Intermediate Wheatgrass Seed Production Responses to Fertilizers and Cultural Practices

James Bernard Weber

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INTERMEDIATE WHEATGRASS SEED PRODUCTION RESPONSES
TO FERTILIZERS AND CULTURAL PRACTICES

BY

JAMES BERNARD WEBER

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Agronomy, South Dakota State University

1972
INTERMEDIATE WHEATGRASS SEED PRODUCTION RESPONSES
TO FERTILIZERS AND CULTURAL PRACTICES

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head, Plant Science
Department
ACKNOWLEDGMENTS

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JEW
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INTRODUCTION

Intermediate wheatgrass *Agropyron intermedium* (Host) Beauv. is a cool season, sod forming rhizomatous and/or stoloniferous grass, best adapted to upland silt or silty clay loam soils. Intermediate wheatgrass has a fast rate of root spread by rhizomes and sometimes stolons with late summer (July 15 - August 30) seed maturity.

The major area of distribution of intermediate wheatgrass in the United States is central North Dakota, South Dakota, Nebraska, Idaho and Washington, with a minor distribution area east to Minnesota and west to Colorado, Montana, and Wyoming.

A growing interest in reseeding the Great Plains, both to improve the rangeland and to convert some cropland to grassland, has increased the demand for grass seed. Intermediate wheatgrass has increased the livestock carrying capacity of the western rangeland in the areas where it is grown with a highly digestible, palatable feed. Skills required to produce high yields of grass seed are much the same as those needed to produce high yields of other farm crops. Seed production fields need to be carefully selected. Cultivation, fertilization, and harvesting must be timely and intelligently carried out. Special skills are necessary in selecting a proper seedbed, planting date and rate, planting machinery, and land free of quackgrass.
The objectives of this research were to determine the effect of certain cultural practices and nitrogen fertilizer treatments on the seed yield of intermediate wheatgrass in South Dakota.

The experimental hypothesis set up for this experiment was that added nitrogen and selected cultural practices have no significant effect on the seed yield of intermediate wheatgrass.
REVIEW OF LITERATURE

The review of literature has been divided into 2 sections. The first section refers to the fertilizer response on grass seed yield and the second section refers to cultural practice comparison on grass seed yield.

Response of Fertilizer on Grass Seed Yield

Cool season grasses make their greatest growth in spring. Supplemental nitrogen is necessary for maximum growth since nitrification, which releases nitrogen by the action of microorganisms in the soil, does not take place until later in the spring when soil temperature has increased. This means that after the first year of production from a new stand the limiting factor for growth is nitrogen, unless it is supplied as a fertilizer or by a legume in association with the grass (29).

The progressively lower seed yields from perennial cool season grasses as the stand ages has been shown to be the direct result of lack of available nitrogen in the soil (3, 11, 12, 18, 23, 32, 33). Buglass (3) in Canada on crested wheatgrass and Canode (8) in Washington on intermediate wheatgrass found the seed yield from the addition of nitrogen has varied with age of stand, moisture conditions, row spacing, and amount of nitrogen applied. There was very little grass seed yield increase from
nitrogen in the first crop year in Canada (33) and Pennsylvania (4). The application of nitrogen fertilizer at this time was of doubtful economic value unless moisture conditions were particularly good. Buglass (3) found in Indian Head, Saskatchewan, Canada on crested wheatgrass, that as the age of stand increased, and with normal or above normal rainfall, there was a progressive increase in seed yield with the use of increasing amounts of nitrogen fertilizer. Seed yields leveled off at about the 150 pound rate of ammonium nitrate. Under good moisture conditions, higher rates of nitrogen produced greater seed yields. Phosphorus used alone, without nitrogen, had no significant effect on seed yield increase. Ross (30) found in South Dakota that phosphorus used alone, without nitrogen, had very little effect on seed yield of bromegrass except on bottomland, where high calcium content of the soil has made this element relatively unavailable. In such circumstances, seed production of bromegrass fertilized with phosphorus and nitrogen together has been much higher than with nitrogen alone. In general, though yields may not be greatly increased, a heavier and plumper seed is obtained when phosphorus is included with nitrogen. About 20 pounds per acre of phosphorus has been found to be adequate.

Heavy rates of nitrogen (3, 11, 12, 19, 23, 32, 33) have been beneficial in producing high grass seed yields as the age of stand increased; however, Evans (12) found that timothy did
not respond to the third and fourth harvest years to heavier rates of nitrogen as did orchardgrass. Crowle (10) found in Saskatchewan, Canada on intermediate wheatgrass, that nitrogen did not give increased seed yield under dryland conditions nor was fertilizer response affected by age of stand. They also found yield reduction resulted from the use of fertilizer for the first 2 years of production, but increases of seed yield occurred the final 3 years of test production.

Evans (12) found grass seed yield showed an increase to all rates of nitrogen in each of the 3 years on cocksfoot and timothy. Stitt (33) found nitrogen did not give a seed yield increase during the application year on Russian wildrye grass, whereas a seed yield increase was limited to the year after application.

Kilcher (18) found in Saskatchewan, Canada that grass plants require a continuous supply of nitrogen from the soil for good growth, and that dense stands of grass quickly depleted the soil of available nitrogen. The resulting stunted growth of grass is often called a "sod-bound" condition. In thinner stands, the plants grow larger and more rapidly with well developed roots penetrating farther and developing larger feeding zones than those in denser stands. A deficiency of nutrients, particularly nitrogen, is deferred longer when the stands have wide spaces between the rows.
Cultural Practice Comparison on Grass Seed Yield

Grasses grown in rows have generally yielded more seed than when grown in solid stands (15).

