# THE EFFECT ON GERMINATION OF ARTIFICIALLY DRYING AND FREEZING SEED CORN

by

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# INTRODUCTION

As hybrid corn has come into general use and has largely replaced open-pollinated varieties the cost of producing hybrid seed has risen markedly due to the complexity of the technics and the greater amount of knowledge, labor, and equipment required. As a result the hybrid seed grower has had to take steps to protect his investment. These measures include insurance on the crop in the field as well as in the crib or warehouse, insurance on storage facilities, protection against freezing by harvesting early and artificially drying the seed.

Artificial drying of seed corn to escape damage due to freezing in the field before the crop is mature is a common practice in the corn belt where commercial hybrid seed has been produced extensively for several years. In Kansas the change from open-pollinated varieties to hybrids has been quite recent. For example, only 13 percent of the total corn acreage in Kansas in 1941 was hybrid (1). In 1945 this figure had risen to approximately 64 percent (2). So the adjustments in corn seed production practices in Kansas are in the early stages of development. The need for artificial drying facilities is becoming generally recognized in the state. As of January 1946 approximately 15 commercial Kansas growers had artificial drying facilities.

Information on artificial drying of seed corn is somewhat limited and there has been no experimental work done on this problem in Kansas. The commercial seed corn producer therefore is handicapped by lack of information, particularly regarding optimum drying temperatures for the various levels of moisture in corn. Drying temperatures ranging from 105° to 110° F. have been generally used.

## PURPOSE

The primary purpose of this study was to determine, if possible, the optimum drying temperatures, under Kansas conditions, for the range in moisture and degree of maturity at which seed growers may artificially dry seed corn. Other factors to be considered included the difference in rate of drying and final germination between a hybrid which dries out slowly in the field and one which dries rapidly, the affect of length of time of exposure to a given temperature on germination, and the relation between the moisture content of the seed when harvested and final germination.

Correlated with this project was a study to determine the differential affect of freezing on the germination of the two types of hybrids mentioned above. It was considered desirable to get data on freezing samples from the same material being dried in the hope that the results might more nearly present a complete picture of the problem and the results. A study was also made of the protection afforded by the husk against damage by freezing. Some seed producers are interested, in certain years, in whether it is wise to store the ear corn in the husk to give it the added protection against freezing. This implies that the crop will be harvested before it is fully dry. Seed growers are likewise interested in the effectiveness of husks in protection against freezing damage in the field.

Information obtained during the early part of these investigations indicated that the germination of some of the artificially dried seed corn might be improved by certain chemical seed treatments. Therefore a study was made to determine the influence of several chemicals on germination in the field.

## REVIEW OF LITERATURE

Wasko (3) dried inbred lines, single-cross seed, double-cross seed, and an open-pollinated variety at temperatures varying from 105° F. to 125° F. at various stages of maturity from early to late dent. Among the factors studied, drying temperature appeared to have the greatest influence on germination and seedling vigor, emergence in soil, and subsequent plant growth. Susceptibility to heat injury was found to be directly related to moisture content. On one series of strain comparisons a drying temperature of 125° F. with an initial moisture content of approximately 35 percent resulted in severe injury, while less severe injury occurred at 120° F. with a comparable moisture percentage. In a second series of tests when the strains ranged from 39.2 percent moisture to 48.4 percent, dried at 125° F., injury resulted to all strains except one inbred line and a double-cross hybrid. At this same temperature no injury occurred when the moisture range of the strains was 17.9 percent to 29.3 percent. With one exception, an inbred line containing 40.1 percent moisture dried at 115° F. drying temperatures of 105° F., 110° F., and 115° F. were not harmful to germination and seedling vigor irrespective of their initial moisture percentage. At any given moisture level the inbred lines were most subject to heat injury, single crosses were intermediate, and double crosses most tolerant. The open-pollinated variety was less tolerant than the double crosses. It was suggested that heat tolerance may be related to vigor. In these studies the germination tests were made by the modified rag-doll method.

Plants from seed dried at 125° F. made slower growth in the field up to the tasseling stage than those from seed dried at lower temperatures. Acre yields produced from seed of a double-cross hybrid and an open-pollinated variety dried at 125° F. were significantly lower than when the seed was dried at non-injurious temperatures. This reduction in yield was a combination of reduced stand and lower yield per plant.

Reiss (4) found decreases in germination to be associated with drying temperature. Two inbred lines were studied, WF9 and R4. Ears dried at 110° F. gave significantly lower germination than those dried at 100° F., and ears dried at 120° F. germinated lower than those dried at 110° F. Increased temperatures resulted in greater injury to germination of WF9 than to R4 at similar moisture levels. In all cases injury was found to be directly related to moisture content. At higher temperatures the reduction in viability was more evident for ears with 40 percent moisture than for those at 30 percent. Tolerance to injury under artificial drying was concluded to be a combination of physiological development and genetic resistance. Reduced viability with increments of temperature and moisture was more pronounced for WF9 than for R4.

Reed and Dungan (5) used temperatures of 80° F. to 170° F. in drying seed during four seasons. In all cases but two temperature as high as 120° F. did not affect viability and yield. No evidence was found to indicate that better results could be obtained by drying at a temperature below 110° F. Above 125° F. the length of exposure became an increasingly important factor, until at 150° F. even six hours drying was detrimental to corn having high moisture. The following maximum drying temperatures for levels of moisture of 20 percent and higher were recommended: 20 percent - 150° F., 25 percent - 130° F., 35 percent - 125° F., and 40 percent - 120° F. Yield was found to be correlated closely with germination.

Kiesselbach (6) found no significant injury to the seed of 26 single-cross hybrids ranging from 16 to 38 percent moisture when dried five days under forced air at 112° F. Seed of the open-pollinated variety Krug dried to a moisture content of five percent at 112° F. showed no effect in germination or vigor when the initial moisture was 30 percent or less. At moisture contents above 50 percent this temperature greatly reduced both germination and vigor. He suggested that one day is sufficient time for artificially drying corn with 20 percent moisture, two days for 30 percent, and three days for 50 percent.

Tatum and Zuber (7) found variations in mechanical methods involved in processing, and genetic differences in seed to be important factors in seed germination of maize.

Pericarp injuries over the germ were the major causes of reduced viability in maize seed germination under adverse conditions. Highly significant correlations were found between field stands and cold-test germination. Reciprocals of single crosses differed in ability to germinate under adverse conditions. Maternal influences in resistance could not be detected when the seed parent was an inbred. Parental lines germinated lower than their single crosses indicating either a relation between vigor and resistance to pathogens responsible for lower germination. or action of resistant genes obtained from the parental lines. Inbreds were found to differ in resistance to reduced germination as well as to the degree of resistance which they transmitted to tester single crosses. Among both inbreds and single crosses no relationship was found between seedling vigor and ability to germinate under adverse conditions, and within a group of single crosses moisture at time of harvest was not related to cold-test germination.

To study the affect of freezing on germination of seed corn Kiesselbach and Ratcliff (8) artificially froze samples containing 25 percent moisture for a period of 24 hours. Samples treated at 28 to 32° F. germinated 100 percent; a temperature ranging 20 to 24° F. resulted in 96 percent germination; 12 to 16° F. gave 88 percent germination; 8 to 12° F. gave 47 percent; and 0 to -5° F. killed all of the seed. They suggested that corn containing 14 percent moisture or less will stand any freezing temperature. These men made similar investigations on corn standing in the field. Corn which was fairly mature, containing 35 percent moisture on October 8, germinated 98 percent after exposure to 24° F. By December 11 the moisture was down to 16 percent, the temperature had been as low as -16° F. and the germination of the seed was 87 percent. By January 17 the moisture was 14 percent, the temperature had been down to -21° F. and the germination was 88 percent. In the same season corn which was rubbery and contained 39 percent moisture on October 8, germinated 94 percent after the 24° F. frost in October. By November 19 the germination was reduced to 56 percent with a minimum temperature up to that time of 17° F.

To determine the advisability of husking seed corn early to avoid freezing in the field ears were harvested early and allowed to dry. Seed harvested in the milk stage germinated 80 percent, that harvested in the late milk stage germinated 92 percent, the roasting-ear stage germinated 94 percent, and the mature stage germinated 96 percent. These figures are the averages of three years' results.

McRostie (9) stored samples of corn ranging in moisture from below 15 percent to over 25 percent at temperatures of

-10° F. to 32° F. from November 10 to March 15. Similar samples were subjected to variations of these temperatures whereby the temperature was changed every five days. For example, one set was changed from 10° F. to 32° F. for five days, back to 10° F. for five days, 32° F. for five days, etc. Minus 10° F. damaged all samples except those with 15 percent moisture or less. At 0° all samples above 15 percent moisture were damaged also. Those below 20 percent moisture germinated over 80 percent; those with 20 to 25 percent moisture germinated only 40 percent after the first five days of storage, and samples with 28 to 33 percent germinated 0.0 percent after the first five days.

At 15° F. samples below 20 percent moisture were undamaged, those 22 to 25 percent germinated 84 percent after four months of storage, and those containing 28 to 36 percent moisture were reduced to 30 percent germination after five days. At 32° F. all samples of less than 25 percent moisture germinated 90 percent or higher. Samples of 28 to 37 percent germinated 74 percent after four months. In all instances, samples were damaged more by fluctuating temperatures than when stored at the same minimum, but uniform, temperature.

Hoppe (10) conducted experiments to determine the relative efficiency of several seed corn disinfectants in the laboratory and in the field. In laboratory tests in which seed infected with the seedling blight fungi, Diplodia zeae, New Improved Semesan Jr. was most efficient in retarding or inhibiting the fungous. DuBay ranked second, Barbak D third, and Spergon was definitely inferior. Similar results were obtained in several repetitions of the experiment. In a field experiment involving Diplodia-infected seed and disease-free seed the following results were secured: The diseased checks germinated 24.4 percent and the clean checks germinated 79.8 percent; the diseased seed treated with Spergon germinated 40 percent and the clean seed 85.4; the diseased seed treated with Barbak D germinated 77.8 percent and the clean seed 82.1 percent; the diseased seed treated with New Improved Semesan germinated 91.1 percent and the clean seed 84.5 percent. Field conditions were favorable for seedling blight development. Spergon proved very inferior to the mercury dusts in controlling the seed-borne infection but it was considered as effective as the mercury dusts in protecting the seed from soil infection, so most of its value might be as a protectant dust for sound seed planted under unfavorable conditions. DuBay, another non-metallic dust, proved far superior to Spergon in the laboratory but unfortunately it was not tested in the field.

Kiesselbach (11) studied seed treatment in relation to date of planting. Plantings were made on seven different dates, starting two weeks before the customary planting date and planting at 10-day intervals. Three grades of seed were used: good, fair, and poor. Half of each of the three lots of seed was treated with uspulun and half was untreated. There seemed to be no significant advantage in favor of treated seed at any date, and the poorest grade as well as the better grades gave no appreciable response to treatment.

W. Crosier and others (12) working in the Division of Seed Investigation of the New York State Agricultural Experiment Station studied several hundred samples of cereal grains, variously treated as well as nontreated, in laboratory germinations. Samples treated with Ceresan, New Improved Ceresan, and Sanoseed usually developed higher percentages of normal sprouts than the untreated or copper treated samples. The fungous growths common and confusing on seed germination trays, Rhizopus nigricans, Alternaria sp., Fusarium spp., and Helminthosporium spp. were consistently absent from the germinated seeds treated with one of the mercury compounds, and samples were easily readable. That particular laboratory now regularly uses a standard treatment when germinating certain small grains, beans, corn, peas, and other large seeds. A very reduced strength of ethyl mercuric phosphate, obtained by mixing one part of New Improved Ceresan with five parts of French talc, is used. The procedure is to shake the seeds and chemical together in a closed flask or a small screw-top bottle. Excess dust is then completely removed by means of a screen or test-tube basket.

Melchers and Brunson (13) stated that Fusarium moniliforme is present internally and externally on 94 percent of all seed corn regardless of season. Species of Rhizopus, Penicillium and Aspergillus occur in greater or lesser amounts and seem to fluctuate with season and amount of ear worm injury. Experiments with seed treatments were conducted for four years, 1927 to 1930 inclusive. In 1927 Improved Semesan Jr. resulted in slightly lower yield and Bayer Dust slightly higher than checks, but differences were not significant. In 1928 using Merko, Bayer Dust, Improved Semesan Jr. and Copper Carb, no increases in stand were obtained. These same treatments gave higher germination than checks in 1929, but no consistent advantage in yield. In 1930 plantings were made on April 25 and May 12 using Sterocide, Merko, and Improved Semesan Jr. The only increased germination was obtained from Improved Semesan Jr. for the early planting. Field germinations were compared with laboratory for two years. In all cases laboratory germinations were 5 to 20 percent better than field.

In 14 tests conducted in Oklahoma, Mississippi, South Carolina, North Carolina, and Virginia in 1944, corn seedlings emergence was increased by Semesan Jr. 5.21 percent over the non-treatment, by Spergon 5.51 percent, by Barbak C 5.95 percent, and by DuBay 1452-F 5.17 percent. Seed treatment resulted in increased seedling emergence in late plantings as well as in early plantings. In general no significant differences were obtained in tests involving rates of application of the various chemicals (14).

