiment was started in August 1955 on Weir silt loam, a claypan soil developed under forest vegetation, at the Southern Illinois Cooperative Agronomy Research Center at Carbondale. The Illinois Agricultural Experiment Station and Southern Illinois University cooperated in this study.

Four depths--9, 18, 27, and 36 inches--of tillage or mixing were used. The soil was thoroughly mixed to these depths and not merely stirred. The Caterpillar Tractor Company, Peoria, Illinois, Furnished the equipment and manpower for the mixing operations, which were done under the supervision of Mr. Jack Diamond. Mixing to the 9-inch depth (D1) was done with an ordinary plow and disk; to the 18-inch depth (D2), with a disk plow; and to the 27- (D3) and 36-inch (D4) depths, with heavy road-working machinery. At the 27- and 36-inch depths, the soil was entirely removed, fertilized, and thoroughly mixed, and then returned to its original space.

Four rates of treatment were established. The lowest rate (F1), consisting of 9 tons of limestone, 3,630 pounds of 0-20-0 (726 lb. P_2O_5), and 1,452 pounds of 0-0-60 (870 lb. K_2O) per acre, represents the treatment needed according to soil tests for 9 inches of soil. Except for nitrogen, no further treatments have been made. The F2, F3, and F4 rates are two, three, and four times the F1 rate, respectively. Check plots (F0) receiving no fertilizer or lime except nitrogen and mixed only to 9 inches were also set up. The check plots, and all other plots, received nitrogen at the rate of 200 pounds per acre as plow-down each year in the spring preceding corn.

Studies of clay content, bulk densities, and moisture-holding and moisture-storage capacities of the mixed zones indicated that the mixing was reasonably good. Mixing of some of the clay from the claypan or subsoil with the silty surface soil increased the moisture-holding capacity, but it also increased the amount of moisture held too tightly for plants to use. Thus it left the available moisture-storage capacity about the same as that of the natural, unmixed soil.

U. S. 13 hybrid corn was grown on all plots. Yields in bushels per acre are given in the table below.

Corn Yields (Bushels per Acre), 1956 to 1959

	Mixing depth D1, 9" Fertilizer rates					Mixing depth D2, 18" Fertilizer rates				
Years	F0	F1	F2	F3	F4	F1	F2	F3	F4	F2
1956	57	106	93	89	77	109	102	91	86	76 1/
1957	61	92	81	49	36	106	86	63	70	84 1/
1958	38	103	89	76	70	91	64	70	71	57 1/
1959	38	102	88	63	58	103	86	74	84	84 1/
Av.	49	101	88	69	60	102	84	74	78	75

	Mixing depth D3, 27" Fertilizer rates					Mixing depth D4, 36" Fertilizer rates				
	F1	F2	F3	F4	F3	F1	F2	F3	F4	F4
1956	93	114	105	101	35 1/	109	109	104	108	51 1/
1957	100	96	85	82	82 1/	101	102	100	101	90 1/
1958	96	82	107	67	71 1/	66	101	86	91	67 1/
1959	94	102	103	100	102 1/	90	111	112	107	99 1/
Av.	96	99	100	88	72	91	106	101	102	77

1/ On this plot the fertilizer was all applied to the surface 9 inches.

To date it can be said that depth of mixing of the soil had no significant effect on yield when all of the fertilizer was applied in the surface 9 inches. At the F1 rate, depth of placement had no apparent effect for the first two years. During the last two years, however, yields were lower where fertilizer at the F1 rate had been mixed with 36 inches of soil than where it had all been applied to the surface 9 inches. Where the F2, F3, and F4 rates were mixed through only the surface 9 inches, there was a decrease in yield for each increase in fertilizer rate. In the fourth year, 1959, this depressing effect of a very heavy fertilizer application to the surface 9 inches had largely disappeared on plots where the soil was mixed to 27 or 36 inches.

Moisture from rainfall has varied widely from year to year, but it seemingly has had no significant effect on the interaction of deep tillage and fertilizer applications.

As a four-year average, the F1 fertilizer rate applied in the surface 9 inches has increased corn yields by 52 bushels an acre a year. No greater amount of fertilizer or deeper mixing practice has provided greater increases.

Root development of the corn was studied on selected plots in 1956. Tillage or mixing alone had little effect on root penetration. Fertilization increased root growth and penetration, especially where the fertilizer was placed throughout the entire mixed zone. The F3 and F4 rates, when placed only in the upper 9 inches of 27- and 36-inch mixed plots, reduced yields, stalk growth, and root penetration. This effect may have been temporary, however, because yields were not reduced on these same plots in 1957.

On the plots with stunted stalk growth and reduced yields, corn roots penetrated to 32 and 36 inches. On the check plot (F0), they penetrated to 42 inches, and on all other plots they penetrated to depths ranging between 48 and 64 inches.

Three experiments on deep plowing and chiseling were established in 1956 on the Leith farm in Effingham county. The results are presented in the following tables.

Effect of Deep Tillage and Fertilization on Corn Yields, Leith Farm, Mason (Effingham Co.), Illinois, 1956 (All corn was planted after alfalfa; all plots received 150 lb. 0-20-20 as starter; average of three replications except as noted)

1. Deep Plowing

Fertility treatment	Yield (bu./A.) at Plowing depth of 6"	12"	18"	Average
Starter only	110.4	107.3 1/	103.4	107.0
Starter + 5 T. lime + 1500 lb. rock P.	111.3	111.8 1/	103.0	108.7
Starter + 10 T. lime + 3000 lb. rock P.	110.0	111.7	104.7	108.2
Ave.	110.6	110.3	103.7	

1/ Two replications only.

2. Chiseling

	No chiseling	12" deep 30" spacing	15" deep 24" spacing	15" deep 30" spacing
Yield, bu./A.1/	108.4	107.7	114.3	112.8

1/ Two replications only.

3. Chiseling

	No chiseling	Chiseled 15" deep, 30" spacing	No chiseling 1000 lb. 10-10-10	Chiseled 15" deep, 30" spacing 1000 lb. 10-10-10
Yield, bu./A.1/	108.4	108.9	113.1	114.1

1/ Two replications only.

The results in these trials must be treated with caution, since they are for only one year at one location. On the whole, they do not indicate a consistent response to deep plowing or chiseling.

An experiment was initiated in 1954 at Dixon Springs on Grantsburg silt loam. This light-colored soil has developed from loess under forest on slopes ranging from 2 to 12 percent. A dense layer ranging in depth from about 34 to 60 inches, called a fragipan, characterizes this soil. This layer is extremely hard and brittle when dry and definitely restricts plant root penetration. Since few roots penetrate this layer, little moisture is obtained in this zone. This experiment compared chiseling with and without deep-placed fertilizer. The four-year average yields are given in the table below.

Effect of Deep Tillage and Fertilization on Corn Yield
Dixon Springs, 1955-58

Treatment: Tillage	Treatment: Fertility	Yield of corn in a corn, wheat, alfalfa-timothy (2 years) rotation
Chiseled 20"1/	Conventional2/ + deep placed	81.2 bu.
Chiseled 20"1/	Conventional only	73.8 bu.
No chiseling	Conventional3/ + 1/2 rate	81.2 bu.
No chiseling	Conventional only	73.9 bu.

1/ Plots were chiseled in the fall preceding each corn crop at 40" intervals.
2/ A basic application of lime, phosphorus, and potash was applied prior to establishment of plots; 200 pounds of 8-8-8 was applied on the corn at planting time and then sidedressed with 60 pounds of nitrogen. Deep-placed fertilizer was 1000 lb. lime, 500 lb. superphosphate, 200 lb. ammonium nitrate, and 200 lb. of muriate of potash placed at 9" and 20".
3/ Nutrients at half the rate indicated for deep-placed were placed on the surface or incorporated in the plow layer.

No differences were observed between the chiseled and non-chiseled plots where the same fertilizer applications had been made. Differences in yield were the result of different fertilizer treatments.

Nine farm trials of deep chiseling were carried out in Will and Kankakee counties in northern Illinois in 1955-1956. The Drummer and Ashkum sites were silty clay loam. The other three soils had a silt loam surface and a silty clay loam or clay loam texture at 18 inches. The results of chiseling to 10-12 inches and 16-18 inches are shown in the tables below.

Effect of Deep Tillage on Corn Yield in Will and Kankakee Counties, 1955-1956 1/

Soil type	Yield (bu./A.) at depth of chiseling of		
	None	10-12"	16-18"
Silty clay loams			
(3 Drummer, 1 Ashkum), 1955	75.2	78.5	78.2
(2 Drummer, 1 Ashkum), 1956	90.9	89.4	93.6
Silt loams			
(2 Elliott, 1 Martinton, 1 Symerton), 1955	73.5	75.4	82.8
(2 " 1 "), 1956	78.3	79.3	82.1
All soils, 1955	74.4	77.0	80.5
1956	84.6	84.3	87.8

1/ Chiseled in September 1954 on first- or second-year legume and fall-plowed. Yield is an average of four replicates of each soil; therefore each figure is an average of 16 observations in 1955 and 12 observations in 1956.

Soil moisture conditions in September 1954 were ideal for achieving maximum shattering from the chiseling practices. Dr. C. A. Van Doren, in the 1955 report of the work, states that an estimated \$2.75 to \$3.50 per acre service charge should be assigned to the 16- to 18-inch depth of chiseling.

The chiseling, although done under what was believed to be ideal moisture conditions, might have given greater responses at some other time in the rotation than immediately following the deep-rooted legumes.

The average yield increase for all soils after chiseling 16-18 inches was 6.1 bushels per acre in the first year and 3.2 bushels in the second year, or a total effect of 9.3 bushels in two years from the original chiseling in 1954. This was a highly profitable operation under this set of conditions. Most of the increase came on the silt loam soils. The response was least on the Drummer and Ashkum soils, which are the kind of soils on which farmers most frequently ask about chiseling.