Klages, et al (19) found bromegrass seed yields were depressed when seeding rates exceeded 4 pounds per acre, but rates of seeding had little effect on orchardgrass, crested wheatgrass, and meadow fescue when nitrogen was at a uniform level on all plots. With all species studied, the number of fertile culms was higher in rows than solid stands. The number of fertile culms decreased with age of stand, but the decrease was more pronounced in solid stands. In their study, all plots with row widths greater than 21 inches were cultivated in spring and fall to control weeds. Rate of seeding in general, has less effect on seed yield than row width. The first crop year seed yields decreased as row widths increased. In the second crop year, the intermediate row widths were superior. In the third year, the seed yields increased markedly as the row width increased up to 28 inches.

Buller, et al (4) found in their research in Pennsylvania that seed production of reed canarygrass, bromegrass, orchardgrass and timothy was highest in the second year. All of these grasses produced significantly higher seed yields in rows than in solid stands under normal dryland conditions.
Fulkerson, et al (14, 15) observed that row spacing exerted its greatest effect on seed yield and had a much less important effect on seed quality. Row width was clearly an important factor in determining seed yield of timothy. The 14, 21, 28 and 35 inch rows were superior in seed yield to the 7 inch essentially broadcast or solid stand rows. There was no significant difference in seed yield between the 14 to 35 inch rows.

Rows spaced 3 feet apart proved desirable for seed production of intermediate wheatgrass and was almost equally effective on dryland as irrigation in Saskatoon, Saskatchewan, Canada, under semi-arid conditions (10).

A decline in the seed production of perennial grasses associated with age of stand has been reported in Georgia (5), Idaho (19), Montana (33), Kentucky (31), and Washington (7, 8, 34). Studies in Canada (21, 30), England (12), and in Denmark and Germany (13), have shown a similar characteristic decline in production of perennial grass seed.

Canode (7) reported an exception where there was an actual increase in seed yield of intermediate wheatgrass for a 3 year period. He explains this unusual yield pattern as being the possible result of thin, uniform initial stands which left space for development of the grass as the stand ages. He also noted a tendency toward a biennial pattern of seed production
for some grasses that did not appear to be associated with climatic conditions. In this pattern, the grasses reached their peak yield in the first crop year, declined sharply in the second, and reached a secondary peak in the third crop year.

Rejuvenation of stands by cultural methods has been studied by Knowles, et al (21, 22) and Crowle, et al (9), who present data to show that shallow plowing of old bromegrass stands every 4 years will give higher average seed yields, even though the seed crop is lost during the season the stand was plowed.

Kilcher (18) found in Saskatchewan, Canada that only in the first and second years were the seed yields of intermediate wheatgrass as high in plots with rows 6 inches apart as the 12, 18, 24, 30, and 36 inch rows. In the third and fifth years, the yields from the 6 inch rows were 45 to 55 percent, respectively, lower than from rows 12 inches apart. Stands with rows over 12 inches apart were very weedy and yielded little more and sometimes less, than those with rows 12 inches apart.

Gross (16) found seed production of intermediate wheatgrass in solid stands or 6 inch row spacings, to be as satisfactory as wide spaced or 3 foot rows in Manitoba, Canada.
MATERIALS AND METHODS

The materials and methods have been divided into 4 sections. Section A refers to the experimental procedure, section B refers to the production of intermediate wheatgrass, section C refers to the harvesting of intermediate wheatgrass, and section D refers to the field management after fall harvest.

Section A. Experimental Procedures

This study was undertaken to determine the effect of 5 different rates of nitrogen and 3 different cultural practices on intermediate wheatgrass seed yields. It was set up in a factorial design to determine the main effects of nitrogen, cultural practices, time, replication and all possible interactions on seed production of intermediate wheatgrass.

This research was located on a Moody silty clay loam soil at the Foundation Seedstock farm along Interstate 29 Roadside Park in Moody County about 11 miles south of Brookings, South Dakota (SE\(\frac{1}{2}\)-18-108-49).

The Moody soils are well-drained Chernozems that have developed under tall grasses in deep calcareous, medium-textured loess, which is underlain by friable to firm loam and clay loam glacial till.

The factorial arrangement of treatments was selected to evaluate main effects and their interactions. In this
experiment there are 4 main effects consisting of 3 cultural practices, 5 fertilizer treatments and replicated 4 times over a 2 year period. One main effect, time (T) has 2 levels, 1970 and 1971. Another main effect is applied nitrogen (N) which has 5 levels - 0, 40, 80, 120, and 240 pounds of nitrogen. A third main effect is cultural practices (C), which has 3 levels - solid stand, non-cultivated 40 inch rows, and cultivated 40 inch rows. All of the first 3 main effects are fixed, or they are specified, whereas the fourth main effect is random. This fourth main effect is replicate (R) which has 4 levels or 4 replicates.

The experiment was designed to try to keep as much bias out of the design as possible. Randomization of cultural practice and fertilizer rates determined each location in the replicate. The data in Table 1 shows the experimental design.

