EFFECT OF SEED VIGOR ON FIELD PERFORMANCE AND
YIELD OF GRAIN SORGHUM (Sorghum bicolor (L) Moench)

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ABSTRACT

Hybrid grain sorghum seed were aged artificially for 0, 3, 5, 7 and 11 days at 42°C and 100% RH, which produced five vigor levels of seed. Among the various laboratory tests performed, standard germination was the least sensitive in discerning the physiological condition of the seed lots. The speed of germination more accurately differentiated the degree of deterioration of the seed lots and was closely correlated to yield.

Planting low vigor seed caused reduced plant height, delayed panicle exsertion, and anthesis, less tillering capacity, and reduced yield. These slow growing plants were significantly inferior in panicle exsertion to those produced from more vigorous seeds. Seeds aged for 7 and 11 days had their process of exsertion delayed 2 and 3 days, respectively. Anthesis, consequently, was also significantly retarded. Tillering capacity of plants produced from low vigor seeds was significantly reduced, as well as grain yield. Primary head yield was also significantly reduced 14% for the more deteriorated seeds, and 12% for the mixed treatment, as compared to the control. Yield reductions of 9, 4 and 3% were also detected in seeds aged for 7, 5 and 3 days, respectively, as compared to the control.

Seed moisture content was generally higher at harvest time for the lower vigor levels of seed indicating that the process of maturation was delayed due to low vigor.

The blended treatment (mixed) was found to be as poor as the most deteriorated seeds in many plant performance characteristics. The drastic reduction in yield in this particular treatment suggests further research using different blending proportions and accurate identification of plants produced from high and low vigor seeds.

Additional index words: deterioration, emergence, anthesis, panicle exsertion.

INTRODUCTION

Seeds are basic in crop production. No agricultural practice can improve a crop beyond the limits set by the seed. The crop may be poorer than the seed planted, but it cannot be better. Kramer and Ross (15) stated that high quality sorghum seed should be high in germination, vigor, and purity. If farmers want to obtain maximum profits from their crop, seed vigor is an important factor of seed quality which must be taken into account.

Verhey (20) reported that plants produced from seeds of low vigor are, in fact, occupying the place of another which could give the farmer a maximum yield. Grabe and Frey (13), working with oats, found that germination percentage
largely determined oat stands. But even with good germination, the yield may be reduced 10 percent if seedling vigor is low. In sorghum, studies of seed vigor have been directed toward some aspects of laboratory response as an aid in evaluating storage potential. Most of these studies have ignored the influence of vigor on plant performance and yield.

The objective of this study was to evaluate the laboratory and field performance of sorghum seed of different vigor levels.

**Review of Literature**

Utilization of vigor tests in the past has been related largely to laboratory studies as an aid in evaluating the "carry-over" potential of seeds. The effect of differential seed vigor levels related to plant performance, including yield, has received much less attention although the idea of the "physiological predetermination" was advanced by Kidd and West (14) in 1918. They believed that the physiological condition of the seed predetermined subsequent growth and performance of plants.

The earliness of seedling emergence in the field has been studied in some crops. Generally, as the vigor level of the seeds decreases (deterioration increases) seedling emergence decreases (3, 5, 6, 9, 10, 12, 19).

