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9. ABSTRACT

A world collection of 7960 oat varieties was partitioned and grown in four locations in South America. Emphasis was placed on finding lines with crown rust resistance, preferably with satisfactory agronomic adaptation. This was found in the Texas variety Coronado, which is being grown commercially in southern Brazil and which also has demonstrated its usefulness for forage, grazing, and grain. However, stem rust can attack Coronado, and only limited sources of oats with this resistance are available and these have only mediocre grain quality. Red leaf, too, is widespread and difficult to combat. Breeding lines assembled at Wisconsin exhibit individual characteristics of earliness, resistance to crown rust and to stem rust, but only moderate tolerance to red leaf. With characteristics available in various sources of germ plasm, it appears quite possible to improve oats by breeding methods to become more competitive with other crops and therefore be used more frequently. The amount of use, or area (acreage) increase of new and improved varieties cannot be predicted, but improvement certainly enhances this long-useful crop.

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ANNUAL REPORT

OF

RESEARCH FINDINGS

FEASIBILITY OF BREEDING OAT CULTIVARS SUITABLE FOR PRODUCTION IN DEVELOPING COUNTRIES

January 1, 1975 - December 31, 1975

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Contract No. AID/ta-c-1171

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FEASIBILITY OF BREEDING OAT CULTIVARS SUITABLE FOR PRODUCTION IN DEVELOPING COUNTRIES

Contract No. AID/ta-C-1171

INTRODUCTION

An adapted disease resistant variety of oats could produce two crops of forage or grain a year in subtropical areas. The caryopses are high in protein and vitamins. Breakfast foods of oats would have highly nutritious contents and could prevent some types of brain damage in early childhood. Oat groats have about 17 to 19 percent protein that has 4 mg lysine per 100 mg protein. Threonine and methionine are present, but in lower proportions. Oat forage is nutritious for livestock. A productive variety would have to be resistant to major diseases (or pests) such as crown rust, stem rust, Ustilago, Helminthosporium, Septoria, mildew, several bacteria and several viruses. Additionally, for drier areas, a variety would need to be drought resistant or drought escaping. Earliness might be a means of escaping drought damage, maturing before heat and winds become frequent.

PLAN

Find varieties or lines with best combination of disease resisting and agronomic characters that would be suitable for production; if none was fully available, find parental breeding stocks. A search of the USDA World Collection of Oats at Beltsville was planned by growing parts of the collection at each of several locations and observing which varieties may have promise for immediate use, or use as a parent. Since workers could not likely grow 7960 entries, the practical approach would be to get each of several workers to grow a portion. Further breeding stocks from active breeding programs could be included for observations.

PRIOR ACCOMPLISHMENTS

Oat varieties and selections have been tested in prior years to learn their crown rust response in Rio Grande do Sul, Brazil, as well as reaction to stem rust. There are several accounts of improvement of oats for groat protein content. Oats with increased groat protein content have provided increased weights of poultry and hogs. Workers in Rio Grande do Sul have obtained high pasturage yields from Coronado (Texas variety) as measured by steer gains, and was followed by high grain yields. Breeding histories of new high yielding varieties from Wisconsin and other states are available. The variety Dal is crown rust resistant in Wisconsin and has high grain yield with high groat protein percent.

EXPERIMENTAL METHODS

Arrangements were made to grow portions of the USDA World Collection at Porto Alegre, Santa Maria, and Passo Fundo in Rio Grande do Sul, Brazil, and at Bogota, Colombia. Personnel or cooperators have given their time generously in this endeavor. Their names and locations are found in Table 1. The list of workers is expanding. Other locations are experimental sites chosen to test some of the more elite stock of breeding material, especially disease responses. Table 2 gives a listing of seed sources in tests at several locations. Table 3 provides a list of locations where tests were conducted, workers (or cooperators), the date, and an abbreviated status of the experimental tests. There was usually one replication of single row plots 1 1/2 or 2 meters long and 30 or 45 cm apart. Rust readings were quantitative, 0-100, except for descriptions such as: Immune, highly resistant, resistant, intermediate, susceptible, etc. Heading dates were recorded as date when 50 percent or more was first headed; ripening date when grain was "binder ripe" and kernel weight as the weight per kernel in

milligrams after counting approximately 5 grams of seed (caryopsis plus lemma and palea).

RESULTS

World Collection

Porto Alegre

At Porto Alegre (with USAID help in sending seed in June 1974) 2004 short rows of the USDA World Collection were planted in late July. Drs. Carvalho and Porto made some plant observations and crown rust readings. Rust readings indicated moderate to light infection, though some rows had only dead plants in early December, 1974. Dr. Carvalho had harvested about 217 rows that were ripe in early December. These grain bundles were reviewed by Shands and noted as being "poor," "fair," "good," or "excellent." Grain samples of approximately 60 selections appeared to have good promise for further testing, including groat protein percentage. The greater portion of the 60 were from the C I 's with higher numbers, 6243 to 7525. A list of 12 was compiled for possible parental uses. Of especial note was C I 2332 named Black Algerian. This selection was very early and it is thought that it might be useful in North Africa where earliness and/or drought resistance is needed. The 12 selections are:

C I 2182	C I 3031	C I 6632	C I 7110
2332	3052	6644	7339
2628	3259	7107	8369

A 1975 Madison test indicated that these selections were questionable as to crown rust resistance; yet some were used as parents in crosses.

Santa Maria

At Santa Maria Mr. Roberto Ritter made crown rust readings on the 2060 USDA entries and noted that about 85 selections had enough tolerance to be useful at that location. Grain characteristics were noted, and 45 had well filled grain. Among those that were promising were Burt, Fulghum, Algerian, Anthony-Bond-Boone, Coker, and Florida derivatives. Perhaps the three most promising rows were from Florida with C I numbers 5397, 5398, and 5399. These three were of less promise than expected when grown at Madison in 1975. There were 21 selections that appeared to be useful on the basis of combined judgments of Ritter and Shands. Of those selections that seemingly were promising, most of them probably had A. byzantina in their parentage. It is speculated that they may have resistance to soil borne mosaic. Ritter sent seed of his harvest in time for a 1975 retest in Wisconsin. Based on the notes recorded at Santa Maria, 57 selections from the world collection were requested from J. C. Craddock. This C I group of selections is listed below:

C I	1108	C I	1979	C I	5096	C I	5398	C I	5730	C I	6005
	1312		1996		5105		5399		5847		6006
	1776		2033		5114		5406		5890		6007
	1822		4184		5115		5419		5898		6008
	1823		4985		5128		5428		5922		6009
	1833		4989		5134		5432		5947		6010
	1837		4990		5349		5500		6001		6011
	1846		5012		5356		5506		6002		
	1862		5015		5371		5675		6003		
	1963		5046		5397		5676		6004		

The retest at Madison indicated some crown rust resistance and/or tolerance; but most were "late rusters."