A. L. Lang, J. B. Fehrenbacher, J. V. Baird, J. P. Vavra, and P. E. Johnson
2/15/60

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS

SOIL PROPERTIES

SP-20

POTENTIAL PRODUCTIVITY OF THE SOILS OF WESTERN ILLINOIS AREA III

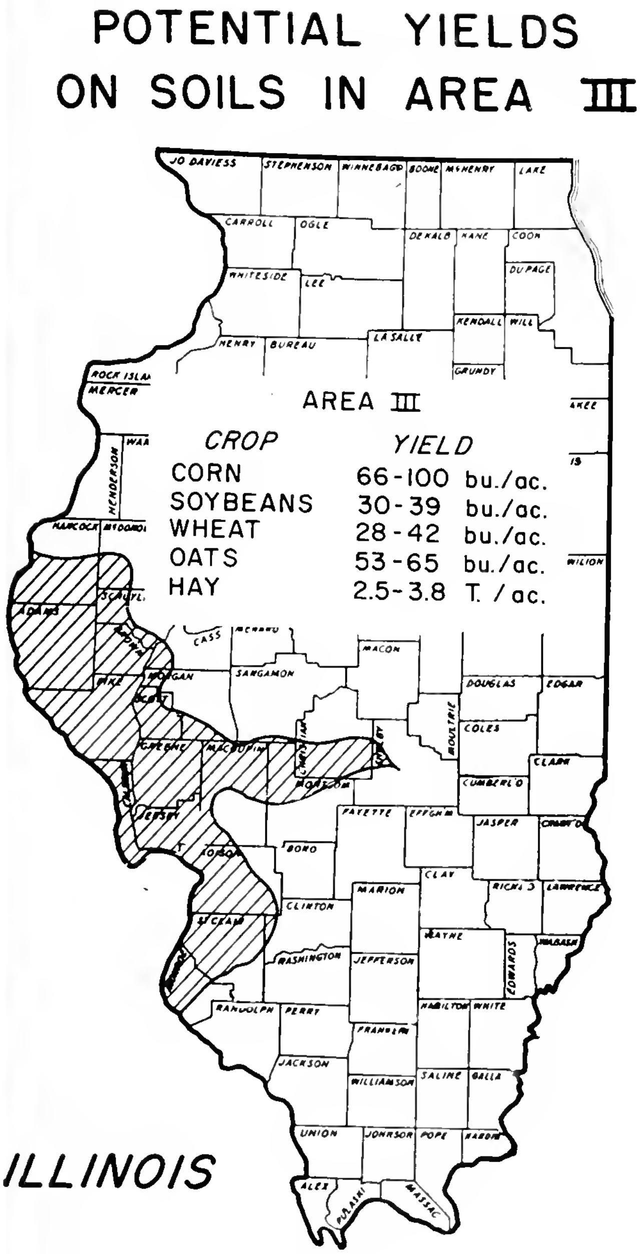


Figure 1

Farmers in western Illinois can combat rising production costs by making most efficient use of the potential productivity of the soils. Figure 1 shows a broad area, called Area III, in west-central Illinois[1] that includes soils formed from deep or moderately deep loess. It also indicates the crop yields that may be obtained under a high level of management[1] over a period of years.

Crop yields vary with kinds of soils, management, and climate. Figures 2 and 3 show the ranges in average yields that may be obtained under four levels of management on some major soils in the area. For example, farmers on Huntsville soils may obtain yields that are higher than the average shown in Figures 2 and 3; farmers on Herrick soils may obtain yields that are near the average; and farmers on the Alma soils may obtain yields that are below the average shown for the area.

Because of variations in temperature and rainfall, additional variations of plus or minus 20 percent may be expected from year to year on all the soils in the area under all levels of management. For example, on Herrick soils under a high level of management, corn yields may range from 67 to 101 bushels an acre, depending on the weather, and occasionally will even fall outside that range.

Table 1 lists some of the major soils in Area III in decreasing order of potential productivity. For example, the Virden soils, which are potentially among the most productive in the area are placed near the top of the list; while the Alma soils, which are among the least productive, are placed near the bottom.

1/ Management levels and potential productivity areas have been defined in SP-17, "Potential Productivity of Illinois Soils," published by the University of Illinois, March 21, 1957.

Table 1 also shows the amount of water that can be stored, available for plants, in the upper 60 inches of the soils in the list; and the estimated amount of water that is available in the normal rooting zone of corn growing in the various soils.2/3/ For example, the Herrick soils retain about 16 acre-inches of water in the upper 60 inches, and yet the corn plants use only about 10 acre-inches. Improved fertility practices may extend corn root penetration and make use of more of the available water in the soil and thereby increase corn yields. On the other hand, the Sawmill soils have only 10 acre-inches of water available in the upper 60 inches, and corn plants use 10 acre-inches.

The last column in Table 1 lists the most important treatments that should be included in soil management programs by farmers who wish to develop their soils to the optimum productivity level.

The information given above is essential if farmers are to obtain either maximum productivity or optimum economic productivity from their soils. Those who use such knowledge can produce crops more efficiently and thus increase their net income.

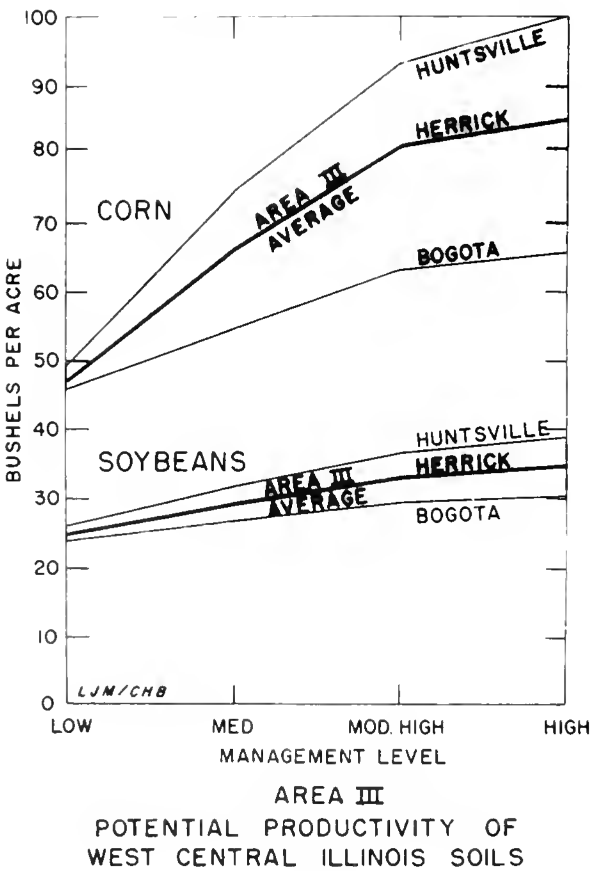


Figure 2

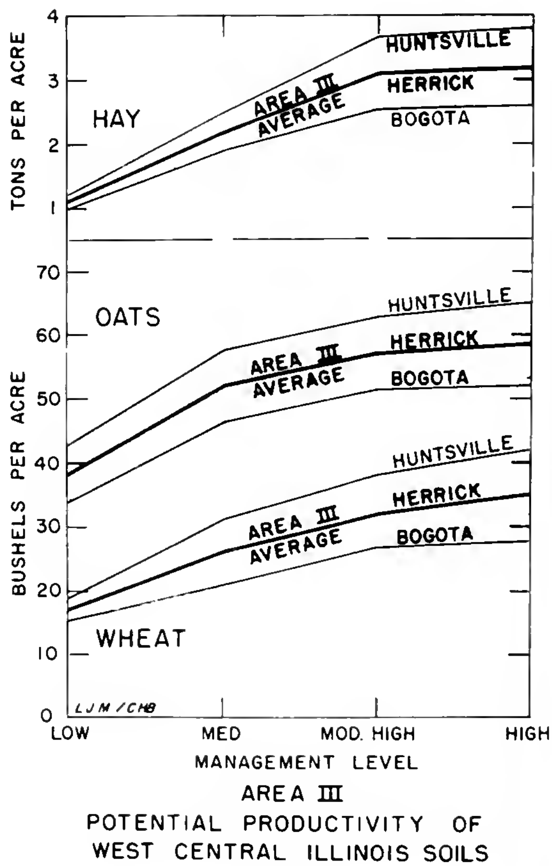


Figure 3

2/ Unpublished data of D. B. Peters and L. J. Bartelli of the U. S. Department of Agriculture.

3/ R. T. Odell, "Available Water-Holding Capacity of Some Illinois Soils," University of Illinois Department of Agronomy, AG-1731.

Table 1.--Special Characteristics of the Soils of Area III

Soil	Available water in soil (acre-inches) in 60-inch depth	Available water in soil (acre-inches) estimated in corn root zone	Special treatments
Virden	--	--	Improve drainage with tile or surface drains; improve fertility.
Herrick	16	10	Improve drainage; improve fertility to encourage roots to penetrate subsoil.
Harrison	--	--	Control erosion; improve fertility to encourage roots to penetrate subsoil.
Huntsville	13	13	Use measures to control flooding; plant primarily spring and summer crops.
Sawmill	10	10	Use measures to control flooding; plant primarily spring and summer crops.
Bogota	--	--	Improve drainage with random tile or surface drains; improve fertility.
Alma	16	10	Control erosion; improve fertility.