Gill (10) planted corn samples varying widely in degree of deterioration. He found that seedlings and plants produced from deteriorated seeds emerged and grew slowly until about 50 days after planting. After 50 days, differences in vegetative growth of the plants were no longer evident. The low vigor of plants from deteriorated seeds, however, apparently influenced yield as plants from the most deteriorated seeds produced 14-18% less grain than the control. All yields were based on equal plant populations. Funk *et al.* (9) studied the performance of new and old hybrid corn seed. They concluded that plants produced from old seed were slower in emergence, had less seedling vigor, and reduced competitive ability. They found highly significant yield reductions for 2, 3, 4 and 5 year-old seed when compared to one-year-old seed. These reductions were as much as 20.2% for 5-year-old seed. In a similar study, Dungan and Koehler (18) planted seed corn ranging from 1-10 years in age. Three-year-old seeds had a 4.8% lower yield than one-year-old seed when both lots had an equal stand. However, when reduced stand was also considered, the yield reduction increased to 7.8%. Yield reductions from 7-year-old seed were 10.1 and 31.7% for equal and reduced stands, respectively. Grabe (11) measured the levels of deterioration in corn seeds and selected those which produced seedlings of high, medium and low vigor. When grown in the same hill, the low vigor seedlings yielded 14% less grain than high vigor, and 13% less than medium vigor seedlings. Medium vigor seedlings yielded 8% less than high vigor. When the three lots were grown in separate plots, yield reductions were not as great as when grown under competition. Yield was highly correlated with the Glutamic Acid Decarboxylase Activity (GADA) test and root growth tests. Further, he stated that a moderate degree of deterioration reduced yield. More severe deterioration also caused reduced stands.
Vechi (19), working with deteriorated cowpea seeds, concluded that plants produced from low vigor seeds tend to produce a lower percentage of fruit set and consequently lower yields. He also observed a trend toward late flowering in plants produced from seeds of low vigor.

Byrd (4) planted Lee-68 soybeans of several vigor levels in competition studies. He found that plants produced from high vigor seeds were consistently taller during the growing season and yielded more seeds than plants produced from medium and low vigor seeds, alone or in various combinations. Smith (17), working with large and small soybean seeds, concluded that plants produced from large seeds yielded more and were taller through the growing season than plants from small seeds. Plants produced from a mixture of large and small seeds in the same row yielded less than either large or small seeds. Torrier (18) reported that soybean crops produced from 2- and 3-year-old seeds were significantly lower in yield and later in maturity than those grown from 1-year-old seeds.

Bishnoi (3) pointed out that low vigor emerged poorly and produced plants that grew slower and yielded about 18% less compared to high vigor seeds. Sittisroung (16) studied the physiological condition of rice seed on plant growth and development. He pointed out that seedlings produced from the less vigorous seeds developed into plants which grew slowly and produced less tillers and less grain.

Abdala and Roberts (1), working with barley, broad beans and peas, found that under normal agricultural conditions, the percentage of seed viability is an excellent indicator of the growth potential of the surviving seeds, irrespective of the particular combination of factors which lead to the loss of seed viability or the rate at which the viability was lost. They further stated that the early inhibition of growth rate may be compensated at later stages of plant development, and providing the initial seed viability was not less than 50%, final yields were not significantly affected. On the other hand, Delouche (6) reported that loss of germinability is the most drastic consequence of deterioration. Before this stage is reached, however, stands are reduced, growth and development retarded, and yield reduced.

**Materials and Methods**

Seed of PAG hybrid 430, an early maturing hybrid grain sorghum (*Sorghum bicolor* (L.) Moench), were obtained from Dorman & Company, Lubbock, Texas on December 20, 1969. The seed were labeled as lot number 3619-A with 95% germination. Immediately after receipt, the seed were stored in a cold room at 7°C and 50% RH until used for the various studies.

**Laboratory Studies**

Preliminary tests were conducted immediately after receiving the seed. Standard germination, speed of germination, and root and shoot growth tests were performed on non-aged seeds, and on seeds aged at 42°C and 45°C, and 100% RH for 15 consecutive days.
Based on preliminary tests, the various vigor levels were obtained by aging the seeds at 42°C and 100% RH for 0, 3, 5, 7 and 11 days. Table 1 shows the identification used for each level of vigor and the aging periods utilized.

Table 1. Identification of vigor levels of sorghum seed aged for 0, 3, 5, 7, and 11 days at 42°C and 100% R.H.