Bogota

At Bogota, Instituto Colombiano Agropecuario, Colombia, Mr. Reinaldo Reyes planted in April 1975 in the "first semester," 1850 rows of the world oat collection. Observations were made in July 1975. Plant development

varied from totally decumbent (winter type probably) to some with partially filled grain. Height varied from near 10 cm to about 140 cm. A wide range in combinations of types was present. The review emphasized finding usable types of crown (leaf) rust resistance. Approximately 120 A. sativa-A. byzantina entries appeared to have moderate tolerance to high resistance. Red leaf or Yellow dwarf was heavy at Bogota. Crown rust was severe enough to produce large open pustules and a coverage of 50 percent or more on susceptible entries. Stem rust was especially severe on early Indian (Asiatic) entries and nearly all world collection selections appeared susceptible at Bogota.

Passo Fundo

There were 2046 CI entries grown at Passo Fundo. Planting was done in July 1975 by Drs. J. C. Santiago and W. F. Kugler. Crown rust was moderately heavy and readings were made by personnel at Passo Fundo. The two units at this location included world collection entries CI 3277 to CI 4950 and CI 7526 to CI 9167. There were upward to 100 entries that had a measure of crown rust tolerance and a smaller number had what appeared to be adequate resistance to crown rust. A greater number with resistance occurred in the higher numbered CI group, evidencing more efficiency in breeding for crown rust resistance in the past dozen years. There were areas within this nursery where plants had been eaten by insects with chewing mouth parts. Many of the entries had large amounts of vegetative tissue (tall plants) suggesting attractiveness for green chop or silage possibilities. Such plants were probably late in heading and maturity. In contrast, there were entries having shorter and earlier plants with crown rust resistance suggesting their possible usefulness as a grain crop that would be early enough to use in a double cropping system (oats followed by soybeans or sorghum). There were

several entries of rust resistant Avena strigosa (2n=14) and at least one entry of an autotetraploid (2n=28) of an original A. strigosa. Some of the A. sativa types and a few A. strigosa entries were promising enough that Dr. Kugler implied that he would harvest some for further testing at Argentina locations and probably a second time at Passo Fundo.

Rust resistance from World Oat Collection

Some of the better appearing selections for rust resistance in the World Collection have been retested at Madison in 1975. Most of them were intermediate in rust response, and tended to show rust late in the season indicating that they are "late rusters" at Madison. There has not been a retest for the better appearing ones at Bogota or Passo Fundo.

Earlier Crown Rust Observations in Brazil

As early as 1965 attempts were made to find agronomically useful oats with adequate crown rust resistance in southern Brazil. Seed of the Coronado variety was sent to Porto Alegre in 1968. Interest in oats for grazing developed. Several newer selections were sent to J. M. Scholl in 1973. His associates made crown rust readings, the results of which are given in Table 4.

The 10 selections from Wisconsin were grown at Centro Agronomico, Guaiba (PA) and notes taken in 1973. Of this group 5 were resistant and 3 were moderately resistant. The same 5 selections with resistance were noted as being resistant in Santa Maria. Notes were taken by Dr. Costaneto and Dr. Bill Murphy, respectively. All these selections appeared to have only very minor or no infection at Madison, and all except one of the seven had passable resistance when tested at Puerto Rico. The exception was one selection of X2739. The resistance sources for the most part are from

Avena sterilis or derivatives of *Avena sterilis*. One exception is C I 8235 which reportedly has resistance that came from a derived tetraploid. Some workers believe that this source of resistance is indeed from Ascencao.

Wisconsin Assembled Lines

Puerto Rico

In the 1974 readings of about 800 Wisconsin breeding lines at Lajas, Puerto Rico, approximately 185 appeared to have resistance to race 264B. There were about 100 separate crosses with resistance. This test of 800 was an accumulation of Wisconsin material bred for crown rust resistance. There was a smaller stem rust test of 64 entries at Isabela, with 7 lines from Minnesota (P. G. Rothman). Only a few lines of Wisconsin origin showed adequate resistance to stem rust race 94. In the 1974-75 tests, 21 lines for stem rust resistance were assembled from Minnesota and Canada (McKenzie and Martens), and were tested for crown rust reaction at two locations. Approximately 290 lines including those for stem rust reaction were sent to Puerto Rico in October 1974, and these were subjected to 264B inoculum at Isabela and to a Minnesota buckthorn rust composite at Lajas. Readings were made at Isabela and at Lajas in March 1975. Crown rust reading at the two locations are given in Table 5 as well as for Madison in 1974.

Race 264B at Isabela had different pathogenic effects than that of the Minnesota buckthorn composite, the latter being more severe at times, and at other times race 264B being more severe, thus having differential effects.

Texas

In the hundred entries sent to Beeville, Texas, in November 1973, M. E. McDaniel reported that 15 showed good crown rust resistance. A larger number of entries was planted at Beeville in Nov. 1974, and readings for

crown rust were made in March and April 1975. These results are given in Table 5, utilizing descriptive letters as R, S, HR, etc. for resistant, susceptible, highly resistant, etc.

Porto Alegre

There were approximately 300 Wisconsin elite selections grown at Porto Alegre including a few early generation segregating populations and about 37 in the USDA elite crown rust resistant group in 1974. This group of approximately 300 rows was observed and a few selections were made in addition to the ones already made by Dr. Carvalho. Of particular note was a row of X2503-2 in which was found a very promising looking plant. This was harvested and left with Carvalho except for a few seeds that were mailed to Madison and planted in the greenhouse for crossing in March of 1975. Some of the 300 selections appeared to be susceptible to crown rust; but a good portion of them appeared to have enough tolerance to be useful agronomically. A selection, X2803, had considerable stem rust infection. Systematically obtained crown rust readings are not available for this test.

Of the 255 Wisconsin assembled entries grown at Porto Alegre in 1975, crown rust notes were taken in November and are assembled in Table 5. For convenience, not all of the entries are listed. There was a high proportion that had enough crown rust resistance for satisfactory oat production. This is not to say that all selections were well adapted agronomically. There were included 24 rising F_2 populations in 2 row plots. These were available for making selections.

The 1974 entries of Wisconsin offered selection opportunities as shown by that portion of Dr. Carvalho's Porto Alegre nursery where a range of agronomic types appeared, some seemingly with promise. However, some of the earlier heading reselections had thin kernels.

Santa Maria

The Santa Maria test included 255 entries and 48 rows of rising F_2 populations. Probably more than half of the non-segregating entries had crown rust resistance that is adequate for the Santa Maria location. Detailed readings are given in Table 5. Some of the new Coker selections made a good showing in 1975. Some of the selections that had good kernel filling in 1974 did not perform well and had mediocre grain at Santa Maria in 1975. Mr. Ritter had a multiple row 4-replicate yield test. C I 3090, C I 3098 and Wis. X1205 seemed promising agronomically and crown rust resistant. C I 8235 and X1309-1-1-1 continued to show crown rust resistance.