L. J. McKenzie
10-14-57

POTENTIAL PRODUCTIVITY OF THE SOILS OF SOUTH-CENTRAL ILLINOIS AREA IV

POTENTIAL YIELDS ON SOILS IN AREA IV

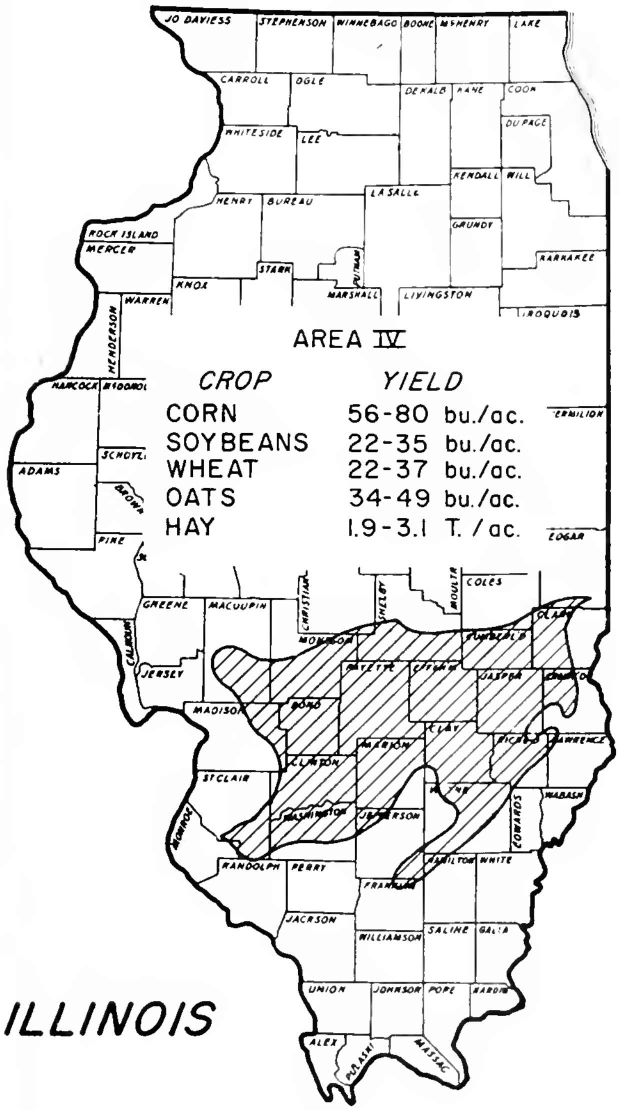


Figure 1

Farmers in south-central Illinois can combat rising production costs by making most efficient use of the potential productivity of their soils. Figure 1 shows a broad area, called Area IV,[1] in south-central Illinois that includes soils formed from moderately deep or thin loess overlying acid, weathered Illinoian glacial drift. It also indicates the crop yields that may be obtained under a high level of management[1] over a period of years.

Crop yields vary with kinds of soil, management, and climate. Figures 2 and 3 show the range in average yields that may be obtained under four levels of management on some major soils in the area. For example, farmers on the Cowden soils may obtain yields that are higher than the average shown in Figures 2 and 3; farmers on Cisne soils obtain yields that are near the average; and farmers on the Huey soils may obtain yields that are below the average shown for the area.

Because of variations in temperature and rainfall, additional variations of plus or minus 20 percent may be expected from year to year on all the soils in the area under all management levels. For example, on the Cisne soils under a high management level, corn yields may range from 54 to 80 bushels an acre, depending on the weather, and occasionally will even fall outside of that range.

Table 1 lists some of the major soils in Area IV in decreasing order of potential productivity. For example, the Oconee soils, which are potentially among

1/ Management levels and potential productivity areas have been defined in SP-17, "Potential Productivity of Illinois Soils." Published by the University of Illinois March 21, 1957.

the most productive in the area, placed near the top of the list in Table 1; while the Huey soils, which are among the least productive for general farm crops, are placed near the bottom.

Table 1 also shows the amount of water that can be stored, available for plants, in the upper 60 inches of the soils in the list and the estimated amount of water that is available in the normal rooting zone of corn growing in the various soils.[2][3] For example, the Cisne soils have about 13 acre-inches of available water in the upper 60 inches, but corn plants can use only about 8 acre-inches. This means that corn roots do not penetrate the lower subsoil and use the water there. Good fertility practices will extend root growth into the subsoil, decreasing drouthiness and making possible higher yields on the Cisne soils.

The last column in Table 1 lists the most important treatments that should be included in soil management programs by farmers who wish to develop their soils to the optimum productivity level.

The information given above is essential if farmers are to obtain either maximum productivity or optimum economic productivity from their soils. Those who use such knowledge should be able to produce crops more efficiently and thus increase their net income.

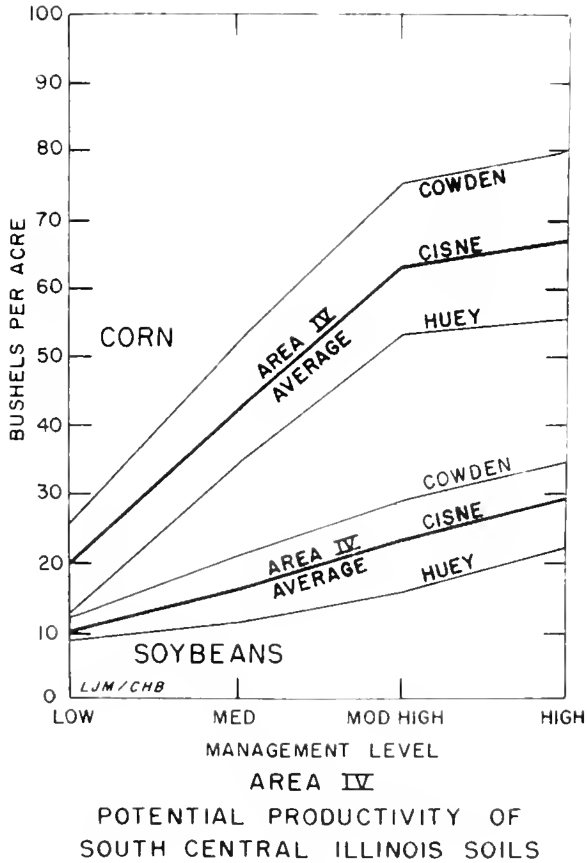


Figure 2

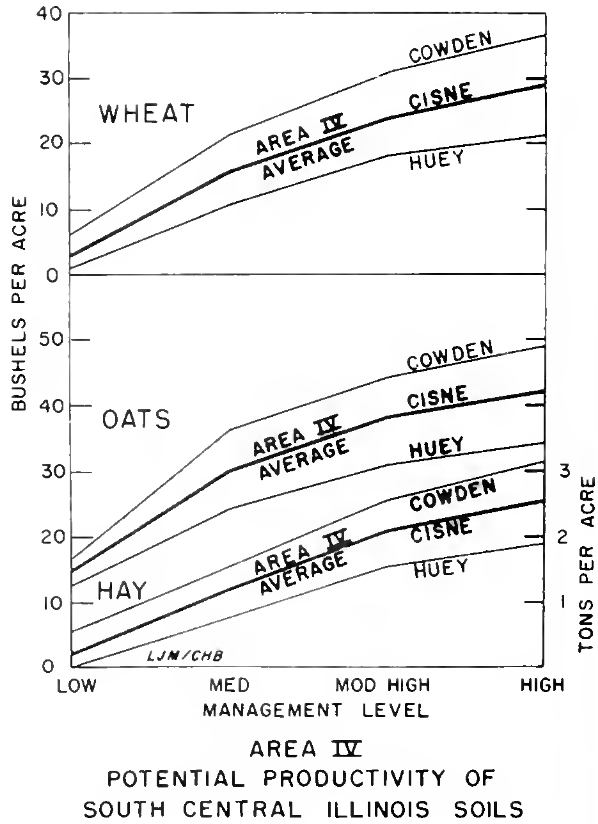


Figure 3

2/ Unpublished data of D. B. Peters and L. J. Bartelli of the U. S. Department of Agriculture.

3/ R. T. Odell, "Available Water-Holding Capacity of Some Illinois Soils," University of Illinois Department of Agronomy, AG1731.

Table 1.--Special Characteristics of Soils of Area IV

Soil	Available water in soil (acre-inches) in 60-inch zone	estimated* in corn root zone	Special treatments
Oconee	--	--	Improve drainage with surface drains; improve fertility to encourage root penetration.
Cowden	14	8	Improve drainage, use only surface drains; improve fertility.
Hoyleton	--	--	Improve drainage with only surface drains; improve drainage to encourage root penetration.
Cisne	13	8 4/	Improve drainage with surface drains; improve fertility to extend root penetration.
Huey	--	--	Improve drainage to increase leaching; not well adapted to grain crops.

*Estimated amounts except where footnote 4 applies.

4/ J. B. Fehrenbacher et al, Soil Sci. 77 (No. 4), April, 1954; Agron. Jour. 47 (No. 10), October, 1955; Soil Sci. 82 (No. 5), November, 1956.

L. J. McKenzie
10-21-57

POTENTIAL PRODUCTIVITY OF THE SOILS OF SOUTHERN ILLINOIS
AREA V

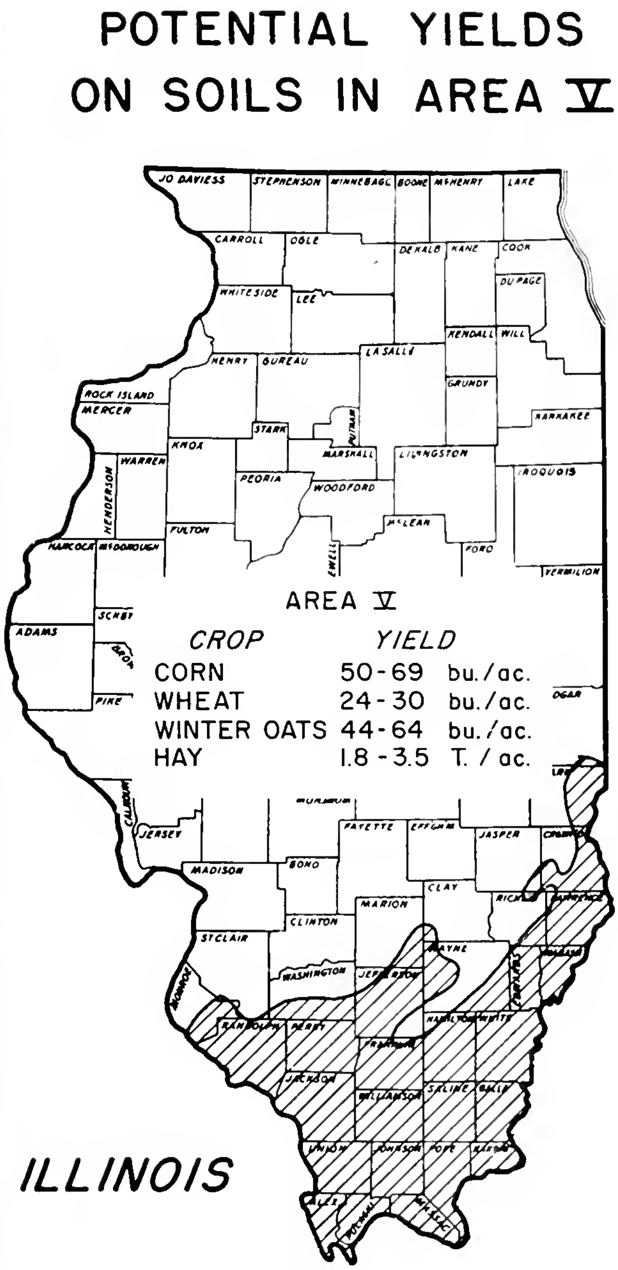


Figure 1

Farmers in southern Illinois can combat rising production costs by making most use of the potential productivity of their soils. Figure 1 shows a broad area, called Area V,[1/] in southern Illinois that includes soils formed from thin loess overlying acid weathered Illinoian drift or bedrock. It also indicates the crop yields that may be obtained under a high level of management[1/] over a period of years.