McLaughlin (18), in cooperation with the Southern Cooperative Corn Disease Research Committee, found at the Oklahoma Experiment Station at Stillwater during 1943, 1944 and 1945 that treatment of seed corn generally increased seedling emergence five to 10 percent, and up to 20 percent or more when cool wet weather followed corn planting. In 1943 five varieties of seed corn were treated with five chemical dusts by applying the dusts in excess and then screening to remove the excess chemical. This test was planted on two dates. The April 19 planting was made in soil with below optimum moisture content resulting in seedlings of low vigor. All treatments resulted in seedling stand increases in most instances and 40 percent were significant increases. The planting on June 4 was made in soil with optimum moisture and high temperature. Two varieties, Golden Queen and Woods Golden Dent, did not respond to treatment, while increases up to 10 percent in stand were obtained with Hays Golden, Mosby, and Jarvis Golden Prolific.

In 1944 early, medium, and late plantings were made using eight treatments. Conditions for all three plantings were very similar, with abundant moisture and cold soil. Seed treatments resulted in significant increases in stands in a majority of instances. Yield data taken on the April 6 planting indicated 10 percent increases in 50 percent of the samples as a result of seed treatment.

In 1945 when cold soil and abundant moisture again resulted in poor emergence of untreated seed, each of the chemicals resulted in 10 percent or more increase in stand and yield in most instances. In studying rate of application of chemical during the three years no significant differences were found between rates of 2.5, 2.0, 1.5, and 1.0 ounces per bushel of seed for any one chemical.

Chemicals used in this study included Arasan, Spergon, Semesan Jr., Barbak C, Barbak D, and DuBay 1451-D. To study their relative efficiency in controling fungi, and to determine the amount of the various fungi attacking seedlings, isolations were made from the mesocotyl of 100 seedlings of each treatment including the nontreatment at eight weeks of age. The lightest infection was found on samples treated with Barbak C and D, DuBay 1451-D and Semesan Jr. Spergon and Arasan gave higher infections, and untreated samples were heavily infected. Spergon was considered the least effective of the chemicals. Fusarium moniliforme was found in greatest concentrations on seedlings. Others found to be important were Fusarium species, Rhinotrichum species, Penicillium species, Cephalosparium acremonium, and Diplodia zeae.

Hume and Franzke (15) obtained ear corn samples from 24 seed houses. They found that the amount of mold spores carried by different lots varied from 12.5 percent to 74.6 percent infested kernels. When these samples were germinated lower percent of moldy kernels was associated with higher germination. A significant correlation existed between high mold and low germination, and low mold and high germination. It was suggested that molds develop because they are favored by the conditions for corn germination.

In comparing various methods of germinating seed corn, Reiss (4) used a cold-test unsteamed soil to simulate adverse field conditions, a normal test unsteamed soil to approximate normal field conditions, and a normal test steamed soil to obtain maximum germination. The three tests gave highly significant differences in germination. The data indicated that under adverse field conditions one might expect an entirely different germination response than that obtained under either optimum field conditions or under laboratory conditions, especially with seed that has been injured by high drying temperatures. Differences found between germination with the two normal test methods, steam soil compared with unsteamed soil, were attributed to soil borne pathogens on the seed and young seedlings. In the cold-test reduced germination resulted from the combined effect of soil borne pathogens and sub-normal temperature. The line WF9 with an initial moisture content of 40.3 percent when dried at 100° F. germinated 90 percent by normal laboratory methods. With a method simulating ideal field conditions it germinated only 61 percent, and only 32 percent under adverse conditions.

Erickson and Porter (16) in comparing methods of laboratory germination for soybeans, found that autoclaved sand or soil at 30 to 32° C. gave higher and more uniform germinations than on moist blotters in a high humidity chamber at 20 to 30° C. Field germination was usually lower than laboratory though not always, and some results showed higher germination in the field than in the laboratory.

## MATERIALS AND METHODS

Two single-cross hybrids used in this study were planted on several different dates to supply samples varying widely in moisture for drying and freezing in the fall. K41 x K55 is a large-eared white hybrid with heavy, tight husk, large cob, and short kernels having a high percentage of horny starch, and is the seed parent of K2234, a late white hybrid. It dries slowly in the fall and frequently has a low germination. The other hybrid used was WF9 x 38-11, which is the seed parent of US13, an early yellow hybrid for Kansas. It is a large-eared yellow hybrid having husks which become loose during ripening, often exposing the ear. The cob is small and kernels long with a relatively large amount of soft starch. This hybrid dries rapidly at maturity and seldom germinates low under normal conditions for maturity.

Before starting the drying and freezing tests all dates of planting were sampled for moisture to determine the moisture levels available. Samples differing in moisture level by about five percent were desired; i.e., 15 percent, 20 percent, 25 percent, etc. Early in September samples containing 35 to 65 percent moisture were available. As many as possible of these were treated at the various temperatures. Later in the season as the corn approached maturity the low-moisture samples were available and were treated. Triplicate samples of ten ears each were selected for drying by husking 30 ears having apparently about the same moisture content and dividing the ears into groups of 10 at random. From eight to 16 samples of each hybrid, depending on the moisture range available, were treated at a time. In the freezing tests quadruplicate samples were used, two of them being treated in the husk and two with husks removed. The amount of material which could be treated at a time was limited by the size of freezer. After freezing samples were dried artificially at 110° F. The tendency for the husks to open on WF9 x 38-11 as the ears approached maturity prevented obtaining samples with tight husks at the lower moisture levels.

For the drying study one 80-bushel bin of the artificial dryer of the Agronomy Department was used. The hot air was blown from the furnace by fan at the rate of 3150 cubic feet per minute, entering at the top of the bin and passing out through the false, slatted floor. Samples were placed uniformly over the bin floor in mesh bags. A hygro-thermograph placed on the floor near the center of the bin recorded temperature and relative humidity. Temperatures used were: 105° F., 110° F., 115° F., 125° F., 135° F. and 140° F. The temperature was controlled thermostatically to within a range of approximately five degrees. A 30-cubic foot freezer of the Agricultural Engineering Department was used in the freezing study. A false floor of hail screen was made to permit maximum air circulation and the ears were removed from sacks and laid in rows on this screen. Temperatures used were: 0° F., 10° F., 18° F., and 30° F. Temperatures were recorded by a thermograph and controlled thermostatically to a range of three degrees.

Samples for moisture determination were obtained by removing two rows of kernels from each of the 10 ears in each sample with a screw-driver. Samples containing 28 percent moisture or less were tested for moisture by use of a Tag-Hepenstall electric moisture meter. For samples of higher moisture screen cups holding approximately 150 grams of corn were made. Samples were weighed, dried at 100° C., reweighed, and the percent moisture calculated. In the drying experiment all treatments except the first two were sampled for moisture during the period of drying to note the rate of loss. Samples which required a short drying time were tested at 12-hour intervals and those requiring more time were tested at 24-hour intervals.

Duplicate samples of all moisture levels in the two hybrids were harvested and hung in mesh bags from the ceiling of the Agronomy Seed House to dry naturally as checks against artificially dried and frozen samples. Temperatures varied from 78° F. to 92° F. during storage, which were higher than normal due to the influence of warm air from the dryer.

After samples were treated and in condition to store all damaged kernels and tip and butt kernels were removed, the samples shelled with a mechanical sheller, and the seed bagged and stored in barrels in the sub-basement of East Waters Hall where the temperature ranged from approximately 65° F. to 75° F. Napthalene crystals were placed in samples to protect the seed from insect damage.

All germination samples were composed of 100 kernels taken at random. Duplicate germination tests were made in the fall and repeated in the spring in the State Seed Testing Laboratory. Field germination tests of all dried material and representative samples of all frozen material were planted in the spring in randomized blocks of four replications, the individual plots consisting of one 12-foot row spaced one foot apart 100 kernels per row. A Columbia mechanical hand planter, on which the planting cylinder had been replaced with a funneled spout, was used. The plantings were made April 19 and they were through the ground in eight days and emergence was counted May 6 to 8. The mean temperature during the germinating period was 74° F. compared to 57° F. normal. One rain of .23 inch fell the third day after planting. The total rainfall from January 1 to emergence was 3.64 inches compared to the long-time average of 6.04 inches. So the seedbed was warmer and drier than normal for that time of year.

The first three sets of samples germinated in the laboratory in the fall were very moldy and difficult to count. This was particularly true of those dried at higher temperatures resulting in low germination. In order to rid the samples of mold, primarily Rhizopus, it was decided to treat all samples with sulfur. So all field and laboratory germinations reported for the drying and freezing experiments are on the basis of sulfur-treated seed.

Treatment with sulfur increased materially the germination of samples tested in the laboratory. This fact stimulated interest and considering the large supply of samples available varying widely in quality, it was decided to conduct a seed treatment study in the field. Three sets of samples dried at 140° F., 125° F., and 110° F. respectively, and involving a total of 40 samples, were used in this study and planted at the same time and under same conditions as the other germination studies. Commercial seed corn disinfectants used were Arasan, Spergon, and Semesan Jr. In addition a sulfur treated sample and an untreated check sample were planted. Four replications were planted in the manner mentioned previously. Seed was treated at the rate of one ounce per bushel for Arasan, 1 1/2 oz. for Spergon and Semesan Jr., and 3 oz. for sulfur. These are the general-purpose rates set up by the seed treatment committee of the American Phytopathological Society (17).

## EXPERIMENTAL RESULTS

### Drying Experiment

In the artificial drying experiment two points of particular interest were noted. Comparing samples with equal moisture content, the K41 x K55 required more time for drying than did WF9 x 38-11. Likewise, there was a highly significant reduction in the germination of K41 x K55 compared to WF9 x 38-11 (see Table 1) when dried at a temperature sufficiently high to affect germination. This can probably be explained by the longer exposure to the critical drying temperature which it required. There may be several factors influencing the slow-drying character in K41 x K55. One of these is generally thought to be its large cob which probably contains more moisture at a given moisture content of grain than does the cob of WF9 x 38-11. Likewise, the hardness of the seed may make it slower in releasing moisture. An observation made during processing which may help explain the slow drying rate was that the grains of K41 x K55 lie very tightly together and also set very tightly to the cob. It seems reasonable, therefore, that the heated air might penetrate the ear of this hybrid more slowly than a hybrid such as WF9 x 38-11 on which the grain does not lie so tightly.

The consistently longer drying time required for K41 x K55 is expressed graphically in Plate II in which groups of samples of the two hybrids dried at each temperature were selected for comparable moisture. Samples dried at 110° F. are not shown because that set was dried late in the season and the WF9 x 38-11 was too dry to be comparable with K41 x K55. The samples dried at 138 - 142° F. were all dried for 43 hours, however, as shown in Table 2, WF9 x 38-11 decreased in moisture percentage from an average of 43.4 to 7.9 while K41 x K55 decreased from 43.2 to 10.1 a difference of 2.4 during the 43 hours; after drying WF9 x 38-11 averaged 44.3 percent germination and K41 x K55 averaged 28.4 (see Table 1). At a drying temperature of 123 - 128° F. with samples averaging approximately 43 percent moisture, WF9 x 38-11 dried to 11.9 percent in 54.5 hours and averaged 38.4 percent germination in spring laboratory tests. K41 x K55 dried to 11.8 percent moisture in 60.8 hours and germinated only 10.8 percent. See Tables 1 and 2 and Plates I and II.

To study the rate of moisture loss during the first 24-hour period Table 3 was prepared for the three sets of samples having moisture readings after 24 hours of drying. Samples of the two hybrids with comparable moisture levels were included in each set. At 26.6 percent moisture with a drying temperature of 133 - 138° F. WF9 x 38-11 lost .46 of a percent moisture per hour or a total of 11.0 percent, while K41 x K55 lost .39 per hour or a total of 9.3 percent during the first 24 hours. WF9 x 38-11 required 33 hours to dry and dried at the average rate of .42 percent moisture per hour, while K41 x K55 dried in 36 hours and lost moisture at .37 percent per hour. This difference was greater for the 114 - 119° F. drying temperature and less for the 103 - 108° F. temperature.

To simulate ordinary drying conditions the average of the two latter sets of data was computed (Table 3). This gives a temperature of 111° F. and a moisture level of approximately 37 percent. For WF9 x 38-11 the mean moisture loss is .70 percent per hour during the first 24 hours, and a total drying time of 64.2 hours with a moisture loss of .38 percent per hour. For K41 x K55 these results are .55 percent, 78.2 hours, and .32 percent respectively.

As already mentioned samples dried at 108 - 112° F. were dried last and too late to get a wide range of moisture. As shown in Table 2 WF9 x 38-11 ranged from 15 to 20 percent moisture, averaging 16.9. The samples dried in 26.8 hours at an average rate of .25 percent per hour. Samples of K41 x K55 averaged 23.2 percent moisture and dried in 48 hours at an average rate of .22 percent per hour.

Data in Table 2 indicate that samples with higher moisture content dried at a faster rate per hour than those with lower moisture. In fact, samples with very high moisture were frequently dry before others containing 10 percent less moisture. In the 123 - 128° F. drying test samples of WF9 x 38-11 containing over 50 percent moisture were dry 10 to 20 hours sooner than samples containing 30 and 40 percent moisture. A sample of K41 x K55 at 52 percent moisture was dry 10 hours before 46-percent samples. This also occurred in the samples dried naturally as shown in Table 5. This perhaps can be explained in the large amount of moisture lost from the grain, resulting in extreme shrinkage and maximum circulation of air around the grain and cob.