Bogota

Sytematic crown rust, and stem rust readings (by R. Reyes) were taken for 293 entries planted the first semester 1975 and are given in Table 5. A large portion appeared crown rust resistant. Since most of the entries were susceptible to stem rust, these readings were omitted.

However, a group with stem rust resistance as the special objective is recorded and results are given in Table 6. The results of seven crown rust tests are also given in Table 6. About 10 selections showed promise for stem rust resistance. Three originated in Wisconsin and the remainder in Minnesota and Canada. Wisconsin selections were from X1588 and X1922. Three from Minnesota including some with A. sterilis in their parentage had adequate stem and crown rust resistance, but with thin kernels. Stem rust readings need to be confirmed later by Reyes.

Only a small portion had virus tolerance which may be a serious shortcoming.

A "second semester" planting was made in August of 1975. Red leaf was generally severe, with a few exhibiting moderate to good tolerance. Crown rust resistance appeared adequate; but stem rust was only in developmental phases and could not be read.

Disease Resistance Sources

Emphasis has been placed on finding lines of oats with superior crown rust resistance. Observations have indicated the need of red leaf resistance and to a lesser extent stem rust resistance. Very likely entries in the World Oat Collection will prove helpful in providing resistances; but this will need confirmation by further tests. The Wisconsin assembled material has the benefit of a program of breeding especially for crown rust resistance derived from both exotic and domestic sources. Some of the original--prior to breeding--germplasm sources for crown rust and stem rust resistance are listed in Table 7. Better grades of crown rust resistance have been derived from the shattering species A. sterilis and its progeny. There is need for bolstering the stocks with red leaf resistance.

Dryland Areas

In addition to the humid areas of South Texas, Puerto Rico and eastern South America, arrangements were made to investigate the performance of the Wisconsin-assembled material in Jordan, Lebanon, and the central plateau of Turkey. These latter areas generally have intermediate to low rainfall. Germplasm under test included residue seed lots of rising F_2, several of which had southern U.S. winter types as parents. A total of 323 entries was sent to each of the above locations in 1974.

Jordan

The nursery at Amman was planted December 14, 1974. Observations were made in early June in cooperation with Dr. M. A. Duwayri. Some grain was mature while some lines had just completed flowering. Some types that appeared late at Madison seemed to mature early at Amman. No rust was seen. M. A. Duwayri recorded heading date, ripening date, height of plants and grain yields per 2 meter plots 30 cm apart. The information for part of

the 323 entries is given in Table 8. In early June 1975 some of the panicles were turning yellow preparatory to ripening. Heading was as early as late April in earlier types. Stands of plants were somewhat irregular and this probably contributed to yield irregularities which in turn produced wide variations in grain production. Yield per row ranged from very low (15 g) to a high of 353 g (not shown) for an F_2 population of the cross X2501-1 x CDA 286. Repeats of a few entries showed large differences, indicating the need of further testing to obtain more stability of yield averages. It is possible that performances in Jordan may be different from those in Madison where notes were taken as to heading, height, and grain yield for row width average of 45 cm. Kernel weights at Madison are also given in Table 8. The range was from 15.6 to 37.5 mg per kernel. The differential heading date performances between Amman and Madison, if indeed they do exist, should be explored further. In early June some notes were made concerning possible parental choices for early steps in a breeding effort. Some of the crosses were made in June-July 1975 at Madison.

Lebanon

Also in early June the Lebanon nursery at the A.U.B. Farm was reviewed with Dr. Hikmat Nasr. This was a non-irrigated nursery as was true of the Jordan nursery. Growth was not heavy and yields were likely low (20-45 bushels per acre). No rust was seen. The entry list of 323 was lost during seed shipments and a second list was given to Dr. Nasr. His planting was done in late January which was later than the time of other portions of the small grain nursery at the A.U.B. Farm. A short list of suggested crosses provided by Dr. Nasr is given below. Crossing attempts will be made in 1976. However, the oat work in Lebanon may be discontinued unless civil strife abates.

Suggested crosses:

X1273-4-3-1	x	X2666-3	X1273-4-3-1	x	73C1217
X1273-4-3-1	x	X2687-2	73C1217	x	Coolabah
X1273-4-3-1	x	X2887-8	X2426-1-1	x	X3443-1

X2426-1-1 x X2666-3

Turkey

The nursery of 323 entries was planted at Eskisehir in April, 1975 and was reviewed June 11 with Mr. Fahri Altay, Mr. Muslim Tanriyakul and Mr. Bayram Bolat. Plants were generally in the preheading stage and showed unmistakable differences as to projected time of heading. Bacterial infection was seen in numerous lines indicating prior availability of moisture helping form favorable conditions for infection. These men indicated a need for high winter survival so that planting may be done in fall. The following is a list of selections with agronomic promise when spring-planted at Eskisehir:

X1385-1	X1987-1	X2221-3	X3056-1
X1656-4-1	X2028-4	Markton	X3441-1
X1824-1	X2051-1	X2887-10	C I 6995
X1933-1	X2078-1	X2895-5	X1588-1
X1983-2	X2082-2	X3056-3	X1922-5
			Min 720183

Oats For Forage

In 1973 Dr. J. M. Scholl and associates made cutting tests in Rio Grande do Sul on vegetative oat plants, weighing the dried material, and also harvesting for grain yields. These results are set forth in Table 9. Here it will be seen that two selections had more than 5,000 kg/ha of forage material. The same varieties were harvested for grain yield, and where no cutting was involved, 3905 kg/ha was harvested for TAM 301. Apparently this variety can produce good forage and good grain yield. It is reported that one man on the faculty of the College of Agriculture of Rio Grande do Sul had 80 hectares (200 acres) of Coronado for seed purposes in 1974, indicating the usefulness of this variety. A small amount of Coronado seed from the Porto Alegre nursery was brought to Madison, dehulled and the protein percentage determined which was 13.7. These were plump, bright groats and were definitely lower in protein than Madison-grown material, which is a suggestion that growing and ripening conditions were very favorable for Coronado at Guaiba in 1974.

Dryland Conditions

H. G. Nasr (personal communication) grew three small grains in a test at A.U.B. research farm located on Beqa's plain in 1971-72. The average grain yield for the three wheats was 2470 kg/ha, and 2916 kg/ha for barley with the Dickson variety having 4500 kg/ha. The oats made a relatively poor showing with 1561 kg/ha. Dr. Nasr indicated that Garland was early and that Lodi looked attractive enough to continue testing. It appears, however, that oats might not be well adapted in the Lebanon area. With the use of early maturing varieties, however, it may be possible to find genotypes that might be useful under non-irrigated conditions in Lebanon, and possibly other dry areas.