<table>
<thead>
<tr>
<th>Aging Period (days)</th>
<th>Vigor Levels</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>control</td>
<td>L₀</td>
</tr>
<tr>
<td>3</td>
<td>high</td>
<td>L₁</td>
</tr>
<tr>
<td>5</td>
<td>medium</td>
<td>L₂</td>
</tr>
<tr>
<td>7</td>
<td>low</td>
<td>L₃</td>
</tr>
<tr>
<td>11</td>
<td>lowest</td>
<td>L₄</td>
</tr>
<tr>
<td>0 + 11</td>
<td>mixed 1:1 ratio</td>
<td>L₅</td>
</tr>
</tbody>
</table>

Accelerated aging procedure—Seed samples from the cold room, after being thoroughly blended in a Boerner Mechanical Divider, were placed in large copper wire baskets and aged at 42°C and 100% RH. Each basket contained 250 grams of seeds which were treated with captan in order to control mold growth during the aging period. The samples were removed from the aging chamber on the third, fifth, seventh and eleventh day, and tested again for standard germination, root and shoot growth and speed of germination.

Standard germination—The germination test procedures used in this experiment were those prescribed in the Association of Official Seed Analyst's Rules for Testing Seeds (2) except that 6 replications of 50 seeds were used, instead of four replications of 100 seeds each.

Speed of germination—Speed of germination was performed using six replications of 50 seeds planted in folded blotters and placed in an alternating 20-30°C germinator. Daily counts of germinated (normal seedlings) seeds were made, and a vigor index was calculated by multiplying the number of seeds germinated on a specific day by the reciprocal of the day on which the germinated seedlings were counted. The sum was the computed vigor index.
Root and shoot growth—Root and shoot growth tests were performed using six replications of 10 seeds each. The seeds were planted on a moist blotter in a straight line approximately 2 to 3 inches from the long edge with the radicle end of each seed oriented downwards in the same direction. Seeds were covered with a second moist blotter and then placed on a tray in an inclined position so that all radicles pointed downward and germinated at a constant 25°C. Shoot and root measurements, in mm, were made 4 days after planting.

Field Studies

Field emergence—A randomized complete block design with six replications was used to evaluate the effect of seed vigor upon field emergence. Fifty seeds were planted in each single row plot on May 27, 1970. Seeds were planted by hand, approximately 4 cm. deep. Rows were 30 cm. apart and the seeds were spaced 2.5 cm. apart in the row. The number of seedlings emerged was recorded each day until emergence was complete. Shoots 1 cm. or more above ground were counted as emerged, and a vigor index was calculated as previously described. Seedlings surviving 21 days after planting were considered in the final count.

Field performance—In order to study the effect of seed vigor on field performance and yield of grain sorghum, an experiment was planted on the Plant Science Farm at Mississippi State, Mississippi, on May 27, 1970.

The design of the experiment was a randomized complete block with six treatments as described in Table 1, and six replications. Each plot consisted of four rows spaced 100 centimeters apart and each row contained 20 hills with two plants per hill. Seeds were spaced 30 cm. apart. Measurements were made on plants of the two middle rows.

The number of seeds planted per hill varied according to the vigor levels. In order to have a stand of two plants per hill, the plants were thinned 15 and 20 days after planting. The final stand was 80 plants per plot—480 plants per treatment.

In order to control sorghum midge and other pests, Sevin (80% wettable powder) was applied at a rate of 6 ounces per acre. A total of six applications were made in order to maintain the experiment essentially free of insect damage.

Plant height—Plant height was measured 3, 5, and 13 weeks after planting. The first two measurements were conducted by measuring the plants from the soil level to the tip of the top leaf. At harvest time, the height was measured from the soil level to the tip of the panicle. The average height of 144 plants per treatment (24 plants per plot) was calculated.

Panicle exsertion and anthesis—Panicles with approximately 5 cm. protruding from the boot were considered as exserted. The results were recorded and a cumulative percentage was calculated daily.

Anthesis, or flowering observation was made 58 days after planting. At that time almost all panicles were exserted. Inflorescences having more than 90% of the spikelets in anthesis were counted and the results per treatment compared.
Number of tillers—Tillers were counted at harvest time, and both total tillers and panicle producing tillers per treatment were recorded. Panicles produced by tillers were threshed separately and the yield recorded.