Crop yields vary with kinds of soils, management, and climate. Figures 2 and 3 show the ranges in average yields that may be obtained under four levels of management on some major soils in the area. For example, farmers on Alford soils may obtain yields that are higher than the average shown in Figures 2 and 3; farmers on the Bluford soils may obtain yields that are near the average; and farmers on the Grantsburg soils may obtain yields that are below the average shown for the area.

Because of variations in temperature and rainfall, additional variations of plus or minus 20 percent may be expected from year to year on all soils under any management level. For example, on Bluford soils under a high management level, corn yields may range from 48 to 72 bushels an acre, depending on the weather, and occasionally may even fall outside of that range.

Table 1 lists some of the major soils in Area V in decreasing order of their potential productivity. For example, the

1/ Management levels and potential productivity areas have been defined in SP-17, "Potential Productivity of Illinois Soils," published by the University of Illinois March 21, 1957.

Alford soils, which are potentially among the most productive in the area, are placed near the top of the list in Table 1; while the Bonnie soils, which are among the least productive, are placed near the bottom.

Table 1 also shows the amount of water that can be stored, available for plants, in the upper 60 inches of the soils in the list, and the estimated amount of water that is available in the normal rooting zone of corn growing in the various soils.2/ 3/ For example, the Patton soils retain about 12 inches of available water in the upper 60 inches, all of which is used by corn plants. This means that corn roots can penetrate to depths of 60 inches. On the other hand, the Hosmer soils retain about 17 acre-inches of available water, but only about 10 acre-inches are used by corn plants. This means that corn roots do not penetrate into the lower subsoil. Improved fertility practices on the Hosmer soils can extend root penetration so that more water is available to the plants growing there.

The last column in Table 1 lists the most essential soil treatments that should be included in soil management programs by farmers who wish to develop their soils to the optimum productivity level.

The information given above is essential if farmers are to obtain either maximum productivity or optimum economic productivity from their soils. Those who use such knowledge should be able to produce crops more efficiently and thus increase their net income.

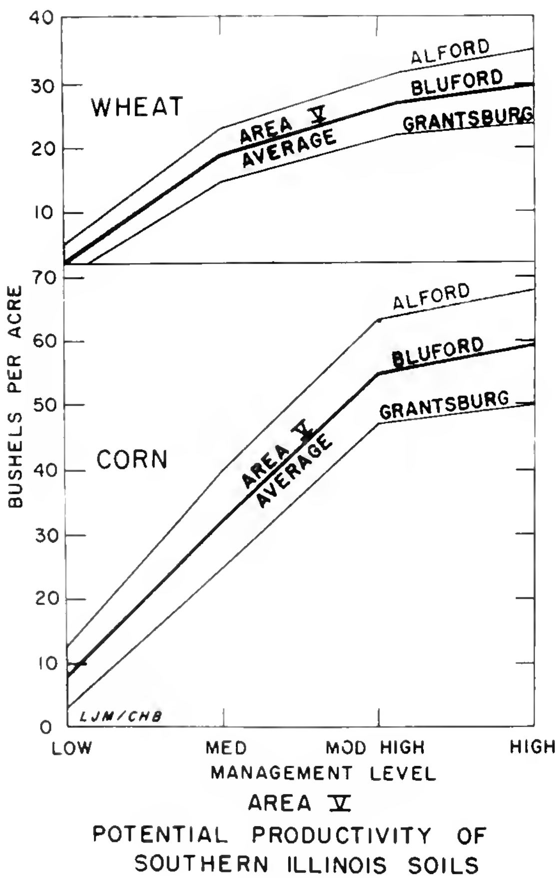


Figure 2

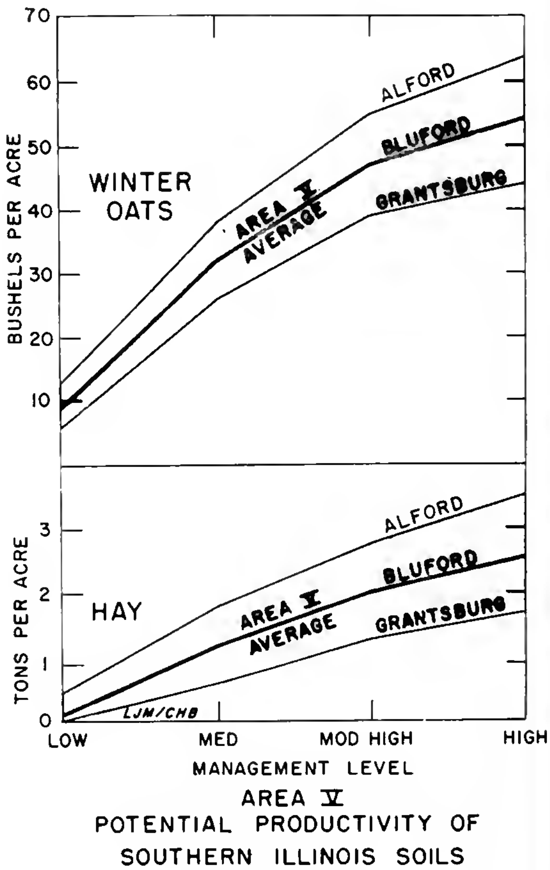


Figure 3

2/ Unpublished data from D. B. Peters and L. J. Bartelli of the U. S. Department of Agriculture.

3/ R. T. Odell, "Available Water-Holding Capacity of Some Illinois Soils," University of Illinois Department of Agronomy, AG-1731.

Table 1.--Special Characteristics of the Soils of Area V

Soil	Available water in soil (acre-inches) in 60-inch depth	estimated in corn root zone	Special treatments
Bonpas	12	12	Improve drainage with tile or surface drains; improve fertility.
Patton	12	12	Improve drainage with surface drains; improve fertility.
Alford	--	--	Control erosion; improve fertility.
Bluford	--	--	Improve drainage with tile or surface drains; improve fertility to encourage root penetration.
Ava	17	9	Control erosion; improve fertility to extend root penetration.
Hosmer	17	10	Control erosion; steep areas not adapted to grain crops; improve fertility.
Sharon	--	--	Protect from flooding; plant primarily spring and summer crops; improve fertility.
Grantsburg	17	8	Control erosion; improve fertility to extend root penetration.
Bonnie	16	10	Protect from flooding; improve drainage; improve fertility.

L. J. McKenzie
10-28-57

SOIL MOISTURE AS A FACTOR IN CROP GROWTH

Living plants are largely water. In addition to the water found in their living tissues, plants absorb large amounts of water that is discharged through their leaf surfaces in the process known as transpiration. In living plants, water serves as a medium for transporting nutrients from the roots to other parts of the plant and for carrying organic metabolites from the leaves to other regions of growth and respiration. Water under pressure in the cells gives the plant mechanical strength and, because of its high specific heat, acts as a temperature stabilizer in the plant.

On a hot, windy day in midsummer, one acre of corn in an Illinois field may transpire as much as 10 tons of water into the atmosphere. Even so, this probably will be only about half of the water lost from the field during that period, because normally water lost by evaporation from the soil surface accounts for about 50 percent of the total midsummer "water use" under Illinois conditions. This high water loss directly from the soil has two very important implications: (1) The efficiency of water use by crops is increased when acre yields are increased, because the fixed unproductive evaporation losses are distributed over more units of product; and (2) the reduction in water loss due to surface evaporation offers a possible means of meeting present and future water needs for agriculture.

Plants are not able to use all the water present in soils because the colloidal soil particles hold some of the moisture with a greater affinity than the plant roots can exert. The part of the total soil moisture that plants can remove is called the "available water." Plants wilt when the supply of available water is exhausted. The moisture percentage at which wilting occurs is known as the permanent wilting percentage, or PWP.

Water moves so slowly through soils that are not saturated that the plant roots are able to obtain it only from a small layer of soil no more than a fraction of an inch thick immediately adjacent to each root surface. As a consequence, plants having extensive root systems that are capable of thoroughly permeating a large volume of soil can get larger amounts of water than those having less well developed root systems.

The rate at which plant roots absorb moisture is determined by (1) the transpiration demands imposed on the roots by the aerial parts of the plant; (2) the moisture content of the soil; and (3) the permeability of the roots, which is related to the degree of maturity and metabolic activity. Low soil temperatures and inadequate aeration can both seriously reduce root permeability and restrict water intake.

The process of growth involves cell division followed by cell enlargement. In the absence of sufficient moisture, both of these processes are slowed down. The result is that the growth rate of the plant is reduced. Significant reductions in growth rate occur before the soil moisture is reduced to the permanent wilting percentage.