This varietal difference in rate of drying and resulting difference in germination was also found by Reiss (4) in his studies with two inbred lines of corn. WF9 required longer drying time and germinated less than did R4 when the drying temperature was sufficiently high to be injurious to germination.

Table 1 gives the germination of all artificially dried samples. The results are also presented in Plate I which was prepared to show the relative germination of the two hybrids at comparable moisture levels for each drying temperature. The fact that K41 x K55 was damaged more than WF9 x 38-11 when dried at high temperatures and high moisture contents has already been discussed. The data present three other points of general interest.

First, the samples with increments of moisture and drying temperature germinated less in the spring after three months of storage than they did in the fall. Second, all samples germinated significantly less in the field than in the laboratory, a result which has been obtained by most workers in similar studies. Third, there was a very close relationship between initial moisture content of samples and final germination, particularly at temperatures above 110° F.

Concerning the various temperatures used in drying and their respective effects on germination, samples dried at 138 - 142° F. with moisture varying from 32 to 54 percent all germinated 72 percent or less in the fall, less than 35 percent in the spring, and gave less than 25 percent emergence in the field on the basis of treatment with sulfur.

At 133 - 138° F. samples of WF9 x 38-11 containing up to 31 percent moisture germinated 92 percent or better with those below 25.7 percent moisture germinating 95 to 97 percent in fall and spring laboratory tests. In the field the samples below 25.7 percent emerged 81 to 88 percent and samples at 30 and 31 percent emerged 76 percent or less. At this temperature samples of K41 x K55 containing 19.7 to 21.8 percent moisture germinated 94 to 95 percent in the fall, 94 to 97 in the spring, and emerged 73 to 89 in the field. It is interesting to note the close relation between moisture content before drying and emergence in the field. In this set of triplicate samples the one containing 19.7 percent moisture emerged 89 percent, the one at 20 percent emerged

87.5 percent, and the one at 21.8 emerged only 73 percent. Samples containing 29.7 to 31.1 percent initial moisture germinated 75.5 to 82.5 percent in the fall, 59.5 to 79.5 in the spring, and emerged 53 to 54 percent in the field.

At a drying temperature of 123 - 128° F., three samples containing 31.7 to 43.0 percent moisture germinated 90.5 to 98 percent in the fall, while samples containing over 43 and up to 56.7 percent moisture ranged from 84 down to 10 percent germination. All samples at this temperature germinated 74 percent or less in the spring, and emerged 42 percent or less in the field. Samples of K41 x K55 contained 34 to 52 percent moisture and germinated 0 to 73.5 in the fall, 0 to 30 in the spring, and emerged 1 to 20.5 in the field. Wasko (3) obtained greatly reduced germination in samples containing 35 percent moisture when dried at 125° F., while Reed and Dungan (5), after three years of study, suggested a drying temperature of 125° F. for samples containing up to 35 percent moisture as a general recommendation for drying double-cross hybrids.

At 114 - 119° F. samples of WF9 x 38-11 contained up to 47.1 percent moisture and all germinated 93 percent or more in the fall. In the spring all samples of 41 percent moisture and less germinated over 90 except one which germinated 86. In the field the emergence was four to 15 percent less, although one sample containing 22.3 percent moisture gave 90 percent emergence after drying at this temperature.

For K41 x K55 samples with up to 45.5 percent initial moisture germinated 88 or higher in the fall while a sample at 48.5 germinated only 82 when dried at 114 - 119° F. In the spring a moisture content of approximately 30 percent was the critical point between good and poor germination. This point remained the same in the field with samples containing less than 30 percent moisture emerging 82 to 90.5 percent, and those above 30 percent showing 74 percent and down to 12.5 emergence. Reed and Dungan (5) recommended a drying temperature of 120° F. for samples containing up to 40 percent moisture. The data presented above for WF9 x 38-11 are quite similar while for K41 x K55 which requires a longer drying period 30 percent initial moisture appeared to be the limit for drying at 114 - 119° F. Wasko (3) found that a drying temperature of 115° F. was not harmful to germination and seedling vigor regardless of initial moisture content with inbred lines, single crosses and double crosses, with one exception--an inbred line containing 40.1 percent moisture was injured.

Data on drying at 108 - 112° F. are limited because this set was dried late in the season when the corn crop was approaching maturity. No samples contained over 24 percent moisture. All samples germinated over 90 percent in the laboratory both fall and spring and the average field emergence was approximately 85 percent. It was concluded that this temperature was not injurious at the moisture levels studied.

At 103 - 108° F. with moisture up to 42 percent all samples of WF9 x 38-11 averaged over 94 percent germination in fall and spring laboratory tests while in the field WF9 x 38-11 gave 77 to 89.5 percent emergence, averaging 83.9, and K41 x K55 gave 65 to 90 percent emergence and averaged 80.2. The emergence of K41 x K55 in the field was reduced most for samples containing over 40 percent initial moisture. Five such samples containing 40.4 to 42.0 percent moisture germinated 65 to 74 percent. Samples of K41 x K55 dried naturally from 43.7 and 45.4 percent moisture germinated 77 and 78 percent respectively (Table 5). This might indicate that drying at 103 - 108° F. resulted in lower germination of this hybrid when the initial moisture content was over 40 percent.

The general reduction in field germination of artificially dried samples compared to laboratory germination also occurred with frozen samples as well as with those dried in natural atmospheric conditions. This reduction therefore is attributed largely to field conditions and not to the treatment since the reduction was as great for the checks as for the samples dried artificially.

Until further study of this problem is made using bin-size lots of grain the data presented above should be considered only as preliminary information. In this experiment small lots of grain were used and the air removed a maximum amount of moisture at all times. In commercial practice the air often becomes saturated before passing out of the bin, thus a longer drying

time is required which probably would result in somewhat dif-
ferent data regarding time for drying and final germination,
than was obtained in this study.

Table 1. Germination of samples artificially dried at various temperatures. Samples were treated with sulfur.

| WF9 x 38-11 | | | | K41 x K55 | | | |
|---|---|---|---|---|---|---|---|
| % | Laboratory | | Field | % | Laboratory | | Field |
| Moisture | Fall | Spring | | Moisture | Fall | Spring | |
| Dried at 138 - 142° F. | | | | | | | |
| 31.9 | 64.5 | 32.0 | 23.0 | 33.0 | 59.0 | 32.5 | 17.0 |
| 35.7 | 72.0 | 34.0 | 17.0 | 36.8 | 35.0 | 15.5 | 9.5 |
| 41.6 | 63.0 | 34.5 | 11.0 | 45.4 | 19.5 | 2.5 | 2.0 |
| 53.4 | 13.0 | 0.0 | 1.5 | 50.1 | 18.0 | 3.5 | 1.0 |
| 54.2 | 9.0 | 0.0 | 0.0 | 50.7 | 10.5 | 1.5 | 1.0 |
| Ave. 43.4 | 44.3 | 20.1 | 10.5 | 43.2 | 28.4 | 11.1 | 6.1 |
| 133 - 138° F. | | | | | | | |
| 14.6 | 96.0 | 97.0 | 85.5 | 19.7 | 94.5 | 94.0 | 89.0 |
| 15.7 | 96.0 | 96.5 | 81.0 | 20.0 | 94.0 | 97.0 | 87.5 |
| 23.2 | 97.0 | 96.5 | 86.5 | 21.8 | 95.0 | 97.0 | 73.0 |
| 23.9 | 97.5 | 97.0 | 85.5 | 29.7 | 82.5 | 79.5 | 54.0 |
| 25.7 | 96.0 | 97.0 | 88.0 | 30.4 | 75.5 | 79.5 | 54.0 |
| 30.0 | 96.0 | 95.0 | 59.0 | 31.1 | 78.5 | 59.5 | 53.0 |
| 30.2 | 95.0 | 94.5 | 76.0 | | | | |
| 31.2 | 92.0 | 92.0 | 71.0 | | | | |
| Ave. 24.3 | 95.7 | 95.7 | 79.1 | 25.5 | 86.7 | 84.4 | 68.4 |
| 123 - 128° F. | | | | | | | |
| 31.7 | 85.0 | 51.0 | 32.0 | 34.0 | 73.5 | 30.0 | 20.5 |
| 31.7 | 98.0 | 74.0 | 42.0 | 34.3 | 53.5 | 19.5 | 17.5 |
| 32.1 | 93.0 | 62.0 | 28.5 | 34.7 | 62.0 | 17.0 | 6.5 |
| 43.0 | 90.5 | 62.0 | 35.0 | 44.3 | 20.5 | 5.0 | 2.0 |
| 43.2 | 84.0 | 47.0 | 20.0 | 45.1 | 26.0 | 10.0 | 5.0 |
| 43.7 | 70.0 | 29.5 | 11.0 | 45.7 | 19.5 | 2.0 | 2.0 |
| 50.1 | 82.0 | 29.0 | 10.0 | 46.4 | 23.0 | 5.5 | 2.0 |
| 50.4 | 65.5 | 20.5 | 5.0 | 48.4 | 45.5 | 8.0 | 1.0 |
| 53.6 | 47.0 | 9.0 | 1.5 | 52.1 | 0.0 | 0.0 | 1.0 |
| 56.7 | 10.0 | 0.0 | 0.0 | | | | |
| Ave. 43.6 | 72.5 | 38.4 | 18.5 | 42.8 | 35.9 | 10.8 | 6.6 |

Table 1 (cont.)

| WF9 x 38-11 | | | | K41 x K55 | | | |
|---|---|---|---|---|---|---|---|
| % Moisture | Laboratory Fall | Laboratory Spring | Field | % Moisture | Laboratory Fall | Laboratory Spring | Field |
| Dried at 114 - 119° F. | | | | | | | |
| 15.8 | 98.0 | 96.5 | 84.0 | 19.7 | 98.0 | 97.0 | 84.0 |
| 16.2 | 97.0 | 97.0 | 93.0 | 19.7 | 96.5 | 97.0 | 83.0 |
| 16.7 | 97.0 | 96.0 | 87.0 | 21.0 | 97.0 | 97.5 | 90.5 |
| 21.0 | 97.5 | 98.0 | 88.5 | 28.0 | 95.5 | 93.0 | 87.0 |
| 22.2 | 97.0 | 96.5 | 83.0 | 28.6 | 94.5 | 97.0 | 82.0 |
| 22.3 | 98.0 | 96.5 | 90.0 | 31.2 | 95.0 | 79.5 | 74.0 |
| 29.9 | 96.0 | 97.0 | 78.0 | 32.8 | 97.0 | 71.0 | 64.0 |
| 31.2 | 97.0 | 96.0 | 82.0 | 33.4 | 94.0 | 75.0 | 62.5 |
| 33.6 | 95.0 | 93.0 | 66.5 | 39.8 | 97.0 | 62.5 | 52.5 |
| 41.2 | 96.0 | 86.0 | 72.0 | 41.3 | 96.0 | 77.0 | 34.0 |
| 41.3 | 96.0 | 91.0 | 56.0 | 42.1 | 97.0 | 58.5 | 42.0 |
| 43.2 | 95.0 | 82.0 | 60.0 | 43.5 | 88.0 | 64.5 | 37.0 |
| 44.6 | 94.5 | 57.0 | 50.0 | 45.5 | 93.5 | 54.0 | 24.0 |
| 47.1 | 93.0 | 50.5 | 31.0 | 48.5 | 82.0 | 42.0 | 12.5 |
| Ave. 30.5 | 96.2 | 88.1 | 63.8 | 33.9 | 94.4 | 76.1 | 59.2 |
| 108 - 112° F. | | | | | | | |
| 15.2 | 99.5 | 98.0 | 82.0 | 22.6 | 93.0 | 98.0 | 91.0 |
| 15.5 | 94.0 | 95.5 | 83.5 | 23.0 | 95.5 | 98.0 | 82.5 |
| 15.7 | 99.5 | 99.0 | 82.5 | 23.2 | 91.5 | 98.0 | 88.5 |
| 16.0 | 99.5 | 98.0 | 84.5 | 23.2 | 95.0 | 98.0 | 90.0 |
| 18.9 | 97.5 | 98.0 | 89.5 | 23.8 | 90.0 | 91.5 | 76.0 |
| 20.0 | 96.0 | 97.0 | 90.0 | | | | |
| Ave. 16.9 | 97.7 | 97.4 | 85.3 | 23.2 | 93.0 | 96.7 | 85.6 |
| 103 - 108° F. | | | | | | | |
| 16.6 | 97.0 | 97.5 | 87.0 | 17.6 | 88.0 | 95.5 | 83.0 |
| 16.7 | 87.0 | 96.0 | 81.0 | 17.9 | 97.0 | 95.5 | 90.0 |
| 16.9 | 97.0 | 99.0 | 89.0 | 18.5 | 96.5 | 97.0 | 87.5 |
| 20.2 | 98.0 | 99.0 | 85.5 | 28.8 | 97.0 | 97.5 | 90.0 |
| 22.2 | 98.0 | 96.5 | 82.0 | 29.1 | 96.0 | 98.0 | 89.5 |
| 22.4 | 93.0 | 98.0 | 79.0 | 29.4 | 96.0 | 98.0 | 83.5 |
| 27.5 | 97.0 | 97.0 | 83.5 | 32.2 | 96.0 | 95.5 | 78.0 |
| 29.8 | 97.0 | 97.5 | 83.0 | 32.2 | 90.5 | 89.5 | 79.0 |
| 25.8 | 95.5 | 93.0 | 89.5 | 32.5 | 94.5 | 97.0 | 88.0 |
| 26.3 | 96.0 | 95.0 | 84.0 | 40.4 | 89.5 | 89.5 | 71.5 |
| 28.4 | 95.0 | 97.0 | 86.0 | 40.8 | 95.0 | 92.5 | 74.0 |
| 33.9 | 95.5 | 96.0 | 88.0 | 41.2 | 92.0 | 94.0 | 73.0 |
| 35.0 | 97.0 | 96.5 | 81.5 | 41.4 | 95.0 | 94.0 | 65.0 |
| 35.3 | 98.0 | 97.5 | 80.5 | 42.0 | 95.0 | 88.5 | 71.0 |
| 38.9 | 98.0 | 94.0 | 86.0 | | | | |
| 41.9 | 96.0 | 95.5 | 77.0 | | | | |
| Ave. 27.4 | 95.9 | 96.6 | 83.9 | 31.7 | 94.1 | 94.4 | 80.2 |