Breeders seed of Oahe intermediate wheatgrass was planted directly in flax stubble on August 29, 1969. Each replicate was divided into thirds. Two-thirds of the replicate was planted with a grass seeder in 40 inch rows, 40 rows wide. Twenty of these rows were cultivated and 20 were not cultivated; thus, making up the cultivated and non-cultivated areas in each replicate. The other third of the replicate was planted with a 7 foot press drill, without any previous cultural practice, into the same flax stubble field. This provided the solid stand portions of the replicate.
Table 1. Experimental Design Consisting of 4 Replicates (R), 3 Cultural Practices (C), 5 Nitrogen Rates (N), with Data Collected for 2 Years (T).

<table>
<thead>
<tr>
<th>Rep I</th>
<th>* 80#N * 40#N * 240#N * 120#N * Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated</td>
<td>Solid Stand</td>
</tr>
<tr>
<td>Non-Cultivated</td>
<td></td>
</tr>
<tr>
<td>Rep II</td>
<td>* Check * 240#N * 120#N * 40#N * 80#N</td>
</tr>
<tr>
<td>Non-Cultivated</td>
<td>Solid Stand</td>
</tr>
<tr>
<td>Cultivated</td>
<td></td>
</tr>
<tr>
<td>Rep III</td>
<td>* 40#N * 120#N * 80#N * Check * 240#N</td>
</tr>
<tr>
<td>Cultivated</td>
<td>Solid Stand</td>
</tr>
<tr>
<td>Non-Cultivated</td>
<td></td>
</tr>
<tr>
<td>Rep IV</td>
<td>* 120#N * Check * 40#N * 80#N * 240#N</td>
</tr>
<tr>
<td>Non-Cultivated</td>
<td>Solid Stand</td>
</tr>
<tr>
<td>Cultivated</td>
<td></td>
</tr>
</tbody>
</table>

* * * * *
The entire replicate, consisting of 1.5 acres, was soil tested at South Dakota State University Soil Testing Laboratory. (Detailed procedures can be obtained from the Soil Testing Laboratory.) Table 2 shows the soil test results.

Ammonium nitrate (34-0-0) fertilizer was used in the nitrogen broadcast treatment and repeated both years of the experiment. Each fertilizer treatment was 1 chain* square with the cultural treatments being 1 chain wide and 5 chains long. Yield data was obtained from 60 nitrogen treatments. Five nitrogen treatments were used on each cultural practice, thus providing yield data for 12 cultural practices.

Phosphorus was recommended by South Dakota State University Soil Testing Laboratory to be applied at 20 pounds of \( P_2O_5 \) per year.

Soil analysis showed high levels of potassium.

Annual precipitation in the test plot area for 1970 was 20 inches, with 17.39 inches falling during the growing season. The 1971 precipitation was 21 inches, with 12.35 inches falling during the growing season from April to August**.

*Aerial photographs from the Agricultural Stabilization and Conservation Service were used and acres are easily measured from these maps in chains with a ruler to this scale. One chain equals 66 feet. Multiplication of a chain X a chain converts directly into acres after pointing off one place to the left.

**Data collected by Agriculture Engineering Farm Manager, T. M. Klosterman, of South Dakota State University.
Table 2. Soil Test Results

<table>
<thead>
<tr>
<th>Replicate</th>
<th>Organic Matter P</th>
<th>Phosphorus P 1bs/A</th>
<th>Potassium K 1bs/A</th>
<th>pH 1:1 dil</th>
<th>Soluble Salts mmho/cm</th>
<th>Soluble Sodium me/1</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep I</td>
<td>3.5</td>
<td>19</td>
<td>314</td>
<td>7.4</td>
<td>.81</td>
<td></td>
<td>sil</td>
</tr>
<tr>
<td>Rep II</td>
<td>3.6</td>
<td>17</td>
<td>397</td>
<td>7.0</td>
<td>.50</td>
<td></td>
<td>sil</td>
</tr>
<tr>
<td>Rep III</td>
<td>3.5</td>
<td>13</td>
<td>353</td>
<td>7.1</td>
<td>.37</td>
<td></td>
<td>sil</td>
</tr>
<tr>
<td>Rep IV</td>
<td>3.7</td>
<td>9</td>
<td>346</td>
<td>7.1</td>
<td>NR</td>
<td>.58</td>
<td>1.04</td>
</tr>
</tbody>
</table>
Section B. Producing Intermediate Wheatgrass Seed

1. Seedbed Preparation.

Moisture and fertility were reduced somewhat by a very good flax crop in August 1969. The flax straw was chopped with the combine straw chopper while harvesting. Since the straw was too thick for planting grass seed, it was raked, baled and removed from the field. Raking and baling the straw was the only seedbed preparation used. Intermediate wheatgrass seed was planted directly into the flax stubble.

2. Time of Planting.

The intermediate wheatgrass was planted August 29, 1969. The soil was extremely dry at planting time, but sufficient rain fell about 3 weeks later and the intermediate wheatgrass emerged to a fairly good start. The 1969 winter brought ideal snow cover and very little winter killing took place.

3. Planting Rate.

Atkins and Smith (1, 2) recommended that in a 40 inch row width no less than 30 pure live seed units be planted per foot of row. This is approximately 9 seeds per square foot. This recommendation could not be followed for only 18 pounds of Oahe intermediate wheatgrass Breeders seed was available. The Foundation Seedstock Division management decided at least 6 acres were needed in the seed production field so the planting rate had to be about
6 pure live intermediate wheatgrass seeds per square foot*. The seed for each of 12 cultural practices in 4 replicates was weighed out before planting, so it would cover the entire 6 acres.