A moisture deficiency in plants due to reduced water intake causes a marked reduction in transpiration because of closure of the leaf stomata. This reduction occurs before wilting or other signs of moisture stress are visible. If the moisture deficiency reduces the moisture in the leaves, it will usually be accompanied by a drop in the rate of photosynthesis, because this process depends on the degree of hydration of the chloroplasts and other protoplasmic constituents.

Plants that are subjected to moisture deficiency usually show a decrease in percentage of starch and an increase in total and reducing sugars. This is attributed to the effect of moisture on the activity of enzymes in the plant. In general, moisture deficiency reduces vegetative growth, but frequently moderate moisture stress hastens maturation and improves the quality of the nonvegetative plant parts.

M. B. Russell
12-23-57

SOIL TEMPERATURE AND PLANT GROWTH

Soil temperature affects plant growth directly by influencing the growth and physiologic functioning of plant roots and indirectly through its effect on nutrient supply, disease incidence, and movement of air and water through the soil. Since soil temperature in the rooting zone changes widely with depth and with time, it is difficult under field conditions to establish quantitative relationships between plant behavior and soil temperature. However, many studies conducted under controlled laboratory and greenhouse conditions have established the nature of root response to temperature conditions. These results have been used to develop a qualitative picture of root behavior under natural field conditions.

Effects of soil temperature on root growth and metabolism. The physiologic processes occurring in plant roots involve chemical and enzymatic reactions and the transport of inorganic and organic materials. These processes as well as such physical reactions as adsorption are all known to depend on temperature. Physiologic activity of roots of most crop plants falls to a very low level at a temperature lower than 40° F. As the temperature is increased, activity increases rapidly until a maximum is reached which varies rather widely for different crops. At higher temperatures activity is reduced by inactivation of certain enzyme systems and by the accumulation of inhibitory products of respiration.

Respiration is the process by which energy is made available for the cellular activities of the plant. Since these activities include the synthesis and translocation of materials used in building new plant tissues, it is clear that respiration is a vital function of living plants. It involves the oxidation of carbohydrates and the liberation of energy. The rate of respiration increases as the temperature rises, unless it is limited by accumulation of respiratory products, by a deficiency of oxygen, or by inactivation of the enzymes involved.

Carbohydrates and other materials move throughout the plant by the process of translocation. This process is also speeded up by increasing temperature. However, since translocation is essentially a physical process, the effects of increasing temperature are less marked than in respiration, which is primarily a chemical process. This difference in temperature response between translocation and respiration is important in the influence of temperature on root reserves, and on winter survival of certain crop plants. The accumulation of such reserves, with the resultant increase in winter-hardiness, is favored by low root temperatures.

The ability of plant roots to absorb both nutrients and water depends upon the permeability of the root surfaces. Since permeability is in turn influenced by the metabolic activity of the roots, it is not surprising that the absorption of both nutrients and water is affected by temperature. The rate of accumulation of ions by root cells has been shown to be doubled by increasing the temperature from 60° to 80° F. Low temperatures also seriously retard water absorption to the extent that wilting will occur. Where water absorption is retarded by cold soils, a considerable amount of winter injury to the aerial parts of the plant may occur, especially during periods of high transpiration rates.

Soil temperature affects nutrient supply. The release of nitrogen from complex organic compounds in soils is a biological process. As such it is strongly affected by temperature. The decomposition of organic matter results in the liberation of ammonia, which is then oxidized to nitrate by the nitrifying organisms of the soil. Both processes essentially cease at temperatures below 40° F. With increasing temperatures the transformations are accelerated, reaching maximum rates in the vicinity of 90° F.

Nitrogen fixation by legume bacteria also shows a marked dependence on temperature, the maximum occurring at about 85° F. The accelerated biological activity associated with higher soil temperatures also facilitates the release of phosphorus from the complex organic forms, as well as the release of potassium and other plant nutrient ions from unavailable combinations in the soil.

Soil temperature affects germination. Germination, emergence, and early growth of plants are intimately related to soil temperature. The minimum temperature for germination and emergence is about 40° F. for such vegetables as radishes, peas, and lettuce. Corn and beans require a temperature of 50° to 55° F. or higher. High soil temperature at planting time results in increased elongation of the subcrown interncde of certain sorghums and wheat. In winter wheat this may contribute to poorer winter survival. Since germination is primarily a process of water absorption, followed by the hydration and activation of enzyme systems in the seed, it is favored by temperatures conducive to rapid water intake.

Soil temperature and plant diseases. The occurrence and severity of some seed- and soil-borne diseases are strongly affected by soil temperature. Seedling blights, root rots, and several wilts are markedly influenced by temperature. In general, this influence is shown through the effect on the growth rate of the causal organism and on the vigor of the invaded plant. Thus the same fungus that causes seedling blight on both corn and wheat causes severe infection cn corn at low temperatures but is serious on wheat only at high temperatures. In a similar fashion pre-emergence damping-off is most prevalent at temperatures less favorable to the host that to the pathogen.

M. B. Russell
1-6-58

USING SOIL SURVEY INFORMATION AS A BASIS FOR EVALUATING FARM LAND FOR TAX PURPOSES

Equitable taxation of rural lands depends on proper assessment of value as affected by the earning capacity of the land. Land values are determined in the market place; but since market values are not available for every tract of land, some method is needed to appraise land for which no market value has been established.

The best criterion of the value of land is some index of its productivity or earning capacity, under different systems of management, for whatever uses are within its capabilities. Productivity indexes can be related to market values. Once the relation is established, the relative value of any tract of land can be determined.

Accuracy in evaluating individual tracts of land is dependent on the accuracy with which soil maps represent the productivity units in each tract. Modern detailed soil survey maps in Illinois show soil mapping units that are sufficiently uniform in productivity to be more than adequate for this purpose. Productivity indexes have been established for the soils at two management levels and for three different uses, namely, cropland, pasture land, and forest land. They are available in Illinois Agricultural Experiment Station publication AG-1443 entitled "Illinois Soil-Type Descriptions," or they may be obtained from the University of Illinois Department of Agronomy.

Soil maps that differ in adequacy for use in land appraisal are available for 85 counties in Illinois, and new detailed maps are being prepared in deficient areas as rapidly as possible. Soil maps for Illinois counties are classified here according to their adequacy for land appraisal purposes.

<u>Class I</u>. Excellent for land appraisal purposes. Soil maps are made on aerial photographs at a scale of 3 1/4 and 4 inches to one mile. Slope and erosion classes are included on all maps except Cass, Christian, Iroquois, Kendall, and Livingston Counties. Not all of these soil maps have yet been published, but field sheets are available for reproduction for all counties except Carroll and LaSalle.

Carroll	Jersey	Livingston
Cass	Johnson	McHenry
Christian	Kendall	Menard
Henderson	LaSalle	Wabash
Iroquois	Lawrence	Will
		Williamson

<u>Class II</u>. Adequate for land appraisal purposes if supplemented by appropriate modern interpretation by a qualified soil scientist. Soil maps are published at a scale of 1/2 and 1 inch per mile, and therefore detail is limited. Slope and erosion classes are not delineated. Some remapping is needed if great accuracy is desired, especially where complex soil patterns occur.

(a) Modern soil-type numbers and names

Alexander	Jackson	Shelby
Boone	Jasper	St. Clair
Clinton	Marshall	Stark
Cumberland	Pulaski	Vermilion
DeWitt	Putnam	Warren
Ford	Schuyler	Washington

(b) Modern soil-type numbers and old descriptive names

Calhoun	Fayette	Macoupin
Effingham	Fulton	Piatt
		Wayne

Class III. Limited usefulness for land appraisal. Old soil-type numbers with descriptive names were used. These soil surveys were completed and published prior to 1930 at a scale of 1/2 inch per mile. In areas where soil patterns are simple, generalized land classification maps can be prepared under the guidance of an experienced soil scientist. Where soil patterns are complex, adequate maps cannot be prepared without a detailed soil survey.

(a) Counties with simple soil patterns

Clay	Franklin	Mercer
Coles	Knox	Morgan
Crawford	Logan	Moultrie
Douglas	McDonough	Peoria
Edgar	Macon	Saline
Edwards	Marion	Sangamon
		Tazewell

(b) Counties with complex soil patterns

Adams	Hardin	Monroe
Bond	Henry	Ogle
Bureau	Kane	Pike
Champaign	Kankakee	Randolph
DeKalb	Lake	Rock Island
DuPage	Lee	White
Grundy	Mason	Whiteside
Hancock	McLean	Winnebago
		Woodford

Class IV. Counties in Illinois for which no soil maps or reports have been published.

Brown	Jefferson	Pope
Clark	JoDaviess	Richland
Cook	Madison	Scott
Gallatin	Massac	Stephenson
Greene	Montgomery*	Union
Hamilton	Perry	

*Field work on a new soil map of Montgomery County is now in progress.

Soil maps can be obtained from the University of Illinois Department of Agronomy. Arrangements for obtaining photographic reproductions of soil survey field sheets can also be made through the Department of Agronomy. University of Illinois soil scientists are available for consultation on any matter involving the interpretation and use of soil maps for land appraisal purposes. Counties that do not have adequate soil maps should prepare generalized land classification maps, using the available soil maps and maps from any other useful sources.

Assuming that accurate records of property ownership are available, the basic steps involved in making equitable appraisals of farm lands for tax assessment purposes are:

(a) Obtain soil maps that show the distribution of each kind of soil or class of land.

(b) Establish base values for each kind of soil or land class in each likely kind of use by correlating soil productivity indexes with market values and recording the base values in some convenient manner.

(c) Calculate the values for individual tracts of land by:

(1) applying the appropriate base value to each kind of soil in the tracts for each kind of land use and

(2) making the necessary adjustments for location, kind of roads, presence of minerals, or other factors that enhance or reduce the value.

The above procedure is applied to the bare land, exclusive of the value of the buildings. The value of the buildings to the farm unit must be determined separately and added to the value of the land for the final appraisal.

Detailed instructions for appraising farm lands for taxation purposes are available in the 1958 reprint of the Real Property Assessment Manual of the Property Tax Division, Illinois Department of Revenue.