Table 2. Rate at which moisture was lost in artificial drying.

| WF9 x 38-11 | | | | | | | | | K41 x K55 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % $H_2O$ Wet | % $H_2O$ after drying 12 Hrs. | 24 Hrs. | 36 Hrs. | 48 Hrs. | 72 Hrs. | % $H_2O$ Dry | Hours dried | $H_2O$ lost per hour | % $H_2O$ Wet | % $H_2O$ after drying 12 Hrs. | 24 Hrs. | 36 Hrs. | 48 Hrs. | 72 Hrs. | % $H_2O$ Dry | Hours dried | $H_2O$ lost per hour |
| Dried at 138-142° F. | | | | | | | | | | | | | | | | | |
| 31.9 | | | | | | 9.4 | 43 | .52 | 33.0 | | | | | | 7.5 | 43 | .59 |
| 35.7 | | | | | | 6.9 | 43 | .67 | 36.8 | | | | | | 11.7 | 43 | .58 |
| 41.6 | | | | | | 7.9 | 43 | .78 | 45.4 | | | | | | 14.4 | 43 | .72 |
| 53.4 | | | | | | 7.9 | 43 | 1.06 | 50.1 | | | | | | 9.1 | 43 | .95 |
| 54.2 | | | | | | 7.5 | 43 | 1.09 | 50.7 | | | | | | 7.9 | 43 | 1.00 |
| *43.4 | | | | | | 7.9 | 43 | .82 | *43.2 | | | | | | 10.1 | 43 | .77 |
| Dried at 133-138° F. | | | | | | | | | | | | | | | | | |
| 14.6 | 12.7 | | | | | 11.5 | 14 | .22 | 19.7 | 16.9 | 12.5 | | | | 12.5 | 24 | .30 |
| 15.7 | 13.3 | | | | | 11.8 | 14 | .28 | 20.0 | 17.1 | 13.6 | | | | 12.2 | 27 | .29 |
| 23.2 | 17.1 | 12.2 | | | | 12.2 | 24 | .46 | 21.8 | 18.6 | 12.8 | | | | 12.8 | 24 | .38 |
| 23.9 | 18.2 | 14.6 | | | | 13.1 | 29 | .37 | 29.7 | 24.7 | 20.0 | 16.4 | | | 13.6 | 43 | .37 |
| 25.7 | 18.8 | 13.6 | | | | 13.0 | 27 | .47 | 30.4 | 25.3 | 20.3 | 15.6 | | | 13.2 | 43 | .40 |
| 30.0 | 23.0 | 18.4 | 14.5 | | | 11.5 | 42 | .44 | 31.1 | 24.9 | 20.0 | 16.6 | | | 13.8 | 43 | .40 |
| 30.2 | 23.9 | 19.1 | 15.2 | | | 13.5 | 43 | .39 | | | | | | | | | |
| 31.2 | 25.4 | 20.3 | 15.3 | | | 12.3 | 43 | .44 | | | | | | | | | |
| *24.3 | 19.1 | 16.4 | 15.0 | | | 12.4 | 29.5 | .41 | *25.5 | 21.3 | 16.5 | 16.2 | | | 13.0 | 34 | .37 |

* Averages

Table 2 (cont.).

| WF9 x 38-11 | | | | | | | | | K41 x K55 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % $H_2O$ Wet | % $H_2O$ after drying 12 Hrs. | 24 Hrs. | 36 Hrs. | 48 Hrs. | 72 Hrs. | % $H_2O$ Dry | Hours dried | $H_2O$ lost per hour | % $H_2O$ Wet | % $H_2O$ after drying 12 Hrs. | 24 Hrs. | 36 Hrs. | 48 Hrs. | 72 Hrs. | % $H_2O$ Dry | Hours dried | $H_2O$ lost per hour |
| Dried at 123-128° F. | | | | | | | | | | | | | | | | | |
| 31.7 | | | | | | 12.6 | 48 | .40 | 34.0 | | | | | | 10.9 | 63 | .37 |
| 31.7 | | | | | | 13.2 | 53 | .35 | 34.3 | | | | | | 10.6 | 63 | .38 |
| 32.1 | | | | | | 13.2 | 53 | .36 | 34.7 | | | | | | 14.1 | 53 | .39 |
| 43.0 | | | | | | 11.2 | 63 | .52 | 44.3 | | | | | | 12.4 | 63 | .51 |
| 43.2 | | | | | | 11.6 | 63 | .50 | 45.1 | | | | | | 12.1 | 63 | .52 |
| 43.7 | | | | | | 10.8 | 53 | .62 | 45.7 | | | | | | 13.3 | 63 | .51 |
| 50.1 | | | | | | 10.1 | 63 | .63 | 46.4 | | | | | | 12.3 | 63 | .54 |
| 50.4 | | | | | | 12.8 | 53 | .71 | 48.4 | | | | | | 10.7 | 63 | .60 |
| 53.6 | | | | | | 12.5 | 53 | .78 | 52.1 | | | | | | 9.7 | 53 | .80 |
| 56.7 | | | | | | 10.8 | 43 | 1.07 | | | | | | | | | |
| *43.6 | | | | | | 11.9 | 54.5 | .58 | *42.8 | | | | | | 11.8 | 60.8 | .51 |
| Dried at 114-119° F. | | | | | | | | | | | | | | | | | |
| 15.8 | | | | | | 9.6 | 21 | .30 | 19.7 | | 14.1 | | | | 12.8 | 30 | .23 |
| 16.2 | | | | | | 10.1 | 21 | .30 | 19.7 | | 14.1 | | | | 12.2 | 30 | .25 |
| 16.7 | | | | | | 10.5 | 21 | .30 | 21.0 | | 16.1 | | | | 14.1 | 30 | .23 |
| 21.0 | | 12.5 | | | | 12.5 | 24 | .35 | 28.0 | | 19.6 | | 14.8 | | 14.7 | 49 | .27 |
| 22.2 | | 13.0 | | | | 13.0 | 24 | .38 | 28.6 | | 20.2 | | 15.5 | | 15.4 | 49 | .27 |
| 22.3 | | 13.2 | | | | 13.2 | 24 | .38 | 31.2 | | 18.2 | | 15.4 | | 10.4 | 67 | .31 |
| 29.9 | | 15.2 | | 12.4 | | 12.4 | 48 | .36 | 32.8 | | 18.5 | | 16.3 | | 13.3 | 67 | .29 |
| 31.2 | | 16.4 | | 12.8 | | 12.8 | 48 | .38 | 33.4 | | 18.8 | | 15.7 | | 11.3 | 67 | .33 |
| 33.6 | | 14.7 | | 12.8 | | 12.8 | 48 | .43 | 39.8 | | 21.9 | | 18.6 | | 13.2 | 67 | .40 |
| 41.2 | | 22.1 | | 14.4 | | 12.0 | 54 | .54 | 41.3 | | 25.0 | | 18.0 | | 12.0 | 67 | .44 |
| 41.3 | | 19.0 | | 12.2 | | 12.2 | 48 | .61 | 42.1 | | 25.9 | | 18.2 | | 12.3 | 67 | .44 |
| 43.2 | | 21.7 | | 12.8 | | 12.8 | 48 | .63 | 43.5 | | 26.1 | | 19.7 | | 14.2 | 67 | .44 |

* Averages

Table 2 (cont.).

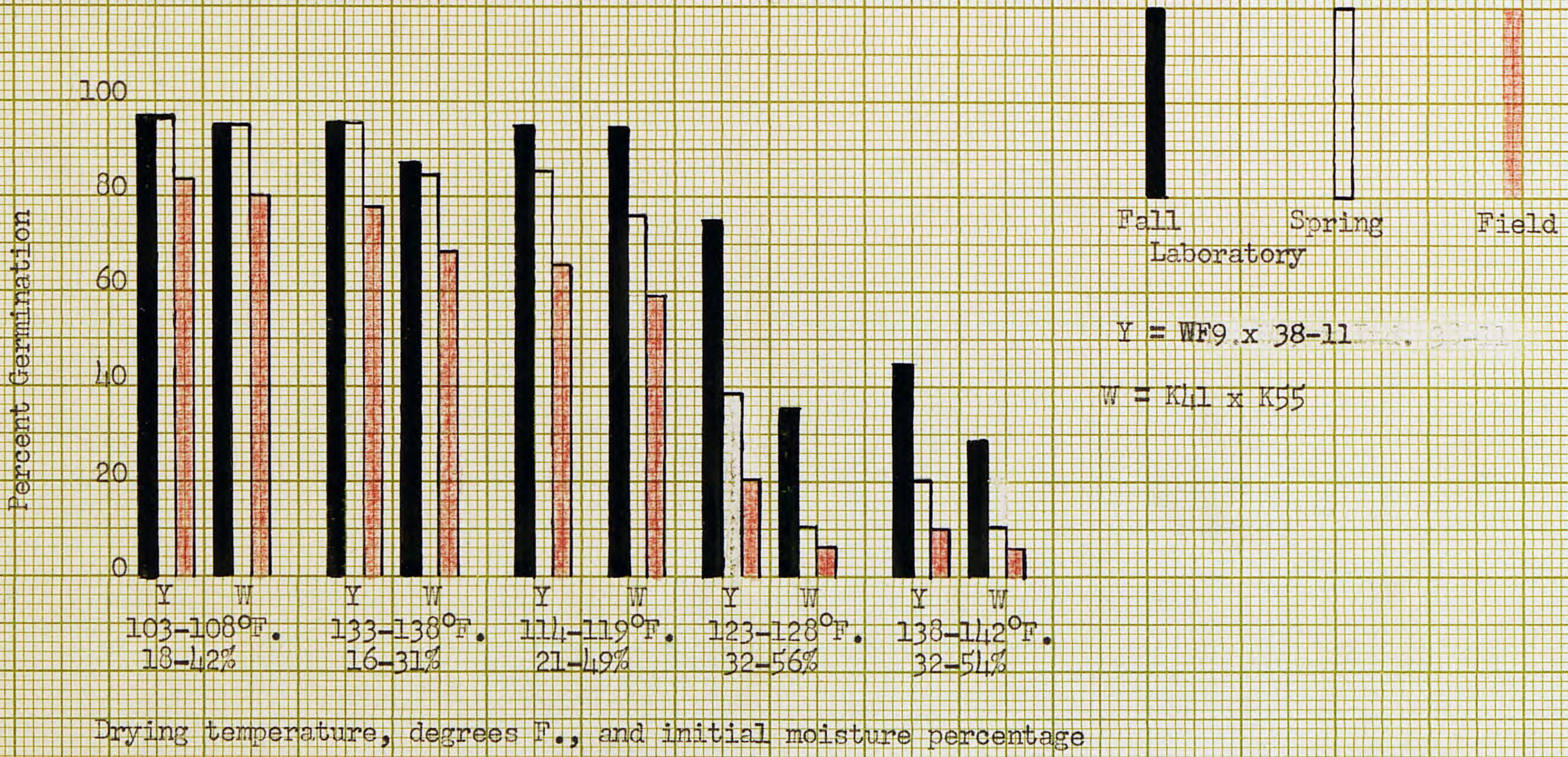
| WF9 x 38-11 | | | | | | | | | K41 x K55 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % $H_2O$ Wet | % $H_2O$ after drying | | | | | % $H_2O$ Dry | Hours dried | $H_2O$ lost per hour | % $H_2O$ Wet | % $H_2O$ after drying | | | | | % $H_2O$ Dry | Hours dried | $H_2O$ lost per hour |
| | 12 Hrs. | 24 Hrs. | 36 Hrs. | 48 Hrs. | 72 Hrs. | | | | | 12 Hrs. | 24 Hrs. | 36 Hrs. | 48 Hrs. | 72 Hrs. | | | |
| Dried at 114-119° F. (cont.) | | | | | | | | | | | | | | | | | |
| 44.6 | | 19.6 | | 14.4 | | 11.9 | 54 | .61 | 45.5 | | 25.7 | | 17.8 | | 12.5 | 67 | .59 |
| 47.1 | | 20.0 | | 12.4 | | 12.4 | 48 | .72 | 48.5 | | 24.9 | | 16.0 | | 9.3 | 67 | .59 |
| *30.5 | | 17.0 | | 13.0 | | 12.0 | 49.5 | .49 | *33.9 | | 20.7 | | 16.9 | | 12.7 | 56.5 | .38 |
| Dried at 108-112° F. | | | | | | | | | | | | | | | | | |
| 15.2 | | 10.0 | | | | 10.0 | 24 | .22 | | | | | | | | | |
| 15.5 | | 9.6 | | | | 9.6 | 24 | .25 | 22.6 | | 17.6 | | 13.3 | | 13.3 | 48 | .19 |
| 15.7 | | 9.7 | | | | 9.7 | 24 | .25 | 23.0 | | 18.0 | | 12.5 | | 12.5 | 48 | .22 |
| 16.0 | | 9.9 | | | | 9.9 | 24 | .25 | 23.2 | | 17.6 | | 12.8 | | 12.8 | 48 | .22 |
| 18.9 | | 11.6 | | | | 11.6 | 24 | .30 | 23.2 | | 17.8 | | 11.7 | | 11.7 | 48 | .24 |
| 20.0 | | 14.3 | | | | 10.8 | 41 | .22 | 23.8 | | 17.8 | | 13.7 | | 13.7 | 48 | .21 |
| *16.9 | | 10.8 | | | | 10.3 | 26.8 | .25 | *23.2 | | 17.8 | | 12.8 | | 12.8 | 48 | .22 |
| Dried at 103-108° F. | | | | | | | | | | | | | | | | | |
| 16.6 | | | | | | 12.2 | 18 | .24 | 17.6 | | 13.6 | | | | 13.6 | 24 | .17 |
| 16.7 | | | | | | 11.9 | 18 | .27 | 17.9 | | 13.6 | | | | 13.6 | 24 | .18 |
| 16.9 | | | | | | 12.0 | 18 | .27 | 18.5 | | 13.4 | | | | 13.4 | 24 | .21 |
| 20.2 | | 14.7 | | | | 12.7 | 39 | .19 | 28.8 | | 21.7 | | 18.7 | 16.9 | 13.6 | 89 | .17 |
| 22.2 | | 15.9 | | | | 13.1 | 39 | .23 | 29.1 | | 22.8 | | 19.1 | 16.9 | 13.4 | 89 | .18 |
| 22.4 | | 14.9 | | | | 12.7 | 39 | .25 | 29.4 | | 22.8 | | 19.2 | 17.3 | 13.6 | 89 | .18 |
| 25.8 | | 16.5 | | 16.0 | | 12.8 | 69 | .19 | 32.2 | | 24.0 | | 21.2 | 14.7 | 12.1 | 89 | .23 |
| 26.3 | | 18.7 | | 16.6 | | 13.1 | 69 | .21 | 32.2 | | 23.3 | | 21.9 | 14.5 | 12.1 | 89 | .23 |
| 27.5 | | 20.2 | | 16.4 | 14.8 | 11.0 | 89 | .19 | 32.5 | | 22.1 | | 20.0 | 13.9 | 11.5 | 86 | .24 |
| 28.4 | | 17.9 | | 17.0 | | 13.8 | 69 | .19 | 40.4 | | 27.7 | | 23.1 | 14.9 | 11.8 | 89 | .32 |
| 29.8 | | 21.7 | | 16.1 | 14.2 | 10.9 | 89 | .21 | 40.8 | | 30.5 | | 25.9 | 14.8 | 11.8 | 89 | .33 |
| 33.9 | | 21.1 | | 19.4 | 14.5 | 13.6 | 81 | .25 | 41.2 | | 29.9 | | 24.6 | 13.8 | 12.6 | 85 | .34 |
| 35.0 | | 21.9 | | 19.7 | 14.6 | 13.4 | 76 | .28 | 41.4 | | 27.9 | | 23.2 | 14.7 | 11.9 | 89 | .33 |
| 35.3 | | 22.1 | | 19.1 | 14.4 | 13.6 | 76 | .29 | 42.0 | | 26.9 | | 24.0 | 14.2 | 12.2 | 89 | .33 |
| 38.9 | | 22.8 | | 18.8 | 13.8 | 12.9 | 76 | .34 | | | | | | | | | |
| * 41.9 | | 22.9 | | 18.8 | 14.2 | 13.2 | 81 | .35 | | | | | | | | | |
| *27.4 | | 19.3 | | 17.8 | 14.4 | 12.7 | 59.1 | .25 | *31.7 | | 22.9 | | 21.9 | 15.1 | 12.7 | 74.6 | .26 |