4. Row Spacing.

Optimum row spacing for most grasses planted for seed production is 40 inches (1). The available grass seeder was permanently set for 40 inch rows. Serious thought about double planting, making 20 inch rows instead of using non-cultivated rows, was considered; however, the Breeders seed was limited.

5. Planting Machinery.

A 4 row individualized plant unit was used with compression springs and depth bands on the discs to plant the 40 inch cultivated and 40 inch non-cultivated areas. A 7 foot press drill, with 6 inch spacings, was used to plant the solid stands. Because of the short supply of seed to be planted on each replicate, 2 students rode the planter, watching 2 planter boxes each, to make certain Oahe intermediate wheatgrass seed was feeding. Likewise, someone rode on the press drill, while

* 93,000 intermediate wheatgrass seeds per pound X 18 pounds available Breeders seed, divided by 6 acres and 43,560 square feet per acre, equals 6 seeds per square foot (Table 1 Farmers Bulletin No. 2226, U.S.D.A.).
drilling, to insure that the intermediate wheatgrass was feeding satisfactorily.

6. Fertilizing and Spraying.

The 1970 fertility applications took place on April 9, 1970. Paul Carson, Professor in Plant Science at South Dakota State University, recommended that a 4-years supply of phosphorus could be put on at the beginning of the experiment. Eighty pounds per acre of P₂O₅ were applied, broadcast over the entire 6 acre plot with a tractor spreader giving a 40 foot spread pattern. One hundred seventy-five pounds of 0-46-0 per acre were used in this broadcast treatment to apply 80 pounds of P₂O₅ per acre.

In 1970 ammonium nitrate (34-0-0) was broadcast on April 9 with a 7 foot broadcast spreader mounted on a small tractor. This application was calibrated to give 0, 40, 80, 120 and 240 pounds of actual nitrogen on each respective fertility plot.

For the 1971 ammonium nitrate (34-0-0) fertility plots, the nitrogen was broadcast in the fall on October 29, 1970.

On May 21, 1970 one pint of Bronate* per acre was sprayed over the entire field. The bromoxinil controlled the wild buckwheat very well, and the MCPA controlled the broad-

---

* 4 oz of Bromoxinil plus 4 oz of M.C.P.A. per gallon.
leaved thistles and mustard. This same application was used on May 29, 1971 and even better control took place. Green foxtail and yellow foxtail could not be controlled in the seedling year because the chemicals, such as Simizine, used to control these weeds, will cause detrimental effects on the intermediate wheatgrass plants when they are young and shallow rooted.

7. Cultivation and Management.

The cultivated rows, or one-third of the entire 6 acre plot, were cultivated. Cultivation was used whenever weeds were a problem. Three cultivations were needed in 1970 and two in 1971.

Annual weeds were clipped with a 24 inch Jarri Mower between the non-cultivated rows to eliminate some of the green foxtail and yellow foxtail in 1970. In 1971, the main problem between the non-cultivated rows was volunteer intermediate wheatgrass. The Foundation Seed Stock could not allow volunteer grass seed to mature because the second generation could cross-pollinate with the original stand, and leave the possibility of a genetic shift in the seed. Annual weeds of green foxtail, yellow foxtail, and wild buckwheat were a real problem in the solid stand high fertility plots the first year. The zero nitrogen plots did not have a weed problem in 1970 or 1971.
8. Roguing.

The intermediate wheatgrass field had to be rogued for bromegrass and quackgrass. Bromegrass was easy to find, but quackgrass was much more difficult. The field happened to have small quackgrass patches. It is extremely difficult to distinguish intermediate wheatgrass from quackgrass, except in the very early seedling stage and later at early heading stage.

Section C. Harvesting Intermediate Wheatgrass Seed

1. Time of Harvest.

The best time to harvest intermediate wheatgrass seed is when the largest amount of seed is ripe (1,2). Seed should be harvested in the hard dough stage for mature, high germinable seed. Maturity starts at the top of the head and moves downward. The rate of maturity or ripening is matched by the rate of shattering. This leaves only a few days for an optimum harvest period. After this optimum harvest period, the rate of shattering exceeds the rate of new seed ripening, and, therefore, too late for maximum yield.


The intermediate wheatgrass testplots were harvested direct with a self-propelled combine (28). The seed from each plot was bagged directly as it was combined and tagged ready
for drying. Harvest was planned so all plots were completed the same day. The cylinder was set at 1400 rpm and 3/8 inch of clearance. The wind was used to maximum benefit, in order to hold the chaff off the sieves and chaffers while doing the best job of cleaning during combining; thus, the maximum amount of seed was saved. The wind must not be too severe or an excess amount of good seed will be lost. A hume-type reel was used to save the maximum seed possible at the feed and sickle end. A uniform combine travel rate in the field was maintained to allow an even flow of cut material to the cylinder and over the chaffer in the cleaning shoe. When the machine capacity is overloaded, the seed will ride out with the tailings and when the machine is underloaded more chaff will go in with the clean seed than is necessary.

3. Drying Seed.

The 1970 seed crop was placed directly into burlap bags when harvested. The seed from each plot was bagged, tagged, and dried. The 1970 crop had a lot of inert matter, green foxtail, yellow foxtail and wild buckwheat to dry along with some immature intermediate wheatgrass. It was dried in the corn dryers for 5 days.

The 1971 seed crop was placed directly into burlap bags when combined. The inert matter and weed seeds were so minute that the grass seed did not need drying. The intermediate
wheatgrass seed was directly cleaned, weighed, and ready for sale as foundation seed to certified intermediate wheatgrass growers.