L. J. McKenzie
4/14/58

NATIVE VEGETATION AND SURFACE SOIL COLOR IN ILLINOIS

Native vegetation, as the term is used here, is the natural vegetation that was present under the climatic, soil, and topographic conditions existing some time previous to and at the time of settlement of Illinois. The natural vegetation of Illinois at the time of settlement was not necessarily in balance with the climate. For example, under the humid temperate climatic conditions that probably have been more or less stable for hundreds and perhaps thousands of years, it is believed that the prairies in Illinois would have eventually given way to forest vegetation. The prairies are therefore thought to result frcm a drier climate that prevailed in this region some 4000 to 6000 years ago. Soil development evidence indicates that there was widespread encroachment of forests upon the prairies along forest-prairie borders in Illinois.

Within each of the three broad areas shown on the accompanying map, there are variations in both native plant species and surface soil color. Probably climatic adaptation and soil moisture conditions are the chief reasons for these variable plant communities. Listed in the accompanying table are the common names of some representative native species of prairie and forest vegetation. In the mixed forest and prairie vegetation areas, various species of both prairie and forest were present. Soil moisture conditions, native plant species, and degree of soil development account for much of the variation in surface soil color within a given area.

In the prairie areas of Illinois, surface soil moist color is lighter and somewhat more brown in the southern upland sections and on the better drained or drier sites in the central and northern sections than on moist and wet sites in the central and northern sections. In general the upland prairies of southern Illinois have more strongly developed soils with lower organic matter content than those of the central and northern sections.

Some of the more rolling prairies, particularly in the southern sections, probably had some shrubs, scattered trees, and brush. The prairies of western Illinois had some distinctly western plants, such as grama grass and the lead plant. Native prairies in Illinois occurred on stream terraces as well as on uplands.

Areas that had native forest vegetation for a sufficient time have light-colored surface soils. These areas had a large number and great variety of native trees. Although surface soils that developed under forest vegetation are light-colored, those in northern Illinois tend to be slightly darker than those in the rest of the state. Light-colored forest soils occur on the uplands, stream terraces, and bottomlands in Illinois.

The third broad area shown on the map--mixed native forest and prairie vegetation with moderately dark- to dark-colored soils--occurs, for the most part, on terraces and bottomlands along many of the major streams in the state. In these physiographic positions the sediments, even in southern Illinois, are chiefly of Wisconsin glacial age and are not highly weathered. Various grasses that were interspersed with the forest vegetation contributed some organic matter. Also, some of the mcderately dark and dark color in some of these soils was inherent in the sediments as they were deposited.

Also included in the mixed forest and prairie vegetation areas with moderately dark- to dark-colored soils are the prairie to forest transition soils, which often occur as rather narrow bands between true prairie and true forest soils. The area in northeastern Will and southern Cook counties is one of the few upland prairie to forest transition areas large enough to be shown on the map. Other areas of transition soils of the narrow, banded type are included with the light-colored soils developed under forest vegetation on the map. Generally the transition soils of the banded type occur next to areas that had prairie vegetation. Native vegetation in the transition zone was a mixture of prairie and forest plants. Bur oak was a common tree in these areas of mixed vegetation where forest had invaded the prairie. The trees, in general, had not been there long enough to cause great changes in some of the soil characteristics imparted by an earlier grass vegetation.

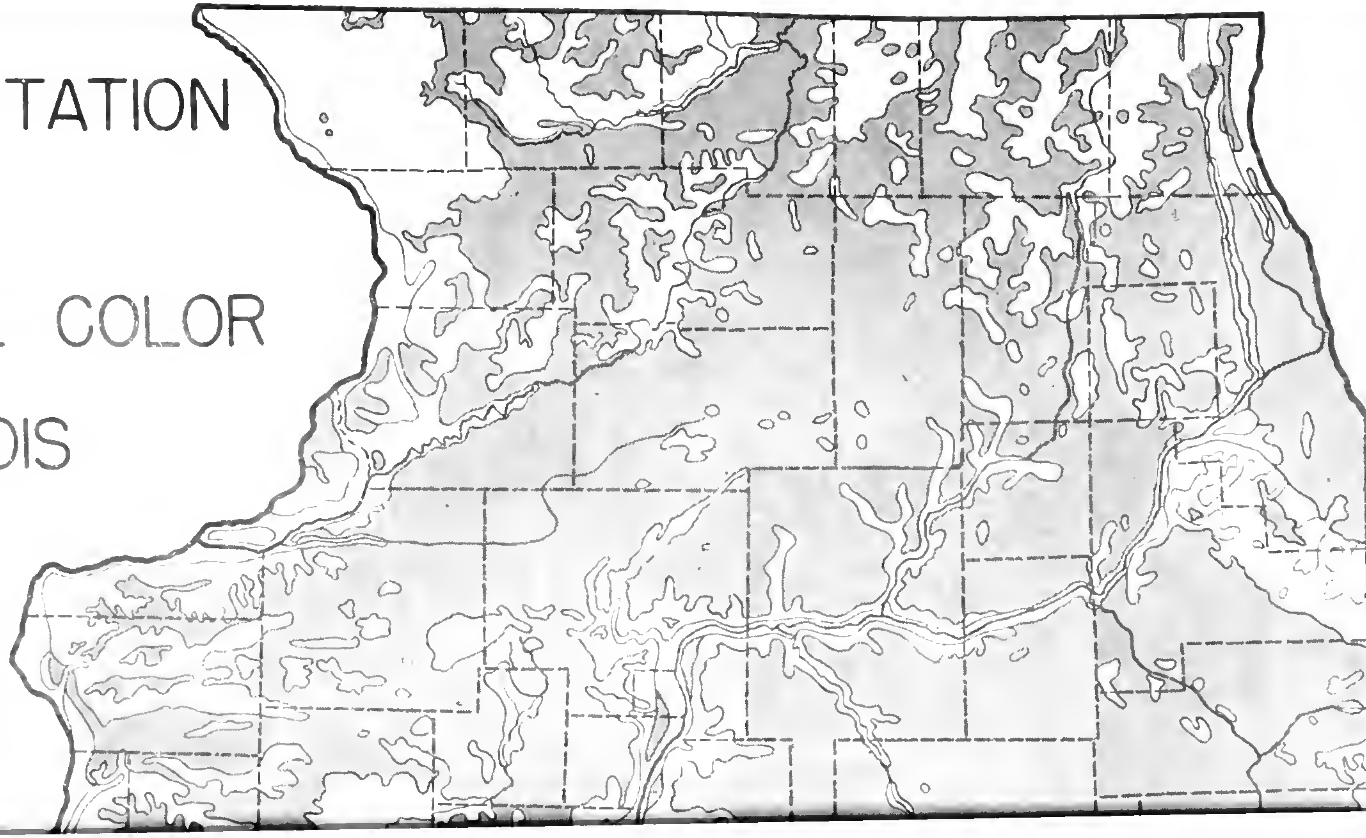
In the following table the common names of some representative plants in the native prairie and forest vegetation of Illinois are arranged according to site, largely on the basis of soil moisture conditions. The moisture site categories are of course arbitrary, and many plants occur to some extent on more than one kind of site. Climatic adaptation from north to south is also indicated for some species. This table was developed with the help of A. G. Vestal and L. C. Bliss of the University of Illinois Botany Department, and R. A. Evers of the Illinois Natural History Survey. References include the USDA Yearbook of Agriculture for 1938, 1948, and 1949; University of Illinois Agricultural Experiment Station Bulletin No. 205, "The Grasses of Illinois," by Edna Mosher, 1918; "Forest Trees of Illinois" by R. B. Miller, Department of Conservation, Springfield, 1935; USDA Misc. Pub. 200, "Manual of the Grasses of the United States" by A. S. Hitchcock, 1935; and University of Illinois Agricultural Experiment Station county soil reports.

J. B. Fehrenbacher and J. D. Alexander
4-28-58

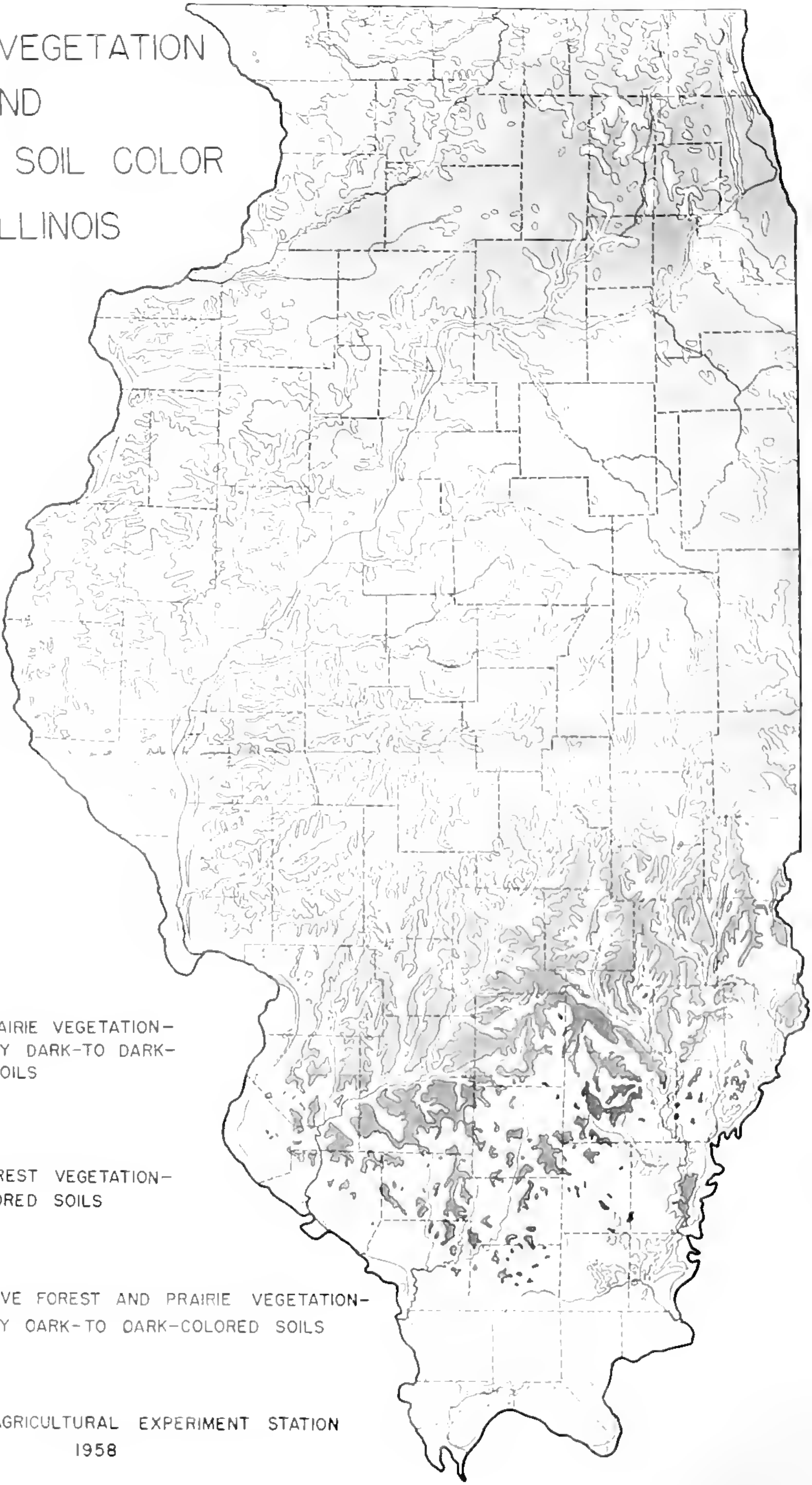
Some Representative Native Prairie and Forest Plants of Illinois Grouped According to Site and Climatic Adaptation