Av

Table 3. Hourly rate of moisture loss in artificial drying (adjusted to comparative moisture levels).

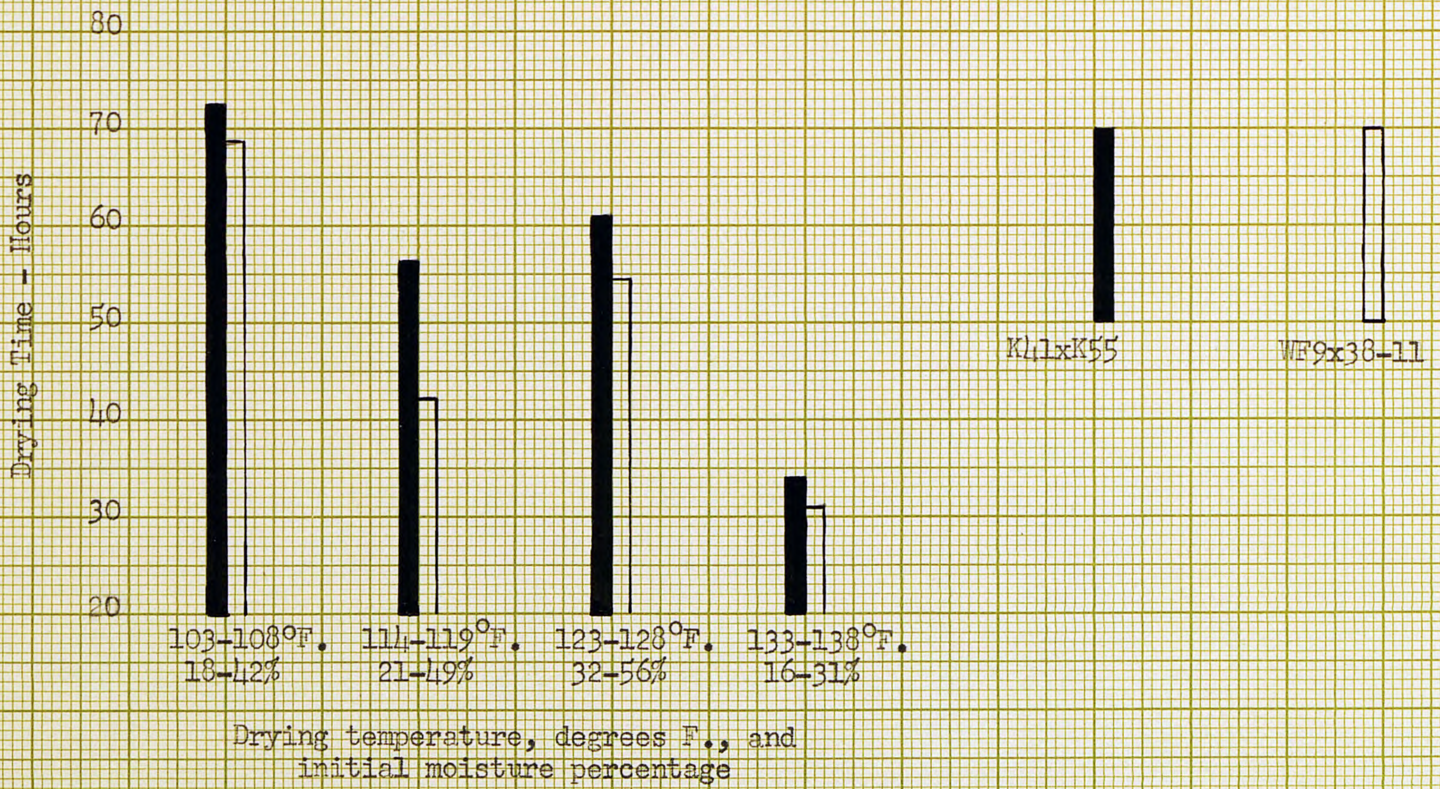
| Drying temperature 0° F. | Hybrid | No. samples | Average % $H_2O$ Wet | Average % $H_2O$ After 24 hours | Average $H_2O$ loss per hr. | % $H_2O$ Dry | Average no. hours dried | Total average $H_2O$ loss | Hourly $H_2O$ loss during drying |
|---|---|---|---|---|---|---|---|---|---|
| 133-138 | WF9 x 38-11 | 5 | 26.6 | 15.6 | .46 | 12.7 | 33.0 | 13.9 | .42 |
| | K41 x K55 | 5 | 26.6 | 17.3 | .39 | 13.1 | 36.0 | 13.5 | .37 |
| 114-119 | WF9 x 38-11 | 8 | 39.0 | 18.6 | .85 | 12.4 | 49.5 | 26.6 | .54 |
| | K41 x K55 | 9 | 39.8 | 22.8 | .71 | 12.1 | 67.0 | 27.7 | .41 |
| 103-108 | WF9 x 38-11 | 7 | 34.6 | 21.8 | .53 | 12.7 | 81.1 | 21.9 | .28 |
| | K41 x K55 | 10 | 34.8 | 25.3 | .40 | 12.4 | 88.3 | 22.4 | .26 |

PLATE I




Comparison of the germination of the two hybrids
after drying at various temperatures

PLATE II




Comparison of the two hybrids in time required
for drying at different temperatures

## Freezing Experiment

In the freezing study K41 x K55 was not damaged more than WF9 x 38-11 by cold as it was by heat in the drying study. Plate III which presents this point graphically was prepared by selecting groups of samples of WF9 x 38-11 and K41 x K55 having comparable moisture percentages. It is evident that the two hybrids were influenced approximately the same by freezing temperatures. Another point noted in comparing the results of artificial freezing with those of artificial drying was that increments of moisture and temperature resulted in a marked decrease in germination during winter storage of the dried samples, while this decrease did not occur in frozen samples.

For field germination five representative samples of WF9 x 38-11 and five of K41 x K55 were selected on the basis of initial moisture content from each of the four freezing treatments. These samples were used in preparing Plate III and are also reported individually in Table 4 which shows the results of the freezing experiment, including the study of protection afforded by husks against freezing injury. At 30° F. for the 12-hour period with samples containing up to 40 percent moisture all samples germinated 90 percent or higher in the laboratory both in fall and spring. Field germinations were lower ranging from 72 to 89 percent, which is similar to field germination of untreated checks.

At 18° F. for twelve hours samples without husk protection having 26 percent moisture and less germinated above 90 percent, but samples with higher moisture were damaged in direct proportion to the moisture content. Samples of WF9 x 38-11 containing up to 33.8 percent moisture were undamaged when protected by husk. Husk protection on K41 x K55 gave variable results at 18° F. One sample containing 38.6 percent moisture germinated 87 percent, another at 38.4 germinated 68 percent, another at 29.4 germinated 85, and another at 29.3 percent moisture germinated 76. However, these were all higher than similar samples without husk protection.

At 10° F. 20 percent moisture appeared to be the critical point between high and reduced germination in the laboratory for both hybrids without husk protection, but 20-percent samples germinated down to 77 percent in the field. With husk protection the critical point was approximately 22 percent moisture. When samples were frozen at 0° F. for 12 hours 17 percent moisture was the approximate critical moisture content for K41 x K55 without husk while all samples of WF9 x 38-11 at 18.4 percent or less germinated over 90 percent. Samples above 19 percent moisture dropped abruptly in germination to 0 at 30 percent moisture. Samples protected by husk germinated 5 to 15 percent at moisture contents up to 37 percent, while at 18 percent moisture husk protection increased germination 10 to 15 percent over unprotected samples.

Table 4. Affect of freezing on laboratory germination and field emergence and the influence of husk as protection against freezing. Samples were treated with sulfur.