BREEDING OATS FOR DEVELOPING COUNTRIES

Breeding Program Started

With the testing and breeding experiences of 1965, 1967 and the disease response data provided by J. M. Scholl and associates in Rio Grande do Sul, it was assumed that breeding could result in improved types where crown rust infection is a major problem. Therefore, it seemed wise to initiate crosses between varieties or selections that might segregate into types having more production and disease resistance than those currently available. Therefore, in the summer of 1974 at Madison, Wisconsin, 50 crosses were made and grown as F_1 in the greenhouse 1974-75. Seeds from these plants were sowed in 3-meter rows, one row per cross in the summer of 1975, producing F_2 plants. The parents of 40 of the crosses are listed in Table 10, and the weights of grain for each cross. The weights ranged from 117 to 290 grams per row. The average yield was 205.9 grams or 61.4 bushels per acre. About 40 crosses have crown rust resistance derived from A. sterilis while the remainder have A. sativa sources. Seed for the F_3 generation was sent to cooperators at six locations in 1975 and more will be sent to additional cooperators early in 1976. Thus segregating material will be available for selection purposes. Parents listed in Table 10 represent a range in agronomic types including those that head very early in spring and others having delayed heading. A new set of crosses was made in the greenhouse in March, 1975, with emphasis on Coronado and TAM 301, and attempts with the Coker 234. The latter variety appears to have small florets and is hard to manipulate for crossing. Additional crosses were made in the summer of 1975.

There is a small group of early maturing selections of X1273, X2317, and X2480. Two of these selections have A. sterilis in the background while X1273 has a derived hexaploid in its background. Another selection of interest is X1385-1 which is a derived hexaploid with Silva 17 tetraploid as a parent. If earliness may be transmitted from the first three selections

to their progenies, this might be valuable for resisting drought or perhaps escaping drought under low rainfall, dry land conditions.

The Madison based oat investigation program concerning breeding oats for developing areas includes the investigation of protein content of groats. Most of the selections have relatively high groat protein content, with results not contained in this report. Apparently the over-wintering type oats produce groats with lower protein.

Potential Chemical Male Gametocide

The compound RH532, provided by D. H. McRae of Rohm and Haas Company, has male serilization properties on wheat. This compound may have a similar effect on oats. If so, hybridization and recombination may be accelerated, thus assisting in breeding. A preliminary trial was initiated at Madison in the summer of 1975 to gain information as to the reaction of selections of Wisconsin origin when treated with RH532. Five cultivars were treated at the flag leaf emergence, early boot, and late boot stage at rates of 1, 2, and 4 lb/acre. Preliminary results indicate a reduction in seed set ranging from moderate to severe, reduced plant height, and other morphologic changes. Some cultivars were more severely affected than others. Rust resistant, untreated rows were interspersed every third row as pollen sources for hybridization. The progeny from the treated cultivars will be grown this summer (1976), and their rust reaction noted as an indication of whether these progeny represent hybrids.

Other Points of Possible Interest

Hulless oats with clean groats might be used by people where there is less mechanization and processing equipment.

Feeding trials of groats at Wisconsin using chicks and rats showed that

the variety Dal with its high groat protein gave larger weight gains than the variety Lodi with lower protein. The variety Dal led in total Wisconsin oat acreage in 1975.

Feeding trials of grain using hogs indicated that oat hulls have an ulcer-preventing material.

SEED DISTRIBUTION

There may be a deficiency in the chain of increase-distribution-utilization of improved oat varieties in Brazil. As early as 1965, X1309 and C.I. 8235 were observed to be crown rust resistant at Pelotas. Tests have been continued over the years since that time and findings indicate that they remain crown rust resistant. However, distribution and utilization of either selection at the farm level probably has not been effected. Further, a faculty member at the University of Rio Grande do Sul at Porto Alegre grew approximately 200 acres of Coronado for seed purposes in 1974, thus helping a variety to expand its usefulness. In other words, standardized foundation seed or seed certification programs supervised by the University or "Secretary of Agriculture" has not reached our attention.

DISCUSSION

The oat genus Avena contains both wild and cultivated types. Both have served man and several domestic animals for centuries. The crop has fallen in usage, partly because of livestocking practices, partly because genetic improvement in other crops has outdistanced that of oats, and partly because scientific interest in oats has not been emphasized by administrators. The oat crop can serve as a partial substitute for other crops. With crop vulnerability (sometimes mistakenly referred to as "genetic vulnerability") being painfully expressed as it is from time to time, it is only logical that Avena be given increased attention to ensure productivity over wide areas of the world.

Half-way measures likely would not mediocre results. This is to say that a comprehensive program utilizing team workers would probably not rewarding results. The team would need to comprise separate disciplines and would need to be manned by dedicated and imaginative workers. Before cultivated oats become endangered (for extinction), measures should be taken to provide genotypes that would have some of the following attributes;

1. High grain yield with good kernel characteristics
2. Resistance to important diseases (pests)
   - Crown rust and its races
   - Stem rust and its races
   - Smuts and their races
   - Helminthosporia and their races
   - Mildew and its races
   - Viruses and their races
   - Bacteria (several species,
   - Septoria
   - Aphids and other animal pests
3. High nutritional qualities
   - High protein including high lysine, methionine and threonine
   - High vitamin content
   - High digestibility
4. Lodging resistance
   - Sturdy straw with good feed value
   - Short straw
   - Good root system
5. High forage yield

6. Adaptation to various environmental conditions
    1. Poor and fertile soil
    2. Low temperature during flowering
    3. Low and high temperatures during growth period
    4. Mineral imbalance
    5. Drought
    6. Existing photoperiods
7. Adaptation to soil nitrogen-fixing organisms

Interest in Other Countries

There is moderate interest to improve oats in some of the foreign countries. This interest could be increased with limited financial grants to help them, as well as USA cooperators, to meet labor needs. After a period of time, a multiple exchange of breeding stocks might improve several on-going breeding programs, and newer ones that might be started.

SUMMARY

Feasibility of breeding improved oats for tropical or developing countries has been examined. The world collection of 7960 oat entries has been partitioned and grown at four locations in South America. Approximately 2000 entries were grown at each Porto Alegre, Santa Maria, Passo Fundo, Brazil and Bogota, Colombia.

Emphasis was placed on finding lines with crown rust resistance, preferably with satisfactory agronomic adaptation. Earlier tests in 1973 showed other breeding selections with resistance to crown rust donated by *A. sterilis*. Agronomic adaptation was found in the Texas variety Coronado which is being grown commercially in southern Brazil. Crown rust populations appear dynamic in South America, thus indicating need of having several sources of resistance so that resistance could be retained should rust races change,

thereby attacking hitherto resistant types. Coronado has demonstrated its usefulness for forage, grazing and grain.