Prairie			Forest		
Wet	Mesic	Dry	Wet	Mesic	Dry
Switch grass	Big bluestem	Little bluestem	SOUTH	SOUTH	SOUTH
Slough grass or cord grass	Indian grass	Switch grass	Cypress	Tulip tree	Blackjack oak
Meadow grasses (Calamagrostis and others)	Prairie drop-seed	Lead plant	Tupelo gum	Sweet gum	Post oak
Sedges	Scribner's panic grass	Bush clover	Swamp cottonwood	Beech	Chestnut oak
Rushes	Purple prairie clover	Compass plant	Swamp hickory	Southern red oak	Persimmon
Water hemlock	Wild indigo	Blazing star	Swamp chestnut oak	Winged elm	Tree huckleberry
	Prairie coneflower	SANDY SOILS	Willow oak	Catalpa	Shortleaf pine
	Rosin weed	Tumble grass	Swamp Spanish oak	Black gum	NORTH
	Big blazing star	Big sand grass	Pumpkin ash	Cucumber magnolia	Jack pine
		Little red tumble grass	Planer tree	NORTH	ENTIRE STATE
		Panic grasses	One-seeded honey locust	Paper birch	Red cedar
		Partridge pea	Sugarberry	White pine	Bur oak
		Trailing bean	NORTH	Choke cherry	Yellow oak
		Perennial ragweed	White cedar	Rock elm	Black oak
		CALCAREOUS LOESS OR HILL PRAIRIE	Tamarack	ENTIRE STATE	Sassafras
		Side oats grass	Yellow birch	White oak	Blue ash
		Wild alfalfa	Quaking aspen	Red oak	
		White prairie clover	Mountain ash	Black oak	
			ENTIRE STATE	Bur oak	
			Swamp white oak	Yellow oak	
			Pin oak	Shingle oak	
			Soft maple	Butternut	
			Sycamore	Bitternut hickory	
			Ash	Mockernut hickory	
			Box elder	Pignut hickory	
			Black willow	Shag-bark hickory	
			Kentucky coffee tree	American elm	
			River birch	Slippery elm	
			Pecan	White ash	
			Red cedar	Green ash	
				Sycamore	
				Black walnut	
				Sugar maple	
				Basswood	
				Red bud	
				Hawthorns	
				Black cherry	
				Ohio buckeye	
				Dogwood	
				Honey locust	
				Kentucky coffee tree	
				Hackberry	
				Mulberry	
				Iron wood	
				Red cedar	

NATIVE VEGETATION AND SURFACE SOIL COLOR IN ILLINOIS



NATIVE VEGETATION AND SURFACE SOIL COLOR IN ILLINOIS



NATIVE PRAIRIE VEGETATION—MODERATELY DARK-TO DARK-COLORED SOILS

NATIVE FOREST VEGETATION—LIGHT-COLORED SOILS

MIXED NATIVE FOREST AND PRAIRIE VEGETATION—MODERATELY DARK-TO DARK-COLORED SOILS

UNIV. OF ILL. AGRICULTURAL EXPERIMENT STATION
1958

INFLUENCE OF NATIVE VEGETATION ON SOIL CHARACTERISTICS

Soil characteristics have been influenced by the native vegetation that grew on the soil prior to cultivation. Two kinds of native vegetation are particularly important in Illinois, namely, prairie and forest. The soils developed under each of these kinds of native vegetation differ from each other in their morphological, chemical, and physical properties.

The morphological features of prairie and forest soils differ markedly (Fig. 1). Soils on which forest has grown for a long time have developed a very light colored, ashy subsurface (A_2) horizon and a surface that is much lighter in color and thinner than those of associated soils developed under grass vegetation. Also, the platy structure of the subsurface (A_2) horizon of a forested soil is quite different from the granular to very fine subangular blocky structure of the lower part of the A_1 horizon that occurs at a comparable depth in a prairie soil. These differences can be readily observed.

The chemical and physical differences are harder to see with the naked eye.

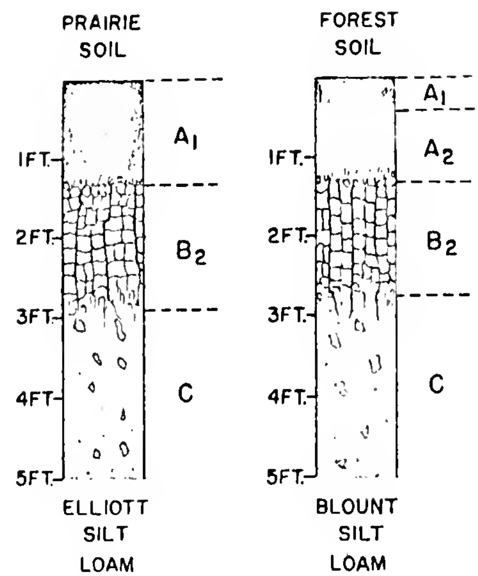


FIG. 1 - COMPARISON OF A FOREST SOIL AND A PRAIRIE SOIL.

Following are some of the chemical differences (Table 1):

1. pH is normally lower in the upper horizon of the forest soil than in the prairie soil.

2. Organic carbon content is less in the forest soil.

Table 1.--Some Chemical and Physical Characteristics of Soils Developed Under Forest and Grass Vegetation

	Depth	Horizon	pH	Organic carbon	Base saturation	Less than 2-micron clay
	in.			%	%	%
Blount silt loam (forest soil)	0-4"	A_1 (surface)	5.6	3.0	75	18
	4-7"	A_2 (subsurface)	5.2	1.4	72	17
	14 1/2-25	B_2 (subsoil)	4.7	.7	80	45
	30+	C (parent material)	8.0	.4	100+	28
Elliott silt loam (prairie soil)	0-5	A_1 (surface)	6.2	4.3	92	25
	14 1/2-24 1/2	B_2 (subsoil)	6.0	1.1	90	40
	29+	C (parent material)	7.9	.6	100+	29

3. Base saturation percentage is lower in the forest soil. Base saturation refers to the relative abundance of such bases as calcium, magnesium, sodium, and potassium in relation to hydrogen attached to the clay colloids.

The main physical difference is in the content of less than 2-micron clay (Table 1). The forest soil has less clay in the surface horizon and more in the subsoil, indicating that some of the clay in the upper horizons has moved into the subsoil.

Where the forest has existed for a relatively short time, the soils have characteristics between those of prairie and forest soils in most respects. These "transition" soils normally occur in narrow bands around the forest soil as it grades into prairie. There are some extensive areas of transition soils in Illinois, the largest being located in northeastern Will County and southern Cook County.

In a summary of the influence of forest vs. prairie vegetation on soil characteristics, the following two points stand out:

1. The distribution of organic matter is different. The forest soil contains only a small amount of organic carbon, which is primarily restricted to a thin surface (A_1) horizon.

2. Translocation of mineral substances is greater under forest than under prairie vegetation. The result is greater leaching and faster development of soils under forest vegetation.

Since the forest soils leach more readily and develop faster than the prairie soils, they are less productive, as indicated by the productivity index, under a low level of management than the transition or prairie soils. The following productivity indexes for grain crops are taken from Ill. Agr. Exp. Sta. publication AG-1443, "Illinois Soil Type Descriptions."

Soil type	Native vegetation	Prod. index under low level of mgt.	Prod. index under mod. high level of mgt.
Elliott silt loam	Prairie	65	110
Beecher silt loam	Prairie-forest	55	90
Blount silt loam	Forest	45	90

J. D. Alexander
May 5, 1958

DARK-COLORED CALCAREOUS SOILS IN ILLINOIS

About a dozen soil series occur in Illinois that are calcareous throughout the soil profile. Of special interest are the dark, naturally poorly or imperfectly drained calcareous soils that occupy several thousand acres in the northern half of the state (Table 1).

These soils are commonly but incorrectly called alkali soils. The term alkali is presently restricted to soils that are either strongly alkaline (pH 8.5 or higher) or have 15 percent or more of the cation exchange capacity saturated with sodium, or both. Alkali soils occur most commonly in arid or semiarid regions.

The term alkaline or calcareous is more correct for the soils discussed here because they are normally mildly to moderately alkaline and will effervesce visibly when treated with dilute hydrochloric acid. Exchangeable sodium percentages are not known to be excessive.