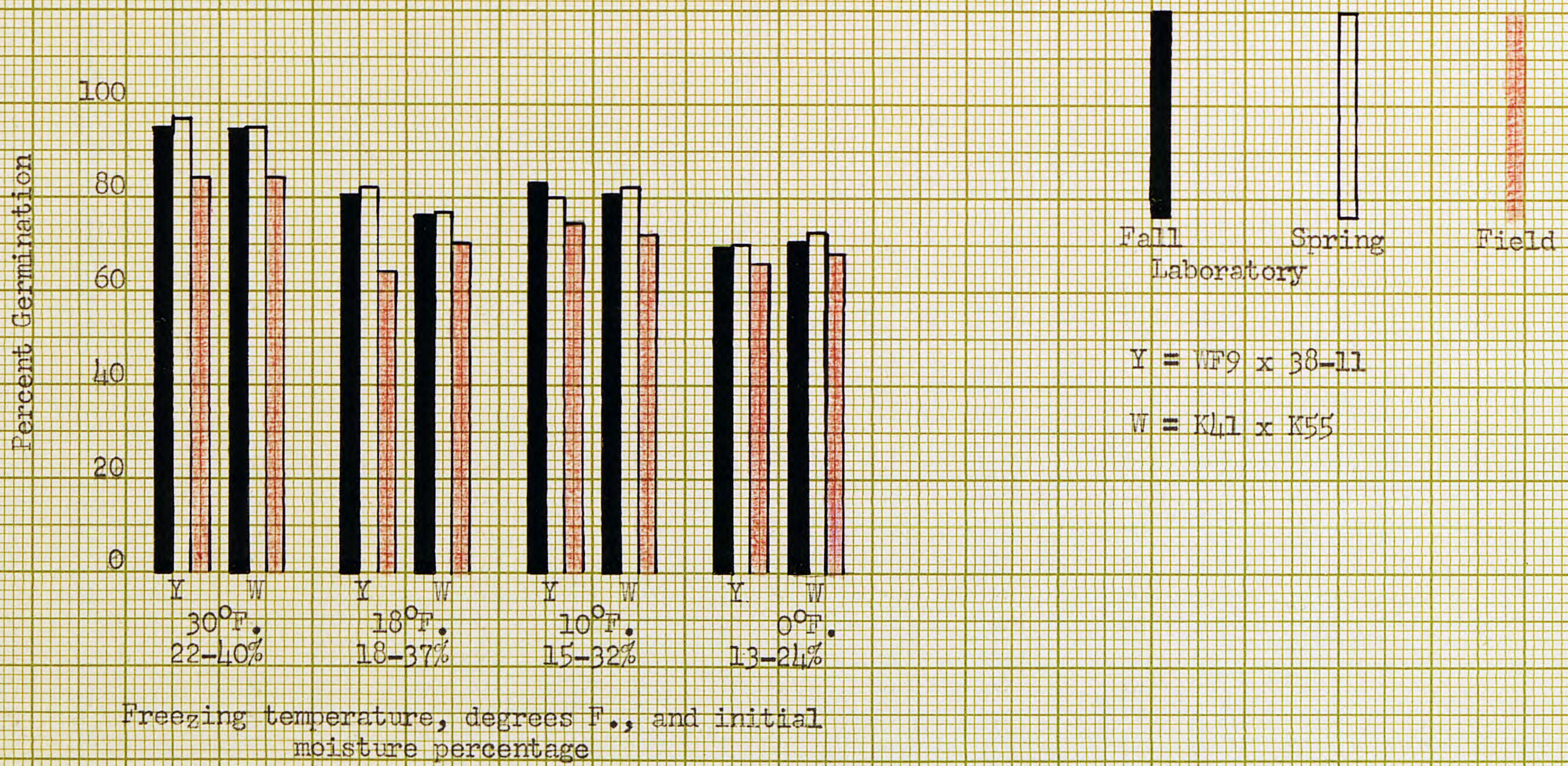
| WF9 x 38-11 | | | | | | | K41 x K55 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In husk | | | Out of husk | | | | In husk | | | Out of husk | | | |
| % | Laboratory | | % | Laboratory | | | % | Laboratory | | % | Laboratory | | |
| $H_2O$ | Fall | Spring | $H_2O$ | Fall | Spring | Field | $H_2O$ | Fall | Spring | $H_2O$ | Fall | Spring | Field |
| Frozen at 30° F. | | | | | | | | | | | | | |
| | | | 16.2 | 99.0 | 97.0 | | 23.3 | 96.5 | 97.5 | 20.6 | 96.5 | 98.0 | |
| | | | 16.9 | 99.0 | 97.5 | | 22.1 | 95.5 | 98.0 | 21.9 | 97.0 | 96.0 | 84.0 |
| | | | 18.8 | 98.0 | 98.0 | | 26.4 | 97.5 | 97.0 | 27.9 | 96.0 | 96.0 | |
| | | | 19.2 | 99.0 | 98.0 | | 26.5 | 98.0 | 98.0 | 27.2 | 97.0 | 96.0 | |
| 24.1 | 96.5 | 97.5 | 22.5 | 91.0 | 93.5 | | 29.8 | 95.5 | 97.0 | 28.0 | 96.0 | 97.0 | 87.5 |
| 27.4 | 96.0 | 98.0 | 23.9 | 94.5 | 97.0 | 82.0 | 35.4 | 96.0 | 97.0 | 28.9 | 95.5 | 97.0 | 84.0 |
| 29.3 | 96.0 | 98.0 | 31.5 | 96.0 | 97.5 | 72.0 | 37.0 | 95.5 | 97.0 | 36.3 | 96.0 | 97.5 | |
| 31.6 | 96.0 | 97.5 | 33.1 | 94.0 | 97.5 | 87.5 | 37.3 | 95.5 | 97.5 | 36.6 | 94.0 | 97.5 | 81.0 |
| 35.7 | 94.0 | 98.0 | 34.5 | 92.0 | 96.0 | 89.0 | 40.2 | 94.0 | 97.0 | 39.5 | 90.5 | 96.0 | 85.0 |
| 37.2 | 96.0 | 98.0 | 34.8 | 96.0 | 98.0 | 87.5 | 40.4 | 96.0 | 96.5 | 40.6 | 93.5 | 96.0 | |
| *30.9 | 95.8 | 98.0 | 25.1 | 95.9 | 97.0 | | 31.8 | 96.0 | 97.3 | 30.8 | 95.2 | 96.7 | |
| Ave. of five planted in field | | | 31.6 | 94.5 | 97.2 | 83.6 | | | | 31.0 | 94.4 | 95.7 | 84.3 |
| 18° F. | | | | | | | | | | | | | |
| | | | | | | | 22.4 | 97.5 | 98.0 | 17.9 | 97.0 | 98.0 | 92.0 |
| | | | | | | | 22.6 | 98.0 | 97.5 | 18.0 | 97.0 | 98.0 | 88.5 |
| | | | 17.5 | 98.0 | 99.0 | | 22.6 | 97.0 | 97.0 | 19.6 | 97.0 | 98.0 | |
| | | | 17.7 | 98.0 | 99.0 | | 23.7 | 87.0 | 94.0 | 20.3 | 97.0 | 98.0 | |
| | | | 18.6 | 98.0 | 98.0 | | 24.9 | 97.0 | 94.0 | 24.1 | 91.0 | 93.5 | |
| | | | 19.2 | 98.0 | 97.5 | 73.0 | 25.7 | 99.0 | 98.0 | 25.0 | 90.5 | 91.0 | 82.5 |
| 22.4 | 93.0 | 93.5 | 21.7 | 92.5 | 95.0 | 68.0 | 29.3 | 66.5 | 76.0 | 27.4 | 72.0 | 85.5 | |
| 22.6 | 91.5 | 91.0 | 23.6 | 79.0 | 91.0 | 78.0 | 29.4 | 77.5 | 85.0 | 29.7 | 51.5 | 57.5 | 51.0 |
| 32.4 | 95.0 | 94.5 | 31.3 | 69.5 | 66.5 | 41.0 | 38.4 | 77.5 | 68.0 | 37.4 | 37.5 | 39.5 | 38.0 |
| 33.8 | 95.5 | 93.5 | 32.3 | 65.0 | 61.5 | 61.0 | 38.6 | 70.5 | 87.0 | 38.9 | 37.0 | 33.5 | |
| *27.8 | 93.8 | 93.1 | 22.7 | 87.3 | 88.4 | | 27.8 | 86.8 | 89.5 | 25.8 | 76.8 | 79.3 | |
| Ave. of five planted in field | | | 25.6 | 80.8 | 82.3 | 64.2 | | | | 25.6 | 74.7 | 76.8 | 70.4 |

Table 4 (cont.).

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$10^{\circ}$ F.** | | | | | | | | | | | | | |
| | | | | | | | | | | 17.2 | 95.5 | 98.0 | 84.0 |
| | | | | | | | | | | 17.8 | 97.0 | 99.0 | 88.0 |
| | | | | | | | 21.3 | 92.0 | 96.5 | 18.5 | 95.0 | 96.5 | |
| | | | | | | | 22.0 | 96.5 | 98.0 | 19.2 | 96.0 | 97.0 | 77.5 |
| | | | | | | | 22.6 | 87.0 | 82.5 | 23.4 | 78.0 | 76.5 | 70.0 |
| | | | 15.4 | 96.0 | 97.0 | 88.5 | 22.5 | 83.0 | 74.0 | 23.4 | 66.0 | 64.5 | |
| 22.4 | 85.5 | 89.0 | 16.0 | 95.0 | 97.5 | 85.0 | 29.0 | 66.0 | 59.0 | 27.9 | 41.5 | 37.0 | |
| 22.5 | 92.0 | 96.0 | 20.5 | 91.0 | 88.0 | 77.0 | 29.1 | 56.0 | 61.0 | 28.3 | 34.5 | 41.5 | 39.0 |
| 31.1 | 71.0 | 63.0 | 22.7 | 82.0 | 74.0 | 76.0 | 37.5 | 48.0 | 52.0 | 37.6 | 2.5 | 1.0 | |
| 32.5 | 66.5 | 74.5 | 31.8 | 51.5 | 46.0 | 45.0 | 38.2 | 49.0 | 55.5 | 37.8 | 11.5 | 13.0 | |
| *27.1 | 78.8 | 80.6 | 21.3 | 83.1 | 80.5 | | 27.8 | 72.2 | 72.3 | 25.1 | 61.8 | 62.4 | |
| Ave. of five planted in field | | | 21.3 | 83.1 | 80.5 | 74.3 | | | | 21.2 | 80.2 | 82.4 | 71.7 |
| **$0^{\circ}$ F.** | | | | | | | | | | | | | |
| | | | | | | | | | | 16.4 | 94.0 | 94.5 | 91.0 |
| | | | 11.9 | 94.0 | 98.0 | | | | | 16.9 | 85.5 | 91.5 | 91.5 |
| | | | 12.5 | 99.5 | 97.5 | 88.0 | 18.1 | 84.5 | 84.5 | 18.2 | 80.5 | 84.0 | 72.0 |
| | | | 18.0 | 97.0 | 97.0 | 87.5 | 19.3 | 63.5 | 75.0 | 19.7 | 77.0 | 79.5 | 67.5 |
| | | | 18.2 | 94.5 | 98.0 | 92.0 | 24.1 | 21.0 | 23.0 | 23.5 | 17.5 | 17.0 | 17.0 |
| | | | 18.4 | 96.0 | 96.5 | | 23.5 | 59.0 | 55.5 | 23.5 | 11.5 | 15.0 | |
| 22.0 | 47.5 | 48.0 | 20.2 | 43.5 | 43.0 | 40.0 | 29.0 | 14.0 | 13.5 | 28.0 | 5.0 | 5.5 | |
| 23.7 | 54.5 | 57.5 | 22.1 | 11.5 | 16.5 | 20.5 | 29.0 | 22.0 | 15.5 | 28.4 | 0 | 5.0 | |
| 28.8 | 35.0 | 36.5 | 29.4 | 0 | 1.0 | | 36.9 | 7.5 | 5.0 | 34.8 | 0 | 0 | |
| 31.6 | 15.5 | 18.5 | 29.7 | 0 | 2.5 | | 37.0 | 17.5 | 13.5 | 36.7 | 0 | 0 | |
| *26.5 | 38.1 | 40.1 | 20.0 | 59.6 | 61.1 | | 27.1 | 36.1 | 35.7 | 24.6 | 37.1 | 39.1 | |
| Ave. of five planted in field | | | 18.2 | 69.2 | 70.4 | 65.6 | | | | 18.6 | 70.9 | 73.3 | 67.8 |

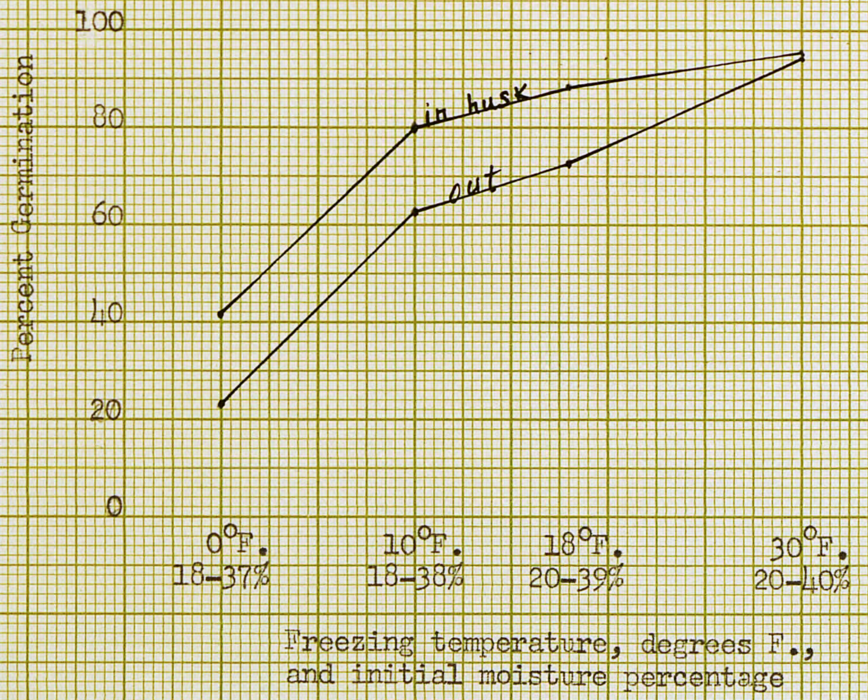
* Averages

PLATE III




The effect of freezing on seed corn germination.