Stem rust can attack Coronado, and this disease is severe in Colombia. Only limited sources of oats with resistance are available, and these have only mediocre grain quality. Red leaf is widespread and sometimes severe. Aphids appear to be on the increase in South America.

One year's observation at Amman, Jordan, Lebanon and Eskisehir, Turkey, suggested needs of drought resistance or perhaps drought escaping, since diseases were in low profile. Early maturing types may be useful in oat production in low rainfall areas. The need for winter survival of oats for Turkey has been expressed.

Breeding lines assembled at Wisconsin exhibit individual characteristics of earliness, resistance to crown rust, resistance to stem rust, but only moderate tolerance to red leaf. With characteristics available in various sources of germplasm it appears quite feasible to improve oats by breeding methods to become more competitive with other crops and therefore be more widely used. The amount of use, or area (acreage) increase of new and improved varieties cannot be predicted; but improvement would certainly enhance this crop that has long been useful.

EXPENDITURES

Expenditures from inception of Contract AID/ta-C-1171 through November 30, 1975, was $8,030.35. There were nominal additional charges that had not reached the business office.

Table 1. Personnel cooperating in oat breeding feasibility study.

Name	Location
U.S.A.	
M. E. McDaniel	Beeville and College Station, Texas
F. A. Kilpatrick	Beltsville, Maryland
Felix Jimenez	Mayaguez, Puerto Rico
R. A. Forsberg	Madison, Wisconsin
R. D. Duerst	Madison, Wisconsin
V. L. Youngs	Madison, Wisconsin
Keith Gilchrist	Madison, Wisconsin
Brazil	
J. C. Santiago	Passo Fundo
W. F. Kugler	Passo Fundo
Fernando Carvalho	Porto Alegre
Miguel Porto	Porto Alegre
Roberto Ritter	Santa Maria
Colombia	
Reinaldo Reyes	Bogota
Jordan	
M. A. Duwayri	Amman
Lebanon	
H. G. Nasr	Beirut
Turkey	
M. N. Nuri	Eskisehir
M. Tanriyakul	Eskisehir
F. Altay	Eskisehir

Others who probably will cooperate: -

G. Varughese, Algeria; A. Maamouri, Tunisia;
M. Romero, Peru; E. Antonelli, Argentina.

Appreciation is expressed for the interest and help given in several phases of this feasibility.

Table 2. Seed sources of oats used in tests at several locations.

Contributor	Number and description of entries	
J. C. Craddock - Maryland	7960	USDA World Oat Collection
R.I.H. McKenzie and J. W. Martens - Manitoba	10	primarily for stem rust resistance
P. G. Rothman - Minnesota	10	" " " "
M. E. McDaniel - Texas	5	" " crown rust resistance
R. D. Barnett and W. H. Chapman - Florida	6	" " " "
D. D. Morey - Georgia	3	" " " "
D. D. Stuthman and Ken Ziegler - Minnesota	10	" " " "
Dale Sechler - Missouri	25	" " virus (red leaf) resistance
M.D. Simons - Iowa	20	" " crown rust resistance
K. J. Frey - Iowa	3	composites
H. J. Marshall - Pennsylvania	7	primarily for winter survival
N. F. Jensen - New York	2	composites
C. H. Murphy - North Carolina	1	primarily for winter resistance
E. L. Smith - Oklahoma	2	" " " "
Steve Lund - New Jersey (Ore)	3	" " " "
Peter Hanson - Cambridge, England	3	hulless types
H. L. Shands, R. A. Forsberg, R. D. Duerst, & Z. M. Arawinko	ca. 200	Wisconsin breeding selections for disease resistances and kernel quality

Appreciation is expressed for each of the contributions listed in Table 2.

Table 3. Summary of oat nurseries grown or planned for disease response and other observations to see if feasible for breeding oats for developing countries.

Location	Year	No. & type entries	Cooperator	Planted	Crown rust readings	Harvest or special note
Puerto Rico	1974	800	Kilpatrick Jimenez	Nov '73	Yes	
	1975	290 Wis	"	Nov '74	Yes	
Texas	1974	100	McDaniel	Nov '73	Yes	
	1975	290 Wis		Nov '74	Yes	
Porto Alegre, Brazil	1974	2004 CI	Carvalho Porto	July '74	Yes	217 selected
	1974	335		July '74	Yes	
	1975	304 Wis	Carvalho	July '75	Yes	
Santa Maria Brazil	1974	2060 CI	Ritter	July '74	Yes	Part of best rows
	1975	304 Wis		July '75	Yes	
Passo Fundo	1975	2046 CI	Santiago Kugler		Yes	150 harvested
Bogota Colombia	1975	1850 PI	Reyes	Apr '75	Yes	Stem rust, virus
1st semester	1975 &	293 Wis		Apr '75	Yes	
2nd semester		304 Wis		Aug '75		
Amman Jordan	1975	323 Wis	Duwayri	Dec '74	No rust	Agronomic notes & harvest
A.U.B. Farm Lebanon	1975	323 Wis	Nasr	Jan '75	No rust	Crosses 1975 suggested
Eskisehir Turkey	1975	323 Wis	Taysi Tanriyakul Altay	Apr '75		Promising lines listed
Njoro Kenya		353 Wis, CI	McGinnis & Oggema	No information		
Algeria		Ca. 300 Wis	Varaghese Seed sent	1975?		
Tunis		Ca. 300 Wis	Maamouri Seed sent	1975?		

Table 4. Crown rust response and other information of Wisconsin selections grown at Madison in 1972 and 3 other locations in 1973.

Cross no.	1972 row no.	Parents	Crown rust readings			
			Madison	P. Rico	Santa Maria 2/	Porto Alegre 3/
X2427	5632	Ab6688 x Froker	tr	0	V.S.	S
X2717	6382	Froker x F34VRII-M	tr	tr	S	S
X2739	6425	IAS2-Mag 29 x Diana	tr	20S	S(has telia)	MR
X2739	6432	" "	tr	tr	MS. nec.	MR
X2801	7856	Lodi x CI8385 1/	tr	1-3	S(has telia)	MR
X2803	7859	Ab6688 x CI8415 1/	tr	tr	R	R
X2908	7035	CI8235 1/xX2763-1	tr	tr	R	R
X3119	8990	F_3 X2060 1/xX1289-4	tr	--	R	R
X3128	9020	X2051-1 1/x Goodland	tr	--	R	R
X3138	9045	X2060 1/x X1187-1	tr	--	R	R

1/ Probable source of resistance to crown rust.
2/ Bill Murphy notes.
3/ J. P. da Costa Neto notes.