Occurrence. The dark calcareous soils, although found throughout northern Illinois, occur most extensively in areas where medium-textured glacial till and outwash of Wisconsin age are the important parent materials. These soils occur frequently in areas as small as a fraction of an acre and occasionally in areas as large as a few hundred acres.

Most areas of these soils were originally swamp land that has been drained and brought under cultivation. Some areas, where drainage outlets are not readily available, still exist in an undrained condition. This is especially true of the Lena and Millington soils.

Most of these soils occur in nearly level areas, in shallow depressions, as low knolls in depressions, or as rings around the edges of depressions. They are occasionally found on slopes where springs or seep water causes drainage to be poor.

Characteristics. These soils have dark-colored surface horizons that are high in organic matter. They have little or no accumulation of clay in the subsoil. The substrata are quite variable because of the variety of parent materials in which they are mapped.

These dark calcareous soils contain variable amounts of calcium carbonate in the surface and oftentimes throughout the profile. They also usually contain smaller amounts of magnesium carbonate. The calcium carbonate is largely in the form of snail shells or shell fragments that may be easily seen with the naked eye. These fragments impart a whitish cast to the soil surface. However, calcareous areas have been observed where no snail shells were present, indicating that carbonates occur in forms other than snail shells.

Origin. Most of the areas are located in topographic positions that suggest old shallow lake beds. Their occurrence in areas of high-lime glacial materials suggests that the ground-water was highly charged with calcium and magnesium. As these lakes filled with sediment, or as the water table was lowered, calcium and magnesium salts could precipitate out. If the water table was high, evaporation at the soil surface could also concentrate these salts.

Special types of vegetation growing in these wet areas may have concentrated calcium and magnesium within their cells and upon dying could have caused accumulations in the soil.

The usual presence of snail shells helps to support the widely accepted theory that the snails were primarily responsible for the calcium and magnesium carbonate accumulation. These elements were available to the snails through the water or vegetation in the area. The abundant shells could concentrate the carbonates quite readily. The location of the areas of shell concentration, often as a ring around a drained area, suggests that the snails lived in a rather critical depth of water or on vegetation that grew in a certain critical depth of water.

The origin of these calcareous soils has been the subject of much speculation, but no entirely acceptable theory has been proposed. It is probable that a combination of factors was responsible for their development.

Effect on crops. Excess carbonates have a detrimental effect on crops growing in these soils. Corn is especially affected. The seed germinates and grows well for a short time, and then the edges of the leaves turn brown and the plants turn yellow, become stunted, and appear to be diseased. The few ears that are produced are small and chaffy. Small grains grow rank, lodge badly, and produce shriveled grain. Sweet clover and alfalfa grow much better than grain crops.

All possible causes of the unproductiveness of these soils when untreated are probably not known. In the past, on the basis of meager evidence, it has been attributed to toxicity of various cations or anions in the soil solution. The present most widely accepted concept is that the unproductiveness is due not to a single factor, but to a combination of factors. The high content of calcium in the soil solution causes the availability of other essential elements to decrease, even though the total amount of these elements may be high. It is believed that low availability of potassium and a high concentration of nitrate nitrogen explain much of the unproductive nature of these soils.1/

Management. When calcareous or alkaline soils are properly drained and fertilized, they can be made as productive as the other dark soils that are associated with them. If this is not done, they will remain relatively unproductive.

The first requirement is to provide adequate drainage. In most areas these soils will tile-drain well where good outlets are available. In a few areas sandy and gravelly substrata interfere with tile installation, and there may be danger of overdrainage.

Potassium fertilization usually produces excellent results, especially for corn. The low availability of potassium is often shown by soil tests. Applications of straw and strawy manure may give better results than potassium salts, although either will be beneficial.

Phosphorus fertilization gives variable results. The phosphorus test currently in use in the county laboratories is not adequate for calcareous soils. When phosphate fertilizers are applied, highly soluble forms should be used. Banding or hill-dropping is recommended for corn to get the most efficient use of fertilizer. Rock phosphate is not recommended on these soils, as it would have very low availability.

Liming is a foolish waste of time and money on these soils, which already have an excess of calcium carbonate.

Little is known about the possible beneficial effects of adding sulfur or other amendments in an attempt to lower the pH and bring about better physiological balance in the soil solution and the exchange complex.

1/ Factors Contributing to the Unproductiveness of "Alkali" Soils in Illinois, O. H. Sears, Soil Science, Vol. 30, No. 5, p. 325, 1930.

Table 1 - Parent Material, Physiography, and Natural Drainage of Dark-Colored Calcareous Soils in Illinois

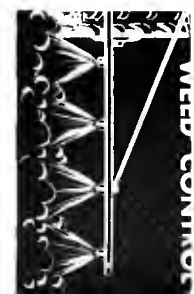
Soil series	Types mapped	Parent material	Physiographic position	Natural drainage
Millington	Loam, silty clay loam	Medium- to fine-textured sediments often over sand and/or gravel	Bottom	Very poor to poor
DuPage	Silt loam	Medium-textured sediments often over sand and/or gravel	Bottom	Imperfect
Harpster	Sandy loam, loam to silt loam, silty clay loam	Medium- to coarse-textured outwash, sandy loam till, loam till, silty clay loam till, and deep loess	Upland and terrace	Very poor to poor
Lena*	Muck and peat	Deep muck and peat or thin muck or peat with varying textures of underlying mineral material	Upland, terrace, and bottom	Very poor

*For discussion on management of organic soils, see SM-20.

B. W. Ray
5/12/58

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE

AGRONOMY FACTS



W-12

HERBICIDES FOR NON-CROP AREAS

Following is a listing of some chemicals that show promise for use as weed killers in fencerows, around farm buildings, in commercial storage areas, and in other non-crop areas. Most of them are long-residue chemicals. Read label directions carefully.

Product	Manufacturer	Material	Physical state	Method of application	Rate	Water solubility	Fire hazard	Remarks
Agronyl P	Socony-Mobil	Aromatic petroleum oil	Liquid	Spray	80-100 gal. per A.	Insoluble	Yes	Inexpensive - not a residual spray.
Ammate	Du Pont	Ammonium sulfamate	Powder or liquid	Dry or spray	3/4 to 1 lb. per gal. water	Soluble	No	Spray plants thoroughly. Not hazardous to humans or livestock. Requires high rate of application.
Atlacide	Chipman	58% sodium chlorate	Powder	Spray or dry	5 to 7 lb. per sq. rod	Soluble	Yes	Soil moisture needed for best results.
Baron	Dow	Erbon	Liquid	Spray	30 to 40 gal. per. A.	Low	No	Some plants resistant. Irritating to skin and eyes. Danger of drift and leaching.
Borascu	Pacific Coast Borax	Sodium chlorate ore	Granular	Dry	15 lb. per sq. rod.	Low	No	Long residue, high rate of application.
Borascu 44 or Conc. Borascu	Pacific Coast Borax	As above	As above	As above	7 to 10 lb. per sq. rod	As above	As above	As above.
Chlorax liquid Chlorax 40	Chipman	Mixed chlorate and borate	Liquid or powder	Spray or dry	400 gal. per A. 6 lb. per sq. rod	Soluble	Reduced	High rate of application needed.
Chlorea	Chipman	Mixed chlorate and borate with CMU	Powder	Spray or dry	6 to 7 lb. per sq. rod	Soluble	Reduced	As above.
Gerstley borate	Pacific Coast Borax	Sodium and calcium borates	Granular	Dry	12 to 15 lb. per sq. rod	Low	No	Long residue, needs abundant rainfall.
HCA	Allied Chem. & Dye Corp.	Hexachloroacetone plus aromatic petrol. deriv.	Liquid	Spray	5 to 15 gal. per A.	Low	Yes	Irritating; avoid mist. Mix with oils - 1 part HCA with 9 parts oil.
PCP (under various trade names)	Monsanto	Pentachlorophenol	Liquid	Spray	1 gal. per A.	Low	No	Highly toxic. Expensive. Mix with oil. No residue.
Polybor	Pacific Coast Borax	Mixed borates	Powder	Spray or dry	6 lb. per sq. rod	Soluble	No	Poor on grasses.
Polybor chlorate	Pacific Coast Borax	Mixed chlorates and borates	Granular	Spray or dry	6 to 7 lb. per sq. rod	Soluble	No	Long residue, poor on grasses.
Radapon	Dow	Dalapon	Powder	Spray	30 to 50 lb. per A.	Soluble	No	Short residue. Good control of grasses only. Safe to use.
Simazin 50W	Geigy	Triazine derivative	Powder	Spray	10 to 20 lb. per A.	Very low	No	Safe to use. Noncorrosive. Not a top killer.
Sodium arsenite	Under various brand names	Powder or solution of sodium arsenite	Powder or liquid	Dry or spray	8 lb. per sq. rod	Low soluble	No	Toxic to man and animals. Liquid difficult to handle.
Sodium chlorate	Under brand names	Sodium chlorate	Powder	Dry or spray	4 to 5 lb. per sq. rod	Soluble	Extremely great	Best results with abundant rainfall. Inexpensive.
Sodium TCA	Mostly Dow	Sodium salt of trichloro acetic acid	Powder	Spray	60 to 100 lb. per A.	Soluble	No	Leaches easily. Good control of grasses.
Telvar DW	Du Pont	Diuron	Powder	Spray	20 to 60 lb. per A.	Low	No	Long residue. Difficult to apply. Irritating to skin and eyes. Leaches.
Telvar W	Du Pont	Monuron	Powder	Spray	20 to 60 lb. per A.	Low	No	As above.
Ureabor	Pacific Coast Borax	Sodium borate and CMU	Granular	Dry	3 to 5 lb. per sq. rod	Low	No	Long residue. Some irritation.
Urox	General Chemical Co.	Dimethylurea-trichloro acetate	Granular	Dry	125 to 150 lb. per A.	Low	No	May leach. Low toxicity to man and animals.

This listing is not intended to be complete. Many compounds are being formulated and evaluated every year for non-selective weed control purposes.

E. C. Spurrier
12/2/57