# PLATE IV




Effect of husk in protecting corn from damage by freezing.
(Average of the two hybrids)

Table 5. Germination of samples dried naturally. Samples treated with sulfur.

| WF9 x 38-11 | | | | | | K41 x K55 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % $H_2O$ | | Days | Lab. germ. | | | % $H_2O$ | | Days | Lab. germ. | | |
| Wet | Dry | dried | Fall | Spring | Field | Wet | Dry | dried | Fall | Spring | Field |
| **Early harvest** | | | | | | | | | | | |
| 30.7 | 9.7 | 21 | 93.5 | 97.0 | 92.0 | 33.9 | 10.5 | 21 | 96.0 | 98.0 | 87.0 |
| 32.1 | 11.0 | 21 | 96.0 | 97.0 | 82.0 | 34.0 | 9.5 | 21 | 96.0 | 97.5 | 88.0 |
| 34.2 | 8.8 | 21 | 96.5 | 97.5 | 89.0 | 37.0 | 8.4 | 21 | 96.0 | 98.0 | 87.0 |
| 34.9 | 9.3 | 21 | 95.5 | 98.0 | 88.5 | 37.4 | 9.7 | 21 | 93.0 | 95.0 | 81.0 |
| 42.7 | 11.7 | 21 | 95.5 | 98.0 | 89.0 | 43.7 | 9.9 | 21 | 95.5 | 91.5 | 77.0 |
| 43.9 | 9.1 | 21 | 95.0 | 97.0 | 82.0 | 45.4 | 10.8 | 21 | 95.5 | 94.0 | 78.0 |
| 53.5 | 8.4 | 21 | 96.5 | 95.5 | 69.0 | 46.6 | 8.4 | 21 | 93.0 | 90.5 | 64.0 |
| 53.9 | 7.8 | 21 | 87.0 | 97.0 | 66.0 | 47.7 | 8.4 | 21 | 88.0 | 94.5 | 76.0 |
| *40.7 | 9.5 | 21 | 94.4 | 97.0 | 82.2 | 40.7 | 9.5 | 21 | 94.1 | 94.9 | 79.8 |
| **Late harvest** | | | | | | | | | | | |
| 22.2 | 9.6 | 14 | 97.0 | 99.0 | 84.0 | 23.5 | 10.3 | 14 | 92.5 | 94.5 | 80.0 |
| 22.6 | 9.6 | 14 | 96.0 | 98.0 | 86.0 | 23.5 | 9.7 | 14 | 96.0 | 97.0 | 86.0 |
| | | | | | | 23.5 | 10.2 | 14 | 90.0 | 94.5 | 77.5 |
| | | | | | | 23.5 | 10.3 | 14 | 94.0 | 93.5 | 84.0 |
| | | | | | | 25.5 | 10.2 | 14 | 96.0 | 98.0 | 90.0 |
| | | | | | | 25.6 | 10.2 | 14 | 94.0 | 96.0 | 88.0 |
| *22.4 | 9.6 | 14 | 96.5 | 98.5 | 85.0 | 24.2 | 10.2 | 14 | 93.8 | 95.6 | 84.3 |

* Averages

## Seed Treatment Experiment - Laboratory

As mentioned previously the first sets of artificially dried samples were heavily infested with various fungi when germinated in the laboratory. The organisms found, listed in order of degree of infestation, were Rhizopus, Fusarium, Aspergillus, Diplodia zeae, Penicillium, and some Alternarium. To clean the samples and make them easier to count they were all treated with sulfur. The results are shown in Table 6 and Plates V and VI. The average germination of all samples of WF9 x 38-11 was increased from 61.2 percent to 77.7 percent by the treatment and the germination of K41 x K55 was increased from 47.5 percent to 56.7 percent for the 44 samples. This increased germination was largely due to the fact that many seedling plants were weak from heavy infestation by fungi, but when the seed was treated with sulfur these same samples produced healthy plants which could be counted as normal germination. Those samples which had been harvested very immature were most susceptible to fungus damage and it was these which gave greatest increased germination with sulfur treatment, provided they had not been too severely damaged by high drying temperatures. High quality seed seemed to produce vigorous seedlings regardless of the fungi present.

Mr. Clare Porter, Secretary-Manager of the Kansas Hybrids Association at Manhattan, reported that the laboratory germination of commercial inbred seed stocks was increased an average of 12 percent by treating with Spergon during the winter of 1945-46. A certified seed grower increased the laboratory germination of his commercial seed of the white hybrid K2234 from 70 percent to above 90 percent this year by chemical treatment. Crosier (12) of the New York Experiment Station at Ithaca obtained results similar to these in experiments with seed treatment for laboratory germination of various crop seeds. Samples treated with Ceresan, New Improved Ceresan, and Sanoseed developed higher percentages of normal sprouts and were much easier to read than those which were not treated.

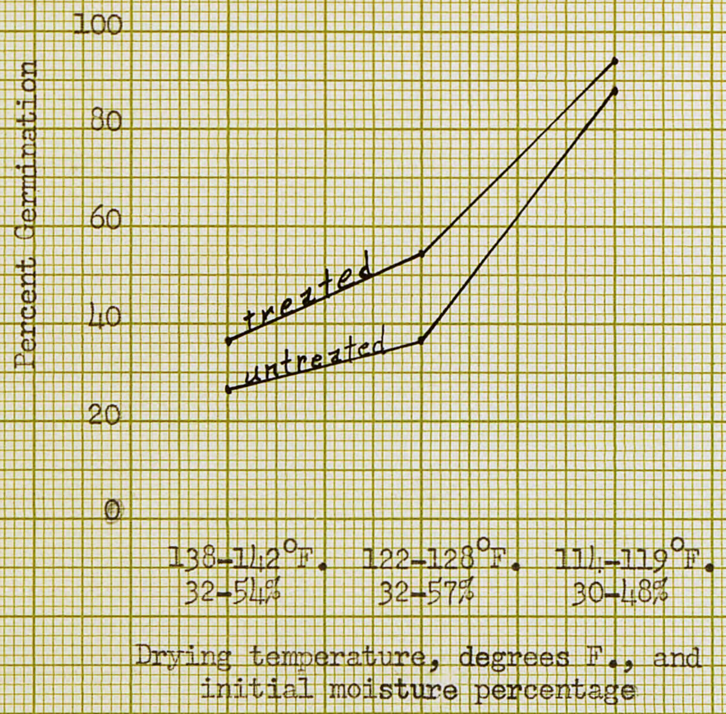
These results are similar to those obtained by Hume and Franzke (15), who found a significant correlation between high mold infestation and low germination, and low mold infestation and high germination in laboratory studies.

Table 6. The affect of treatment with sulfur on the germination of seed corn in the laboratory.

| WF9 x 38-11 | | | K41 x K55 | | |
|---|---|---|---|---|---|
| % Moisture | No Treatment | Treated | % Moisture | No Treatment | Treated |
| | | Dried at 138 - 142° F. | | | |
| 31.9 | 55.5 | 64.5 | 33.0 | 36.0 | 59.0 |
| 35.7 | 52.5 | 72.0 | 36.8 | 25.0 | 35.0 |
| 41.6 | 47.5 | 63.0 | 45.4 | 20.5 | 19.5 |
| 53.4 | 7.5 | 13.0 | 50.1 | 16.5 | 18.0 |
| 54.2 | 6.0 | 9.0 | 50.7 | 11.0 | 10.5 |
| Ave.43.4 | 33.8 | 44.3 | 43.2 | 21.8 | 28.4 |
| | | Dried at 122 - 128° F. | | | |
| 31.7 | 68.0 | 85.0 | 34.0 | 54.5 | 73.5 |
| 31.7 | 79.0 | 98.0 | 34.3 | 55.5 | 53.5 |
| 32.1 | 77.5 | 93.0 | 34.7 | 43.5 | 62.0 |
| 43.0 | 77.0 | 90.5 | 44.3 | 8.0 | 20.5 |
| 43.2 | 52.5 | 84.0 | 45.1 | 23.5 | 26.0 |
| 43.7 | 52.0 | 70.0 | 45.7 | 13.5 | 19.5 |
| 50.1 | 34.5 | 82.0 | 46.4 | 6.0 | 23.0 |
| 50.4 | 37.5 | 65.5 | 48.4 | 14.0 | 45.5 |
| 53.6 | 17.5 | 47.0 | 52.1 | 0.0 | 0.0 |
| 56.7 | 2.0 | 10.0 | | | |
| Ave.43.6 | 49.8 | 72.5 | 42.8 | 24.3 | 35.9 |
| | | Dried at 114 - 119° F. | | | |
| 29.9 | 95.0 | 96.0 | 31.2 | 95.0 | 95.0 |
| 31.2 | 95.0 | 97.0 | 32.8 | 89.5 | 97.0 |
| 33.6 | 94.0 | 95.0 | 33.4 | 95.5 | 94.0 |
| 41.2 | 95.0 | 96.0 | 39.8 | 95.0 | 97.0 |
| 41.3 | 92.0 | 96.0 | 41.3 | 95.0 | 96.0 |
| 43.2 | 94.0 | 95.0 | 42.1 | 87.5 | 97.0 |
| 44.6 | 94.0 | 94.5 | 43.5 | 74.5 | 88.0 |
| 47.1 | 83.0 | 93.0 | 45.5 | 70.0 | 93.5 |
| | | | 48.5 | 64.0 | 82.0 |
| Ave.39.0 | 92.8 | 95.3 | 39.8 | 85.1 | 93.3 |
| Grand Ave. | 61.2 | 77.7* | | 47.5 | 56.7 |

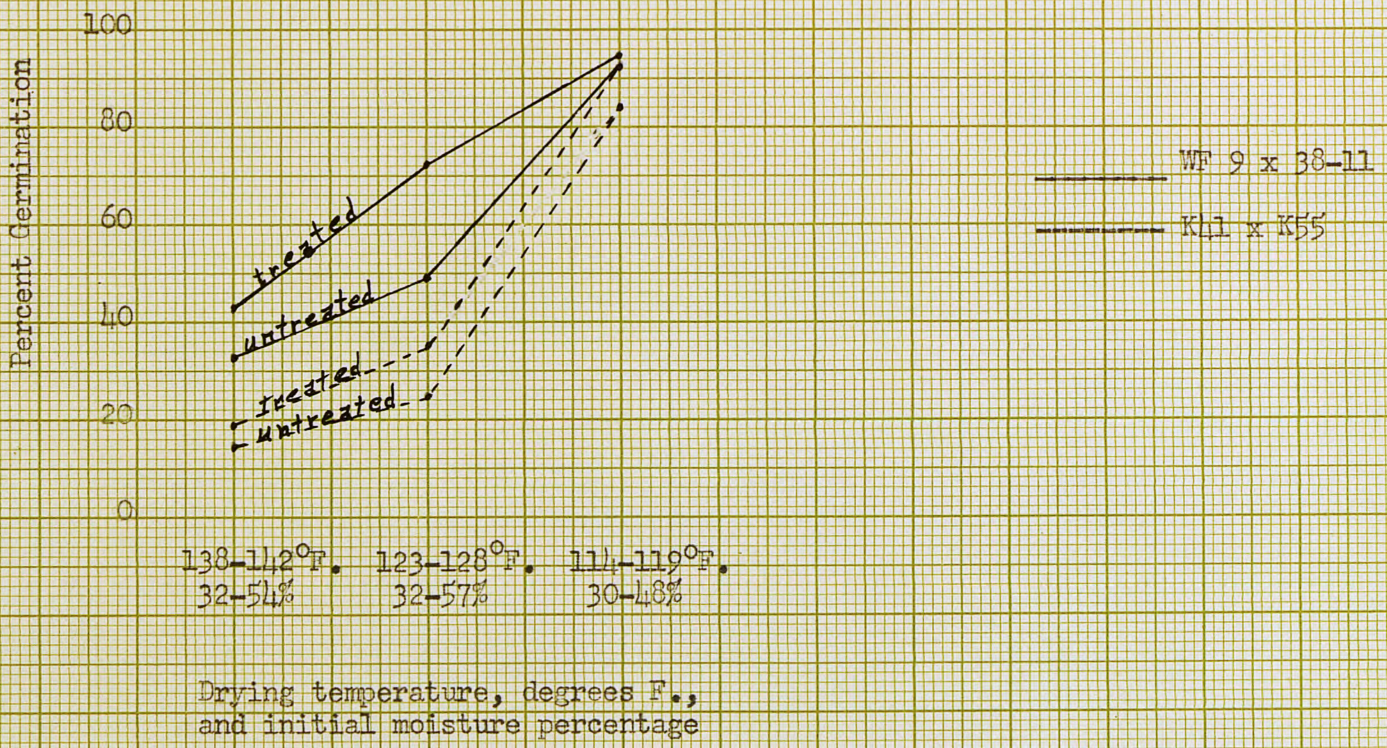
* Statistically significant.

PLATE V




Effect of seed treatment with sulphur
on laboratory germination of two hybrids
artificially dried at three temperatures.