Table 5. DISEASE READINGS. Crown rust response of oat varieties and selections grown at Madison, Wisconsin, in 1974, and other locations in 1975. Readings at Beeville, Texas, by M. E. McDanie readings of rust and red leaf at Bogota, Colombia, by R. Reyes.

Variety or selection	Crown rust 0-100, R(res.)-S(sus.) at Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isa-bela 1975	Lajas 1975	Bee-ville 1975	Bogota 1975	Redl leaf Bogota 1975
Coker 227		4	5	5	tr	VR 3/	10R	5
Coker 234	0	4	3	tr	tr	R	0	8
Coker 1214	tr	R	tr+	tr	1	R?	0	8
Coker 1217	0	tr	tr+	tr	tr	R	0	8
Coker 1518	0	tr	tr+	tr	tr	R	0	9
Coronado	tr	5	10	20	1	MR	5R	6
Dal	tr			15	2	MS	60S	8
Elan		10	20	10	2	MR-MS	0	6
Ga. 7199		10	20	20	tr-5	MR	30S	8
Goodland	tr			--	15	MS	5MS	5
Sure. bc	2	3	30	10	tr	R-MS	5MS	6
TAM 301	tr	tr	2	tr	tr	VR	5MR	6
TAM 312	tr	tr	tr	tr	tr	Imm	10R	5
Tx. 64c4194-2	tr	3	15	10	tr	MR	5R	7
Wright	1	30	50					
Fla 67ab 113	2	tr	tr	tr	8	Imm	0	6
Fla 67Q1R 113	2			tr-10	tr-20	R-MR	5MS	8
Fla 70Q1093	tr	3	tr	tr	1	VR	0	6
Fla 70Q1153 2/	0	0	tr	tr	tr	Imm	0	4
Fla 68Q2912	tr			tr-12	tr	Imm	10MR	8
CDA 28	tr	2	2	tr	tr	2%S	5R	7
CDA 139	tr	1	3	tr	tr	VR	5MS	8
CDA 286	tr	tr	tr	tr	tr	0-tr	10MS	6
CDA 1812	tr			tr	tr-6	VR	0	4
CI 6965	5			15	20	MR	60S	6
CI 7010 2/	0			tr	tr	0	0	4
CI 7172	2	tr	tr	tr	tr	MR-MS	0	8
CI 8150	1			5	5	VR	5R	6
CI 8234	2	6	dying	1-10	tr	MR-MS	0	6
CI 8235	1-	tr	R	tr	12	VR	0	9
CI 8360	tr	tr	tr	tr	tr	R	0	7

1/ Red leaf 1-9; 1=resistant, 9=very susceptible.

2/ *A. strigosa*.

3/ Very resistant.

Variety or selection	Crown rust 0-100, R(res.)-S(sus.) at Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isa-bela 1975	Lajas 1975	Bee-ville 1975	Bogota 1975	Red leaf Bogota 1975 1/
X1273-4-1	15			tr	15	S	0,10MR	7
X1309-1-1-1	3	tr	tr	0	10	VR	--	--
X1385-1	tr	tr	tr	0	tr	VR	--	--
X1552-1	3	50	40	tr	8	R-MS	5R	8
X1573-1	18			tr	50	MR	5R	4
X1656-4-1	3	30	50	50	5	S	20S	9
X1656-4-2				15	3	S	5MS	9
X1667-4	tr	tr	25	mat. 4/	3	MR	5R	8
X1764-2	tr	5	tr	tr	tr	R-MR	5R	7
X1772-2	tr	tr	tr	1	tr	VR	10MR	7
X1779-2	tr	30	40	tr	1	MS	5MR	6
X1824-1	1			15	2	MS	70S	7
X1913-3	tr	3	10	tr	2	VR	0	8
X1922-2	2			25	tr	S	30S	7
X1933-1	4			25	5	MS	5MR	8
X1983-2	1			50	15	S	20S	6
X1985-1	2			60	4	S	30S	6
X1985-2	1			50	2	S	10R	8
X1986-1	3			30	3	MS-S	5MR	5
X1987-1	3			tr-25	20	VR	0	8
X2028-4	1			30	tr	S	40S	6
X2028-8	1			40	tr	S	20S	8
X2051-1	tr	tr	3	tr	tr	R-MR	0	8
X2051-2	tr			tr	-	VR	0-tr	7
X2051-6	tr	tr	tr	tr	tr	VR	0	8
X2052-1	tr-10			25	tr	MR	20R	7
X2055-1	tr	tr	tr	tr	0	R	5R	8
X2060-5	tr	tr	5	tr	1	MR	0	7
X2067-2	tr	tr	tr	tr mat	tr-	MR	0	7
X2078-1	0			30	tr	MR	10R	9
X2080-1	1			40	tr	R	5MS	7
X2082-1	3			tr mat	20	R-MR	5MS	8
X2082-2	tr	tr	tr	tr mat	15	R	5R	7
X2159-1	tr			tr	30	VR	0	5
X2185-1	tr	tr	tr	tr	tr	VR	5R	7
X2185-2	1	tr	tr	tr	tr	R	5R	7
X2186-1	tr	tr	tr	tr	15	R-MR	0	5
X2188-3	tr			10	1	S	20S	7
X2194-2	tr	7	10	tr mat	1	S	5S	5
X2200-1	1			50	1	S	30S	4

4/ Mature.

Variety or selection	Crown rust 0-100, R(res.)-S(sus.) at Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isa-bela 1975	Lajas 1975	Bee-ville 1975	Bogota 1975	Red leaf Bogota 1975 1/
X2219-3-1	0	50	30	4	1	S	40S	5
X2222-3	tr	30	20	-	5	MS	20S	5
X2220-1	3			35	5	S	30S	8
X2220-2	tr			25	4	S	10MR	7
X2221-2	tr			10	3	S	20S	5
X2221-3	2			35	10	S	40S	6
X2221-5	2			25	2	S	30S	7
X2223-1	1	10	30	5	2	MS	60S	6
X2225-2	0			25	8	MS	40S	2
X2225-3	6			30	5	S	30S	2
X2255-1	4	15	30	10	5	S	20S	4
X2286-2	tr	tr	tr	tr mat	tr	VR	0	7
X2295-2-1	4			40	5	MS	5S	8
X2299-3	2	tr	tr	tr	15	VR	0	6
X2300-2	tr	tr	tr	tr mat	3	R	5R	6
X2300-4	tr	tr	--	tr mat	tr	R	5R	7
X2300-5	tr	tr	--	tr	tr	R	0	8
X2305-2	2			4	tr	MR-MS	5R	5
X2305-3	7	tr	15	30	10	MS	0	8
X2309-2	2			25	5	S	5MS	8
X2309-7	3			20	tr	S	5R	8
X2317-1	tr			tr	3	R?	0	6
X2317-3	tr	tr	tr	tr	10	MR-MS	0	6
X2341-1	tr	tr	tr	4	-	R-MR	20MR	6
X2343-1	tr	tr	tr	tr mat	3	VR	5MR	5
X2347-1	tr			50	3	S	5S	6
X2357-1-1	5	3	tr	6	10	VR	40S	6
X2357-2	tr	tr	tr	5	tr	VR	20S	6
X2360-1	4			20	40	MR	50S	7
X2365-1	3			1-30	2	R-MR	5MR	6
X2379-6	2			25	3	MR	30S	8
X2379-8	1	tr	10	5	2	VR	5R	6
X2379-9	3	tr	10	5	2	VR	5R	8
X2390-1	7			tr	20	R-MR	0	7
X2423-1	tr			50	tr	MR-MS	10MS	6
X2426-1-1	0	tr	5	4	tr	MS	5MS	6
X2426-4	1			60	2	S	10S	7
X2426-6	2			50	tr	S	5R	8
X2427-4	4			30 late	2	dead	5S	6
X2437-1	4			10	40	MS	5MS	5