4. Cleaning, Processing and Weighing Seed.

The 1970 crop of intermediate wheatgrass was very difficult to clean. The first step in cleaning this crop was running it over 2 screens scalping the inert material over the top screen and keeping the salvagable seed running over the top of the second screen. This process made the green foxtail, yellow foxtail, wild buckwheat, and intermediate wheatgrass seed ready for the cleaning process.

The model M2B clipper fanning mill, with a number nine round screen in the top position, and a number 6 X 20 wire mesh screen in the bottom position, was used with as much wind as possible to give maximum amounts of clean seed.

This cleaning process still did not give a sufficiently clean product because of the presence of green foxtail, yellow foxtail and wild buckwheat seeds.

The indent Carter disc, with appropriate discs (17, 24 25), was used to bring the green foxtail, yellow foxtail, and wild buckwheat seeds down to an acceptable level.

Ergot caused the inert matter to be too high for certification of this seed as Foundation intermediate wheatgrass seed; therefore, this seed had to be run over the gravity cleaner to remove the ergot.
Seeds that are the same size cannot be separated on a sieve or disc machine, but can be separated on the gravity machine if the seeds vary in weight. The ergot bodies and naked caryopses are heavier and will come over the top area of the gravity machine and the slightly lighter intermediate wheatgrass seeds flow out the center area of the gravity mill. The lightest seeds and some green foxtail and yellow foxtail seeds, along with some inert material, will ride out the bottom area of the gravity mill. About 10 percent of the total amount of seed is lost in this process.

The seed from each plot in 1970 was weighed after it was cleaned 3 times. It was cleaned over the M2B clipper cleaner, Carter disc, and M2B clipper cleaner, respectively.

The grass seed in 1971 was weighed after being run over the M2B clipper cleaner once.

Section D. Field Management After Fall Harvest

Immediately after combining intermediate wheatgrass seed, the field was rotary mowed as close to the ground as possible to rid the field of as much stubble as possible. The fall regrowth grew up about 3 to 4 inches.
RESULTS AND DISCUSSION

Cultural Practice Comparison on
Intermediate Wheatgrass Seed Yield

One of the first spring observations of this experiment was the greening of the Oahe intermediate wheatgrass in early April 1970.

The purpose of photograph number 1, 2, and 3 is to show the intermediate wheatgrass growing directly in the flax stubble without any mechanical cultivation before planting.

Photograph number 1 illustrates the 40 inch non-cultivated rows with undisturbed flax stubble between the rows. This should be compared to photograph number 2, which shows the solid stand of intermediate wheatgrass planted directly into the undisturbed flax stubble in August 1969. This solid stand was planted with a 6 inch spaced press drill. The fall growth emerged to about 1/2 the stubble height and the 5 inch stubble carried a full blanket of snow all winter. Photograph number 3 illustrates the 40 inch cultivated rows of intermediate wheatgrass planted directly into the flax stubble and cultivated once shortly before the photograph was taken.

The yield of intermediate wheatgrass in 1970-1971, as affected by the treatments, is presented in Table 3.

The average seed yield in pounds per acre in the solid stand, non-cultivated rows, and cultivated rows, as shown in
Photograph 1. Forty Inch Non-Cultivated Rows Showing Flax Stubble Between the Rows.
June 1970 Photograph.
Photograph 2. Solid Stand of Intermediate Wheatgrass Planted Directly into Flax Stubble.
June 1970 Photograph.
Table 3 for 1970 and 1971, respectively, was: 267 pounds per acre, 164 pounds per acre, and 227 pounds per acre.

The seed yield mean for applied nitrogen on the 0, 40, 80, 120, and 240 pounds of actual nitrogen as shown in Table 3, for 1970-1971, respectively, was: 157 pounds per acre, 209 pounds per acre, 225 pounds per acre, 228 pounds per acre, and 227 pounds per acre.

The analysis of variance of the 1970-1971 seed yield of intermediate wheatgrass as influenced by cultural treatments and applied nitrogen is shown in Table 4.
Table 3. 1970-1971 Seed Yield in Pounds Per Acre of Intermediate Wheatgrass as Influenced by Cultural Treatments and Applied Nitrogen.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90</td>
<td>208</td>
<td>52</td>
<td>197</td>
<td>44</td>
<td>350</td>
<td>62</td>
<td>157</td>
<td>252</td>
</tr>
<tr>
<td>40</td>
<td>131</td>
<td>332</td>
<td>55</td>
<td>271</td>
<td>69</td>
<td>395</td>
<td>85</td>
<td>209</td>
<td>333</td>
</tr>
<tr>
<td>80</td>
<td>145</td>
<td>404</td>
<td>76</td>
<td>281</td>
<td>75</td>
<td>373</td>
<td>99</td>
<td>225</td>
<td>352</td>
</tr>
<tr>
<td>120</td>
<td>135</td>
<td>386</td>
<td>70</td>
<td>303</td>
<td>80</td>
<td>394</td>
<td>95</td>
<td>228</td>
<td>361</td>
</tr>
<tr>
<td>240</td>
<td>171</td>
<td>369</td>
<td>83</td>
<td>248</td>
<td>90</td>
<td>399</td>
<td>115</td>
<td>227</td>
<td>339</td>
</tr>
<tr>
<td>Mean</td>
<td>134</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 year Mean</td>
<td>267</td>
<td></td>
<td>164</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>227</td>
</tr>
</tbody>
</table>
Table 4. The Degrees of Freedom, Sum of Squares, and Mean Squares are Shown With the Source of the Factorial Analysis of Variance Along With 4 Main Effects and All Possible Interactions.