PLATE VI




Comparison of the two hybrids in response to sulphur treatment in laboratory germination

Seed Treatment Experiment - Field

Marked differences in the different seed treatments occurred in the field in samples dried at 138 - 142° F. and 123 - 128° F., in which all germinations were relatively low, while for samples dried at 108 - 112° F. and having normal germination the treated samples showed no advantage over untreated checks. Arasan gave consistently higher germinations than Spergon in the two tests where significant differences were obtained, both bringing the germination up above the spring laboratory germinations. Semesan Jr. ranked third, and sulfur and no treatment ranked about the same and slightly under Semesan Jr. The germination of checks and sulfur treated samples was somewhat below the laboratory germination. Samples treated with Semesan Jr. germinated in general slightly less than the laboratory germinations.

Germination of all samples is shown in Table 7 and the statistical analysis is shown in Tables 8, 9, 10, 11, and 12. For WF9 x 38-11 dried at 138 - 142° F. the following average percent germinations are shown: spring laboratory - 20.1 percent, check - 10.3, sulfur - 10.5, Semesan Jr. - 14.0, Spergon - 25.7, and Arasan - 32.5 percent. For K41 x K55: spring laboratory - 11.1, check - 5.5, sulfur - 5.5, Semesan Jr. - 8.5, Spergon - 14.5, and Arasan - 24.5. The initial average moisture of the two hybrids was 43.4 and 43.2 percent.

For samples dried at 123 - 128° F. the following results were obtained; for WF9 x 38-11: spring laboratory - 38.4 percent, check - 20.9, sulfur - 18.5, Semesan Jr. 27.1, Spergon - 34.5, and Arasan - 44.3; and for K41 x K55: spring laboratory - 10.8, check - 7.5, sulfur - 6.6, Semesan Jr. - 11.4, Spergon - 18.1, and Arasan - 26.8 percent. The initial moisture of the two hybrids was 43.6 percent and 42.8 percent respectively.

For samples dried at 108 - 110° F. and containing less than 25 percent initial moisture WF9 x 38-11 gave the following germinations: spring laboratory - 97.6, check - 87.1, sulfur - 85.3, Spergon - 87.7, Arasan - 88.6, and Semesan Jr. - 88.8. For K41 x K55: spring laboratory - 96.7, check - 86.1, sulfur - 85.6, Spergon - 86.2, Arasan - 88.0, and Semesan Jr. - 88.6 percent germination. These germinations do not show statistical significance between treatments as they did when germinations were lower and seed was of reduced quality due to high drying temperatures and higher moisture in samples when dried. This indicates that seed treatment might be of most benefit with seed of poor quality.

Table 7. Results of field seed treatment study. Each sample is the average of four replications.

| | WF9 x 38-11 | | | | | | | K41 x K55 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percent Emergence | | | | | | | Percent Emergence | | | | | |
| | Spring | No | Treatment | | | | | Spring | No | Treatment | | | |
| % $H_2O$ | Laboratory | Treatment | Sulfur | Spergon | Arasan | Semesan Jr. | % $H_2O$ | Laboratory | Treatment | Sulfur | Spergon | Arasan | Semesan Jr. |
| **Dried at 138 - 142° F.** | | | | | | | | | | | | | |
| 31.9 | 32.0 | 14.5 | 23.0 | 35.0 | 41.0 | 23.0 | 33.0 | 32.5 | 14.0 | 14.0 | 25.0 | 30.0 | 17.5 |
| 35.7 | 34.0 | 17.0 | 17.0 | 46.5 | 52.0 | 31.0 | 36.8 | 15.5 | 10.0 | 9.5 | 20.5 | 31.5 | 14.0 |
| 41.6 | 34.5 | 19.0 | 11.0 | 40.0 | 53.5 | 14.0 | 45.4 | 2.5 | 2.5 | 2.0 | 15.0 | 28.5 | 6.0 |
| 53.4 | 0.0 | 1.0 | 1.5 | 5.0 | 7.5 | 2.0 | 50.1 | 3.5 | 0.0 | 1.0 | 5.5 | 13.5 | 2.0 |
| 54.2 | 0.0 | 0.0 | 0.0 | 2.0 | 7.5 | 0.0 | 50.7 | 1.5 | 1.0 | 1.0 | 6.5 | 19.0 | 3.0 |
| *43.4 | 20.1 | 10.3 | 10.5 | 25.7 | 32.5 | 14.0 | 43.2 | 11.1 | 5.5 | 5.5 | 14.5 | 24.5 | 8.5 |
| Least significant difference between means of treatments - 2.8% | | | | | | | | | | | | | |
| **Dried at 123 - 128° F.** | | | | | | | | | | | | | |
| 31.7 | 51.0 | 27.0 | 32.0 | 48.0 | 51.5 | 44.5 | | | | | | | |
| 31.7 | 74.0 | 44.5 | 42.0 | 60.0 | 72.5 | 58.0 | 34.0 | 30.0 | 22.5 | 20.5 | 44.0 | 52.0 | 33.0 |
| 32.1 | 62.0 | 35.0 | 28.5 | 53.0 | 53.5 | 40.0 | 34.3 | 19.5 | 21.0 | 17.5 | 44.0 | 50.0 | 26.0 |
| 43.0 | 62.0 | 41.0 | 35.0 | 55.0 | 74.0 | 49.0 | 34.7 | 17.0 | 10.0 | 6.5 | 21.5 | 27.0 | 13.0 |
| 43.2 | 47.0 | 26.0 | 20.0 | 43.0 | 55.0 | 26.0 | 44.3 | 5.0 | 2.5 | 2.0 | 5.5 | 12.0 | 2.0 |
| 43.7 | 29.5 | 13.0 | 11.0 | 30.0 | 41.5 | 20.5 | 45.1 | 10.0 | 5.0 | 5.0 | 17.0 | 34.0 | 6.8 |
| 50.1 | 29.0 | 13.0 | 10.0 | 29.5 | 39.5 | 19.0 | 45.7 | 2.0 | 2.0 | 2.0 | 6.0 | 14.0 | 5.0 |
| 50.4 | 20.5 | 8.0 | 5.0 | 20.5 | 37.0 | 11.0 | 46.4 | 5.5 | 1.5 | 2.0 | 8.0 | 16.0 | 3.0 |
| 53.6 | 9.0 | 1.0 | 1.5 | 5.5 | 16.0 | 3.0 | 48.4 | 8.0 | 2.5 | 1.0 | 16.0 | 35.0 | 13.0 |
| 56.7 | 0.0 | 0.5 | 0.0 | 0.5 | 2.0 | 0.0 | 52.1 | 0.0 | 0.5 | 1.0 | 0.5 | 1.5 | 0.5 |
| *43.6 | 38.4 | 20.9 | 18.5 | 34.5 | 44.3 | 27.1 | 42.8 | 10.8 | 7.5 | 6.6 | 18.1 | 26.8 | 11.4 |
| Least significant difference between means of treatments - 2.7% | | | | | | | | | | | | | |

Table 7 (cont.).

| | | | | | | | Dried at 108 - 112° F. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15.2 | 98.0 | 79.5 | 82.0 | 87.0 | 89.0 | 91.0 | | | | | | | |
| 15.5 | 95.5 | 89.0 | 83.5 | 86.0 | 84.5 | 85.0 | 22.6 | 98.0 | 87.0 | 91.0 | 83.5 | 90.0 | 83.0 |
| 15.7 | 99.0 | 90.5 | 82.5 | 89.0 | 91.0 | 93.5 | 23.0 | 98.0 | 89.0 | 82.5 | 87.0 | 92.0 | 88.0 |
| 16.0 | 98.0 | 86.0 | 84.5 | 83.0 | 84.0 | 85.5 | 23.2 | 98.0 | 86.0 | 88.5 | 88.0 | 91.0 | 93.5 |
| 18.9 | 98.0 | 89.0 | 89.5 | 90.0 | 91.0 | 88.0 | 23.2 | 98.0 | 91.0 | 90.0 | 88.0 | 86.0 | 93.0 |
| 20.0 | 97.0 | 89.0 | 90.0 | 91.0 | 92.0 | 90.0 | 23.8 | 91.5 | 77.5 | 76.0 | 84.5 | 81.0 | 84.0 |
| *16.9 | 97.6 | 87.1 | 85.3 | 87.7 | 88.6 | 88.8 | 23.2 | 96.7 | 86.1 | 85.6 | 86.2 | 88.0 | 88.3 |

* Averages

Table 8. Analysis of variance of seed corn emergence in the field as influenced by seed treatment of samples dried artificially at 138 - 142° F.

| Factor | Degrees of freedom | Sum of squares | Variance |
|---|---|---|---|
| Total | 199 | 44364.42 | |
| Treatments | 4 | 13015.42 | 3253.36** |
| Varieties | 1 | 2380.50 | 2380.50** |
| Treatment x varieties | 4 | 324.40 | 81.10 |
| Replications | 30 | 1571.90 | 52.40 |
| Error | 160 | 6299.98 | 39.37 |

** Highly significant

Table 9. Comparison of the several seed treatments on corn dried at 138 - 142° F.

| Treatment | WF9 x 38-11 | | K41 x K55 | |
|---|---|---|---|---|
| | Percent emergence | Difference | Percent emergence | Difference |
| Arasan | 44.3 | | 26.8 | |
| Spergon | 34.5 | 9.8 | 18.1 | 8.7 |
| Semesan Jr. | 27.1 | 7.4 | 11.4 | 6.7 |
| Check | 20.9 | 6.2 | 7.5 | 3.9 |
| Sulfur | 18.5 | 2.4 | 6.6 | 0.9 |

2.8% = least significant difference in emergence between treatment means.

Table 10. Analysis of variance of seed corn emergence in the field as influenced by seed treatment of samples dried artificially at 123 - 128° F.

| Factor | Degrees of freedom | Sum of squares | Variance |
|---|---|---|---|
| Total | 359 | 145020.12 | |
| Treatments | 4 | 29138.92 | 7284.73** |
| Varieties | 1 | 29484.90 | 29484.90** |
| Treatment x variety | 4 | 797.47 | 199.37** |
| Replications | 54 | 7620.40 | 141.12** |
| Error | 296 | 11518.01 | 38.91 |

** Highly significant

Table 11. Comparison of the several seed treatments on corn dried at 123 - 128° F.

| Treatment | WF9 x 38-11 | | K41 x K55 | |
|---|---|---|---|---|
| | Percent emergence | Difference | Percent emergence | Difference |
| Arasan | 32.5 | | 24.5 | |
| Spergon | 25.7 | 6.8 | 14.5 | 10.0 |
| Semesan Jr. | 14.0 | 11.7 | 8.5 | 6.0 |
| Sulfur | 10.5 | 3.5 | 5.5 | 3.0 |
| Check | 10.3 | 0.2 | 5.5 | 0.0 |

2.7% = least significant difference in emergence between treatment means.

Table 12. Analysis of variance of seed corn emergence in the field as influenced by seed treatment of samples dried artificially at 108 - 112° F.

| Factor | Degrees of freedom | Sum of squares | Variance |
|---|---|---|---|
| Total | 199 | 11382.08 | |
| Treatments | 4 | 177.98 | 44.50 |
| Varieties | 1 | 48.02 | 48.02 |
| Treatment x variety | 4 | 44.38 | 11.10 |
| Replications | 30 | 2622.00 | 87.40** |
| Error | 160 | 6903.24 | 43.15 |

** Highly significant

## SUMMARY AND CONCLUSIONS

1. The single-cross hybrid K41 x K55 dried at a slower rate than did WF9 x 38-11.

2. K41 x K55 germinated less on the average than WF9 x 38-11 when dried at the higher temperatures, probably because of the longer exposure to the drying process.

3. The initial moisture content appeared to be the primary factor influencing germination of samples dried at a given temperature.

4. Samples of both hybrids when dried at the higher temperatures or with a combination of high moisture content and moderately high temperature, germinated higher immediately after drying than they did after three months in storage.

5. A temperature of 138 - 142° F. was injurious to all samples studied. These involved only moisture levels over 31 percent. Considering field emergence, drying temperature of

133 - 138° F. was not injurious to samples of WF9 x 38-11 containing up to 25.7 percent moisture, and of K41 x K55 with moisture up to 20 percent. At 114 - 119° F. the germination of WF9 x 38-11 was not reduced till the moisture content exceeded 31 percent, and 28.6 percent for K41 x K55. Samples dried at 108 - 112° F. were uninjured, however only samples containing 24 percent moisture or less were studied. Temperatures of 103 - 108° F. were not injurious even though samples were included which contained up to 42 percent moisture.

6. Since only small lots were used in this experiment further studies should be made using bin-size lots before general recommendations can be made regarding proper temperatures to use in drying corn. Such recommendations should be established for corn of various moisture levels and for varieties differing in rate of drying.

7. Results obtained in the freezing experiment indicate that differences in germination caused by freezing are due principally to the moisture content of the grain and not to varietal differences, except as one may mature earlier or later than another. Small differences in moisture content often resulted in wide differences in germination after freezing at a given temperature.

8. Samples subjected to freezing did not show loss in germination during storage as did artificially dried samples which were not frozen.

9. Results of the laboratory seed treatment study indicate that the germinability of samples in the laboratory might be measured more accurately by treating the seed to control molds and other organisms attacking the seed and seedling.

10. Treatment with commercial fungicides increased the field emergence of low-germinating seed markedly over the untreated seed and seed treated with sulfur. Arasan ranked best, Spergon second, and Semesan Jr. third. For samples showing strong germination the field emergence for untreated samples was as high as the treated samples.

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