Variety or selection	Crown rust 0-100, R(res.)-S(sus.) at Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isa-bela 1975	Lajas 1975	Bee-ville 1975	Bogota 1975	Red leaf Bogota 1975 1/
X2438-4	2			35	10	S	40S	7
X2456-2	1	30	35	50	3	S	10S	7
X2456-3	1			50	5	S	-	-
X2456-6	2			30	8	S	-	-
X2459-1	2			30	3	MR	5MS	6
X2459-2	1	20	40	10	-	R	10R	6
X2459-6	tr			20	3	MR	20R	5
X2470-1	4	15	30	10	10	MR-MS	10R	6
X2471-1	tr			tr mat	30	MR	-	-
X2471-2	1	tr	tr	tr mat	8	MR-MS	0	0
X2480-2	tr	tr	tr	tr mat	tr	MR	5R	0
X2480-4	4			25	25	S	60S	6
X2503-1	1	tr	8	tr-10	3	R	0	7
X2503-2	tr	2	5	tr	3	VR	0	6
X2503-3	tr	tr	15	tr	6	M-MS	0	5
X2505-2	4			tr	50	MR	30S	6
X2505-3	2	tr	tr	tr	-	MR	5R	7
X2505-4	1	tr	tr	tr	5	R-MR	0	6
X2506-3	1	25	tr	tr	-	VR?	0	8
X2507-1	tr			3	40	VR	10R	9
X2508-1	6			tr-50	50	MR-MS	0	7
X2509-1	tr	tr dying	tr	tr v late	8	MR	0	7
X2510-2	1	tr	tr	tr	10	R	5R	6
X2529-2	6	8	tr	tr	10	R	10R	8
X2590-1	5	8	30	10	20	MS	70S	8
X2616-1	0	tr	tr	tr	tr	VR	0	8
X2638-1	tr	30	10	tr	tr	MR	0	7
X2638-4	1	tr	15	tr	tr	VR	0	7
X2638-5	tr	20	15	tr	tr	MR-MS	90S	7
X2642-1	5			tr	10	MR-MS	100S	8
X2664-2	8			25	50	S	100S	8
X2666-3	2			30	2	S	90S	8
X2670-1	tr	25	40	30	4	S	60S	7
X2670-2	2			15	5	R-MR	50S	7
X2678-1	2	20	50	15	5	MS	5MS	7
X2681-1	0	tr	tr	3	tr	VR	5S	6
X2682-1	0	tr	tr	tr	3	R	5R	8
X2684-1	2			60	3	S	----	---
X2684-2	3			50	3	S	20S	6
X2687-1	2	20	8	tr	2	MS	--	-

Variety or selection	Crown rust 0-100, R(res.)-S(sus.) at Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isa-bela 1975	Lajas 1975	Bee-ville 1975	Bogota 1975	Red leaf Bogota 1975
X2687-2	1			3	2	MR-MS	0	8
X2738-1	3	tr+	tr	3	15	R	0	6
X2739-2	5			40	25	MR-MS	0	9
X2760-1	2	tr	tr weak	4	--	VR	0	6
X2780-1	2			4	25	MR-MS	0	8
X2795-1	tr	10	tr	15	tr-10	MR	20MS	6
X2795-2	tr	15	4	8	1-40	MS	20R	7
X2803-1	tr	tr	tr	tr	7	R-MR	0	8
X2822-2	tr	tr	tr	4	5	S	0	8
X2832-1	tr	10	10	tr	tr	R-MR	20MR	8
X2833-1-1	tr			40	3	MS	5S	9
X2851-1	1	15	tr	tr	2	MR-MS	0	8
X2851-2	2			20	1	MS	0	8
X2851-3	2			25	1	S	5MS	8
X2852-1	5			35	2-20	S	5R	7
X2853-1	R-			1	25	VR	0	6
X2876-5	3			12	tr	MR	5R	9
X2876-6	tr			15	6	MS	0	8
X2876-7	tr	tr	tr	tr	tr	R	5MS	8
X2881-1	2	tr	tr	5-20	6	MS	10R	8
X2882-4	1	15	tr	tr	3	MS	5MS	9
X2887-8	3			40	5	S	20MR	7
X2887-10	2			15	5	MS	5MS	9
X2895-5	3			20	tr	MR	50S	6
X2907-1	tr	10	20	3	tr	R,MR-MS	0	6
X2907-2	1			tr	tr-40	MR	0	6
X2908-1	5	3	tr	tr-40	30	MR	0	6
X2909A-6	3			4	2	VR	20R	5
X2909A2	1	6	40	10	5	MR-MS	0	9
X2914B-1	4	tr		tr	50	R-MR	R	7
X2977-1	4	tr	3	15	0-6	VR	5MS	7
X3004-1	tr			50	3	MS	20S	7
X3005-1	tr			60	3	MS	40S	7
X3025-1	1			50	3	MR-MS	5MS	6
X3056-2	tr	tr	tr	tr	tr	VR	0	7
X3056-3	tr	tr	tr	tr	tr	VR	0	6
X3056-1	tr	tr	tr	tr	tr	VR	0	7
X3060-1	tr			tr	10	Imm	0	7
X3060-2	1	tr	tr	tr	70	10-MS	0	7
X3086-1	tr	40	15	tr-25	2	MS	20S	7