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>119</td>
<td>2,286,002</td>
<td></td>
</tr>
<tr>
<td>Replication (R)</td>
<td>3</td>
<td>32,375</td>
<td>10,792**</td>
</tr>
<tr>
<td>Cultural Practices (C)</td>
<td>2</td>
<td>126,318</td>
<td>63,159**</td>
</tr>
<tr>
<td>RC</td>
<td>6</td>
<td>11,743</td>
<td>1,957ns</td>
</tr>
<tr>
<td>Nitrogen Levels (N)</td>
<td>4</td>
<td>89,201</td>
<td>22,300**</td>
</tr>
<tr>
<td>RN</td>
<td>12</td>
<td>48,620</td>
<td>4,052**</td>
</tr>
<tr>
<td>CN</td>
<td>8</td>
<td>27,647</td>
<td>3,456**</td>
</tr>
<tr>
<td>RCN</td>
<td>24</td>
<td>22,386</td>
<td>932ns</td>
</tr>
<tr>
<td>Years (T)</td>
<td>1</td>
<td>1,673,949</td>
<td>1,673,949**</td>
</tr>
<tr>
<td>RT</td>
<td>3</td>
<td>7,783</td>
<td>2,594ns</td>
</tr>
<tr>
<td>CT</td>
<td>2</td>
<td>83,912</td>
<td>41,956**</td>
</tr>
<tr>
<td>NT</td>
<td>4</td>
<td>22,088</td>
<td>5,522ns</td>
</tr>
<tr>
<td>CNT</td>
<td>8</td>
<td>15,713</td>
<td>1,964ns</td>
</tr>
<tr>
<td>RCT</td>
<td>6</td>
<td>4,449</td>
<td>741ns</td>
</tr>
<tr>
<td>RNT</td>
<td>12</td>
<td>90,654</td>
<td>7,555**</td>
</tr>
<tr>
<td>RCNT</td>
<td>24</td>
<td>29,165</td>
<td>1,215</td>
</tr>
</tbody>
</table>

** Significant at the .01 level of probability.
ns Not significant at .05 or .01 level of probability.
The non-cultivated rows had a lower seed yield than either the cultivated rows or the solid stand over the entire period of the experiment as clearly shown in Figure I. Weeds were much more of a problem in the non-cultivated rows than either the cultivated rows or the solid stand in 1970.

Volunteer intermediate wheatgrass was considered intolerable in the second year of seed production in the non-cultivated rows, but not too much of a problem in the solid stand and the cultivated rows in 1971. The areas between the rows on the non-cultivated rows were mowed after the intermediate wheatgrass was headed out, but before it started to pollinate. This procedure allowed the volunteer intermediate wheatgrass to compete for moisture and nutrients in the non-cultivated areas about the same as in the cultivated and solid stand areas. Competition in the solid stand and cultivation in the cultivated rows seemed to hold the volunteer seedlings from getting started. The volunteer intermediate wheatgrass in this foundation seed increase field was considered intolerable, in that no crossing is allowed for seed purposes. This is the reason only 2 years of foundation seed production is normally allowed for seed production purposes.

The data in Figure I are the cultural practices and time interactions of intermediate wheatgrass seed yield. The solid stand gave the highest seed yield per acre in 1970, and the
Figure I. Intermediate Wheatgrass Seed Yield in Pounds Per Acre Attributed to the Interaction of Cultural Practice and Time.
cultivated rows gave the highest seed yield per acre in 1971. Seed yields were higher in all 3 cultural practices in 1971 than 1970. This verifies an observation made by Buller, et al. They found in their research in Pennsylvania that seed production of reed canarygrass, bromegrass, orchardgrass and timothy was the highest the second year. The solid stand, if averaged over a 2 year period, produced a greater seed yield per acre than the cultivated rows.

The means of cultural practice-time interaction in Table 3 were highly significant, which means that no specific cultural practice recommendation can be made without consideration of time or age of stand.

The means of solid stand, non-cultivated rows and cultivated rows are in Table 5. Cultural practices have been broken down into orthogonal single degree of freedom comparisons. It was found that the seed yield means of the solid stand and cultivated rows were significantly different at the .01 level than from the non-cultivated rows. The seed yield means of the solid stand and cultivated rows differ by 40 pounds per acre, and statistically, there was no significant difference.
Table 5. 1970-1971 Seed Yield Means in Pounds Per Acre and Orthogonal Single Degree of Freedom Comparisons Within 3 Cultural Practices. Means are Averages of 5 Nitrogen Levels, 2 Years, and 4 Replications.

<table>
<thead>
<tr>
<th>Cultural Practice</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-cultivated rows compared to solid stand and cultivated rows</td>
<td>1</td>
<td>124,397</td>
<td>124,397**</td>
</tr>
<tr>
<td>Solid Stand compared to cultivated rows</td>
<td>1</td>
<td>1,926</td>
<td>1,926ns</td>
</tr>
<tr>
<td>Cultural Practice</td>
<td>2</td>
<td>126,323</td>
<td>63,162</td>
</tr>
</tbody>
</table>

** Significant at the .01 level of probability. ns Not significant at .05 or .01 level of probability.
Response of Fertilizer on Intermediate Wheatgrass Seed Yield

The effects of cultural practices and nitrogen response are shown in photographs 4, 5, and 6. Weeds, such as green foxtail and yellow foxtail, were a problem the first year on all plots. The weeds grew taller where higher rates of nitrogen were applied.