Yield—Panicles were harvested by hand 93 days after planting. Immediately after harvest, the panicles were dried in a forage research dryer for 24 hours at 60°C and thereafter retained in a dehumidified cold storage room 3 weeks for future studies.

Panicles were threshed with a small plot thresher and cleaned with a small laboratory model aspirator. The cleaned grain was weighed and corrected to 12.6% moisture content.

RESULTS AND DISCUSSION

Laboratory Studies

Response of the various vigor levels of sorghum seed to the standard germination test, speed of germination, and root and shoot growth tests are presented in Figure 1.

Standard germination—Germination percentages generally decreased as the aging period increased from 3 to 11 days. Statistically, seeds aged for 3, 5, and 7 days did not differ significantly from the control (L0) in germination. Neither did they differ among themselves. Germination was 86% after 11 days aging (L11) and 91% for the mixture (L3). The mixture was significantly lower in germination than treatments L0 (control), L1 (3 days aging), and L2 (5 days). The mixed treatment (L3) performed as well as the low vigor seed L3 and significantly better than the lowest vigor level (L0).

Speed of germination—The speed of germination test indicated that as the aging period increased the speed of germination decreased. The speed of germination test indicated that the control and seeds aged for 3 days did not differ significantly from each other, while both were significantly better than seed aged for 5, 7 and 11 days and the mixed treatment. Seeds aged for 5 days differed significantly from those aged for 7 days, 11 days and from the mixed treatment. Seeds aged for 7 days did not differ from the mixed treatment when germination percentage was considered, since the weak seeds within the lot had enough time to grow and produce seedlings which were considered as normal seedlings at the end of the test.

Root and shoot growth—The results of the rate of root growth followed approximately the same trend as speed of germination. Seeds aged for 0 and 3 days did not differ from each other, but differed from those aged for 5, 7 and 11 days and from the mixed treatment.

The rate of shoot growth indicated that the check treatment (L0) was significantly better than all the others. This suggests that shoot growth was more sensitive in detecting small differences in initial stages of seed deterioration.
Figure 1. Response of various vigor levels of sorghum seed to various laboratory tests.

Field Studies

Field emergence—Field emergence and final stand counts were made in order to evaluate the emergence and survival capacity of seedlings produced from seeds of different vigor levels. The data obtained in this experiment are presented in Figure 2. The standard germination percentage was also plotted in order to make a comparison among field emergence, final stand, and germination. The field emergence test indicated that seeds aged for 3 and 5 days did not differ from the
check ($L_0$), but were significantly better than seeds aged for 7 ($L_1$) and 11 ($L_3$) days. Seeds aged for 11 days were significantly lower in field emergence than those aged for 7 days ($L_2$).

![Graph](image)

**Figure 2.** Field emergence, final stand, and standard germination percentage of six vigor levels of sorghum seed.

*Plant performance—Plant height was measured three times during the growing season—23 and 35 days after planting and at harvest time. The data obtained in this experiment are presented in Figure 3. Plants which were measured on the 23rd gave no significant differences among the first three vigor levels ($L_0$, $L_1$, $L_2$), but they were significantly taller than the plants produced from seeds aged for 7 days, 11 days, and the mixed treatment.

At the end of the season, 91 days after planting, plants produced from seeds aged for 3 days ($L_1$) were significantly taller than those aged for 5 days, 11 days, and the mixed treatment. Non-aged seeds ($L_0$) and seeds aged for 7 days also differed from the mixed treatment ($L_3$). There were no significant differences among plants produced from seeds aged for 3 days, 7 days, and the control.