In the high fertility plots the weeds grew tall enough to be cut by the combine sickle bar and add to the total volume of material which contributed to the additional cleaning processes needed the first year. The zero nitrogen plots had approximately as many weeds per square foot as the high fertility plots, but the weeds grew about half as tall as the intermediate wheatgrass and allowed the combine sickle bar to cut low enough to get all the grass heads and still high enough to be above most of the weeds.

There was very little lodging of intermediate wheatgrass in either 1970 or 1971.

The growth of intermediate wheatgrass in 40 inch cultivated rows is shown in photograph number 4. The check or zero nitrogen treatment is in the foreground and about half way up the photograph, the 240 pound rate of nitrogen may be seen. The intermediate wheatgrass was more densely headed in the plots receiving the 240 pounds of nitrogen per acre than the check plot.
Notice the sparseness of the heads in the foreground check, compared to the denseness of the intermediate wheatgrass heads in the high fertility background area.

The intermediate wheatgrass in 40 inch non-cultivated rows is shown in photograph number 5. The check is in the foreground, and there are approximately as many weeds per square foot as in the background area with 240 pounds of nitrogen. The weeds grew only about half as tall in the foreground check area, as in the 240 pound rate of nitrogen area. Notice the denseness of heads in the 240 pound rate of nitrogen versus the sparseness of the heads in the foreground check. The check area was combined low enough to leave the weeds seed below the cutter bar.

The intermediate wheatgrass in a solid stand is shown in photograph number 6. The check area is in the foreground and the 240 pound rate of nitrogen is in the background. The denseness of stand shows up conspicuously over the sparseness of the check. Green foxtail and yellow foxtail were about equally as thick per square foot in all fertility levels, yet the higher the fertility, the taller the weed growth.

The seed yield means of 0, 40, 80, 120 and 240 pounds of nitrogen are in Table 6. Fertility levels have been broken down into orthogonal single degree of freedom comparisons. It was found that the seed yield means of 0 versus 40, 30, 120, and 240 pounds of applied nitrogen are significantly different at the .01 level. It may be noted in Table 6, that the seed
Table 6. 1970-1971 Seed Yield Means in Pounds Per Acre and Orthogonal Single Degree of Freedom Comparisons Within 5 Fertility Levels. Means are Averages of 3 Cultural Treatments, 2 Years, and 4 Replications.

<table>
<thead>
<tr>
<th>Treatments Means</th>
<th>0</th>
<th>40</th>
<th>80</th>
<th>120</th>
<th>240</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>157</td>
<td>209</td>
<td>225</td>
<td>228</td>
<td>227</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lbs/acre nitrogen orthogonal comparisons</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Vs 40, 80, 120, 240</td>
<td>1</td>
<td>83,398</td>
<td>83,398**</td>
</tr>
<tr>
<td>40 Vs 80, 120, 240</td>
<td>1</td>
<td>5,716</td>
<td>5,716ns</td>
</tr>
<tr>
<td>80 Vs 120, 240</td>
<td>1</td>
<td>67</td>
<td>67ns</td>
</tr>
<tr>
<td>120 Vs 240</td>
<td>1</td>
<td>21</td>
<td>21ns</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>4</td>
<td>89,202</td>
<td>22,300**</td>
</tr>
</tbody>
</table>

**Significant at the .01 level of probability.
nsNot significant at .05 or .01 level of probability.
yield means vary only by 19 pounds per acre at the maximum when comparing the 40 to 240 pound rate of applied nitrogen. It was found that no statistical significant difference exists between the 40 - 240 pounds of applied nitrogen.

The average seed yields in pounds per acre as influenced by the nitrogen treatments shown in Table 3 for 1970 - 1971, respectively, were: 157 pounds of grass seed per acre, 209 pounds per acre, 225 pounds per acre, 228 pounds per acre, and 227 pounds per acre.

The nitrogen-cultural practice interaction of intermediate wheatgrass seed yield in pounds per acre is shown in Figure II.

Note in Table 3 that the nitrogen-cultural practice interaction was highly significant, which means that a specific recommendation of a certain fertility level without consideration to cultural practice could not be made.

Looking at Figure II, it may be noted that cultural practice as well as fertility level affected the seed yield of intermediate wheatgrass.

Referring back to Table 5, the solid stand and cultivated rows were significantly different in seed yield from the non-cultivated rows at the .01 level of probability, yet there was no significant seed yield difference between the solid stand and cultivated rows.

Referring back to Table 6, the 40 pound rate of nitrogen
Figure II. Intermediate Wheatgrass Seed Yield in Pounds Per Acre Influenced by the Interaction of Cultural Practice and Nitrogen Rates.
was significantly higher in seed yield than the zero rate of nitrogen on all 3 cultural practices. Fertility levels higher than 40 and 240 pounds of applied nitrogen was not significantly different on all 3 cultural practices.

The seed yield means from both Table 5 and 6 is illustrated in Figure II, which shows the solid stand to be the only cultural practice of the three with an increase in seed yield of more than 40 pounds of nitrogen.

The effects of seed yield increases in pounds per acre of intermediate wheatgrass over no fertilizer application is shown in Table 7. The grass seed yield was increased 82 pounds per acre when 40 pounds of nitrogen was applied on the solid stand versus no fertilizer.