In this experiment plants produced from the first three vigor levels germinated, emerged, and grew faster than those from less vigorous seeds, including the mixed treatment. The mixed treatment did not perform as well as seeds aged for 3 days, 7 days and the control. This could be attributed to the fact that the average plant height for the mixed treatment was obtained from a population composed of non-uniform plants which suffered the effect of competition within each hill.
Figure 3. Average plant height in millimeters of six vigor levels of sorghum seed at various intervals after planting.
Panicle exsertion—Observations on panicle exsertion were made daily from the time of onset until exsertion was completed. The number of panicles exerted were noted and cumulative percentage calculated. The results are presented in Figure 4. Generally, plants produced from more deteriorated seeds (L₂, L₃) were delayed in panicle exsertion by 2 and 3 days, respectively.

Anthesis—At the time anthesis observations were made almost all the panicles were exerted. The results are presented in Table 2. The control treatment (L₀) was significantly earlier in anthesis than the mixed, L₅, L₁ treatments. Seeds aged for 3 (L₁) and 5 (L₂) days different significantly from those aged for 7 (L₃) and 11 (L₄) days. The mixed treatment performed significantly better than the L₃ and L₅ treatments.

Table 2. Percentage of plants in complete anthesis of six vigor levels of sorghum seed measured fifty eight days after planting.

<table>
<thead>
<tr>
<th>Vigor Levels</th>
<th>L₀</th>
<th>L₁</th>
<th>L₂</th>
<th>L₃</th>
<th>L₄</th>
<th>L₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthesis %</td>
<td>33.95 a</td>
<td>27.50 ab</td>
<td>30.83 ab</td>
<td>9.17 e</td>
<td>12.50 c</td>
<td>18.75 b</td>
</tr>
</tbody>
</table>

Any two means not followed by the same small letter are significantly different at the 5% level of probability as determined by Duncan's New Multiple Range Test.

Number of tillers—Number of tillers per plant was measured at harvest time. The results were recorded as total number of tillers as well as number of productive and unproductive tillers (Figure 5). As deterioration increased, tillering was
reduced. Plants from seeds aged for 7 days (L₂) produced 57% less tillers than the control (L₀). Treatments L₂, L₃, L₄, and L₅ produced a significantly lower number of productive tillers than the control (L₀). The control had significantly fewer unproductive tillers compared to other treatments. Plants from poor quality seeds produced fewer tillers and tiller yield was reduced. Treatments L₀...
and $L_1$ were significantly higher than $L_0$, $L_4$, and $L_5$. Treatment $L_2$ differed significantly from $L_0$ and $L_5$, but performed equal to treatment $L_1$. Yield from treatments $L_0$, $L_4$ and $L_5$ were not significantly different among themselves. Lower grain yield from tillers (on a plot basis) can be attributed to the low rate of tillering on plants produced from low vigor seeds. Also panicle exsertion was delayed and the tillers were not old enough to produce grain and contribute to yield at harvest.

Yield—Grain yield is presented in Table 3. The control ($L_0$) was significantly better than $L_0$, $L_4$, and $L_5$. This indicates that the deterioration of the seeds did affect the field performance of plants produced from them. The mixed treatment yielded no better than plants produced from seeds aged for 7 and 11 days.

Table 3. Yield of six vigor levels of sorghum seed.

<table>
<thead>
<tr>
<th>Vigor Levels</th>
<th>Primary Head Yield Kg/plot</th>
<th>Total Yield Kg/plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_0$</td>
<td>3.709 a</td>
<td>3.910</td>
</tr>
<tr>
<td>$L_1$</td>
<td>3.628 ab</td>
<td>3.794</td>
</tr>
<tr>
<td>$L_2$</td>
<td>3.563 abc</td>
<td>3.722</td>
</tr>
<tr>
<td>$L_3$</td>
<td>3.370 bcd</td>
<td>3.465</td>
</tr>
<tr>
<td>$L_4$</td>
<td>3.158 d</td>
<td>3.287</td>
</tr>
<tr>
<td>$L_5$</td>
<td>3.263 cd</td>
<td>3.372</td>
</tr>
</tbody>
</table>

Any two means not followed by the same small letter is significantly different at the 5% level of probability as determined by Duncan's New Multiple Range Test.

Literature Cited