The grass seed yield was increased 37 pounds per acre when 40 pounds of nitrogen was applied on the non-cultivated rows versus no fertilizer and grass seed yield increased 35 pounds per acre when 40 pounds of nitrogen was applied on the cultivated rows versus no fertilizer. The seed yield increase produced by higher rates of application was smaller.

An estimation of the economic values of this trial is shown in Table 8. The seed yield increase from solid stand, non-cultivated rows and cultivated rows with the application of 40 pounds of nitrogen was a profitable application. The break even point for 40 pounds of applied nitrogen is 16 pounds of intermediate wheatgrass seed. Notice in Table 7 that the grass seed yield is from 2 to 5 times greater than the 16 pounds
Table 7. Increased Seed Yield in Pounds Per Acre of Intermediate Wheatgrass Over No Fertilizer for 1970-1971.

<table>
<thead>
<tr>
<th>Nitrogen lb/acre</th>
<th>Solid Stand</th>
<th>Non-Cultivated</th>
<th>Cultivated</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>82</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>80</td>
<td>126</td>
<td>54</td>
<td>27</td>
</tr>
<tr>
<td>120</td>
<td>111</td>
<td>62</td>
<td>40</td>
</tr>
<tr>
<td>240</td>
<td>122</td>
<td>40</td>
<td>48</td>
</tr>
</tbody>
</table>
Table 8. The Break Even Point is Shown in Pounds of Seed Per Acre When Nitrogen is Selling for 10¢ Per Pound and Intermediate Wheatgrass is Selling for 25¢ Per Pound.

<table>
<thead>
<tr>
<th>Nitrogen lb/acre</th>
<th>Cost of N @ 10¢/lb</th>
<th>Income of grass seed at 25¢/lb</th>
<th>Break even point in lbs seed to pay for fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>$4.00</td>
<td>$4.00</td>
<td>16</td>
</tr>
<tr>
<td>80</td>
<td>8.00</td>
<td>8.00</td>
<td>32</td>
</tr>
<tr>
<td>120</td>
<td>12.00</td>
<td>12.00</td>
<td>48</td>
</tr>
<tr>
<td>240</td>
<td>24.00</td>
<td>24.00</td>
<td>96</td>
</tr>
</tbody>
</table>
necessary to break even when 40 pounds of nitrogen is applied on all 3 cultural practices. Also, note in Table 7 that the grass seed yield is 4 times greater than the 32 pounds necessary to break even when 80 pounds of nitrogen is applied on the solid stand. The grass seed yield is 1 3/4 times greater than the 32 pounds necessary to break even when 80 pounds of nitrogen is applied on the non-cultivated rows, but the grass seed yield falls 5 pounds per acre short of the 32 pounds per acre grass seed yield necessary to break even when 80 pounds of nitrogen is applied to the cultivated rows.
SUMMARY AND CONCLUSION

Intermediate wheatgrass planted in a fall no-tillage flax stubble yielded from 60 to 130 pounds of grass seed per acre the first year.

The first year grass seed yield of the solid stand was 134 pounds per acre, contrasted with the cultivated rows yielding 72 pounds of grass seed per acre, and the non-cultivated rows yielding 68 pounds of grass seed per acre.

The second year grass seed yield of the cultivated rows was 382 pounds per acre contrasted with the solid stand yielding 339 pounds of grass seed per acre, and the non-cultivated rows being the lowest yielding the second year in a row with 260 pounds of grass seed per acre.

The two-year mean yield of solid stand was the highest yielding cultural practice when compared to cultivated rows and non-cultivated rows.

The 1970 first year 0, 40, 80, 120, and 240 pounds per acre nitrogen level did not show any color or height response differences until about 2 weeks before heading time, but greener color and taller, denser stands were very apparent from early season until harvest in 1971, using 40 to 240 pounds of nitrogen.

The nitrogen-cultural practice interaction was highly significant, which means that a specific recommendation of a certain fertility level without consideration to the cultural
practice could not be made. The grass seed yield increase peaked at the 40 pound rate of nitrogen in the cultivated and non-cultivated rows and the seed yield increase peaked closer to the 80 pound rate of nitrogen in the solid stand.

The cultural practice-time interaction was highly significantly different, which means that no specific cultural practice recommendation can be made without consideration to time or age of stand.

Additional nitrogen increased the weed problem. The first year experienced more weeds than the second year.

Weed competition of annuals, such as wild buckwheat, green foxtail and yellow foxtail, were easily detected by the differential height of the weeds that grew in the 0, 40, 80, 120, and 240 pound nitrogen level areas. The higher rates of nitrogen had a taller and denser stand than the zero rate of nitrogen.

The cultivated rows had very little of a weed problem during the entire length of the experiment, yet they did not produce the highest seed yield per acre on a two-year average.

When nitrogen is selling for 10 cents per pound and intermediate wheatgrass is selling for 25 cents per pound, the profitable seed yield increase in pounds per acre over zero nitrogen were as follows:

1. 40 pounds of nitrogen was profitable on solid stand, non-cultivated rows and cultivated rows.
2. 80 pounds of nitrogen was profitable on solid stand and non-cultivated rows.

3. 120 pounds of nitrogen was profitable on solid stands and non-cultivated rows.

4. 240 pounds of nitrogen was profitable on solid stand only.
LIST OF REFERENCES