Variety or selection	Crown rust 0-100, R(res.)-S(sus.) at Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isa-bela 1975	Lajas 1975	Bee-ville 1975	Bogota 1975	Red leaf Bogota 1975
X3119-1	tr			20	5	MR	10MS	7
X3128-1	tr	20	25	20	tr-20	VR	10R	6
X3138-1	1	tr	30	4	10	R-MR	10R	6
X3139-1	tr			40	4	MS	30S	8
X3183-3	tr	30	20	4	tr	VR	0	7
X3184-1	1	40	30	tr	4	R	40S	5
X3189-1	tr	40	15	5	4	VR tr inte R	0	6
X3189-2	2			5	20	R	0	8
X3194-1	5			10	7	MR-MS	5R	5
X3212-1	2	50	20	tr	15	VR	30S	8
X3216-1	tr	50	25	1	25	Imm	0	6
X3217-1	1-5	tr	tr	tr-30	25	VR	40S	6
X3236-2	3			tr	1-10	MR	--	-
X3236-1	2	10	15	tr	10	MR	0	6
X3246-1	4			tr-20	10	VR	40S	5
X3271-1	4			15	10	MR	0	4
X3277-1	1	50	20	tr	8	R	0	9
X3279-1	tr	50	20	4	tr	VR	0	6
X3304-1	3			tr	25	VR	-	-
X3308-1	1	50	25	10	tr	MR-MS	5MS	5
X3314-1	5			30	35	MR-MS	10MS	6
X3320-1	1			tr	3	10S	20MS	6
X3334-1	tr-	tr	tr	tr	tr-10	VR	0	7
X3337-1	1			dead	dead Helminth	MR-MS	30R	7
X3351-1	tr	tr	8	tr	tr	VR	0	6
X3441-1	1-4			4	30	VR & S	20S	7
X3443-2	3			3	25	R	30S	6
X3443-1	3			tr	tr-10	het S MS	20R	8
X3444-1	1			tr	10	Tr S	20MS	8
X3444-2	1	50	20	tr	tr-20	Tr S	20MS	8
H427				10	2	MR	0	7
H432		8	10	4	4	R	5R	6
H432				5	20	MR-MS	0	5
H543				12	4	MR-MS	0	5
H543				tr-10	1-5	R	0	5
H544				tr	25	R	0	8
H545				tr	1-5	VR	0	5
H546				tr	tr	R?	0	5
H547				tr	tr	VR	0	6
H548				tr	-	VR	5R	6
H549				tr	tr	R	0	4

Variety or selection	Crown rust 0-100, R(res.)-S(sus.) at Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isa-bela 1975	Lajas 1975	Bee-ville 1975	Bogota 1975	Red leaf 1/ Bogota 1975
H550				tr	2-10	VR	0	6
H554				tr	25	VR	0	5
H555		20	7	tr	tr	R	0	8
H555				tr	1	MR	0	6
H556		tr	tr	tr	2	VR	0	8
H558				tr	12	R	0	5
H441R-28				tr	tr	R	0	7
H443-4				tr	tr	R	0	6

Table 6. DISEASE READINGS. Stem rust grouping tested at several locations in 1974 and 1975.
Crown rust, red leaf and stem rust

Source and selection	Crown rust						Bogota		
	Madison 1974	Porto Alegre 1975	Santa Maria 1975	Isabela 1975	Lajas 1975	Bee-ville 1975	Crown rust 1975	Red leaf 1975	Stem rust 1975
CI 6995	7			80 dead	35	VS	30R	6	80S
CI 7069	5-20			25	25	MS	40S	9	80S
CI 7171	tr	tr	tr	4	tr	R	10R	9	80S
X1588-1	4	tr	5	tr?	8	MR-MS	5R	7	60S
X1588-3	5			tr?	8	MR-MS	30R	8	30S-MR
X1922-4	7	10	tr	15	40	S	50S	6	10 MR
X1922-5	4			10	50	MS	0	8	10 MR
MN 720183	tr	tr	tr	tr	10	VR	0	6	0
" 720226	6	10	20	tr?	20	VS	60S	7	20S-MR
" 720968	8			tr?	40	VS	50S	5	40S
" 721015	4	5	25	25	25	VS	40S	8	40S
" 730781	1	5	tr	tr	20	MR-MS	0	5	0
" 730353	3			tr	-	MS	60S	5	60S
" 730052	4			10	50	MS	20S	7	20MS-MR
" 732051	12			40	50	MS-S	50S	6	30MS-MR
" 732457	2	5	tr	tr	20	MR	0	6	5MR
" 734470-2	3	tr+	tr	tr	15	VR	5MS	6	0
MN 734503-1	1-10	tr	8	tr	20	VR	5R	4	20MR
Can CI9139 Rdy0	4	5	40	40	40	S	10S	7	0-5R
" 73IIN2211	6	30	25	40	25	MS	10S	6	60S
" 73IIN615	30	30	dead	40	50	VS	10S	8	60S
" CI3034x Rdy4	4	8	5	30	25	S	40S	7	60S
" Rld Pg 2	30	40	40	40	60	S	60S	2	80S
Can Jst. Pg 3	15	30	30	50	50	S	-	-	-
" Rdy. Pg 4	5	30	30	40	40	MR-MS	50S	8	80S
" Eg.2 4023 Pg8	15	dead	20	50	50	50	S	5	60S
" Ukraine Pg 9	3	3	tr	35	15	MR-MRS	30S	6	60S
" CW490-2 x Rdy02 Pg 13	5	50	10	50	50	MS	80S	6	80S

Table 7. List of germplasm parents used in oat breeding program.

Exotic		
CI 8077	Wahl 9	PI 295932
CI 8081	PI 292549	PI 296244
A st 6-76-4-3	PI 292562	SS 58-241-6
I-6-328	PI 295909	Ab 101 tet.
843 Belt. Gh.	PI 295919	Silva 17 tet.

Mostly domestic		
Ark 674	Coolabah	PI 174544
Ascencao	Coronado	Portage
Belar	Dal	Suregrain bc
Clintland 64	Goodland	TAM 301
Coker 234	La Provision	Trispernia

Stem rust resistance sources		
MN 720571 (CI 3034)	X1588 (Hajira Canuck Hulless)	X2859 (Prob. from Purdue 6316A-2)
X1913-3 (Resistant at Porto Alegre)		

Table 8. Agronomic response of oat varieties and selections grown in 2-meter rows 30 cm apart at Amman. Jordan, and in 1.5 meter rows 45 cm apart at Madison, Wisconsin, in 1975.

Variety or selection	Amman, Jordan				Madison, Wisconsin			
	Head date May (Apr)	Ripe date June	Plant height cm	Grain yield grams	Head date June (July)	Plant height cm	Grain yield 1 m gm	Kernel wt mg
Coker 227	5	12	100	130	7-1	92	141	31.9
" 234	5	14	80	125	7-3	100	140	28.8
" 1214	4-29	14	80	105	7-3	96	127	31.7
" 1217	4-29	14	75	158	7-4	99	125	29.9
" 1518	4-30	14	75	64	7-15	104	135	32.0
Coolabah	4-25	14	90	118	22	92	105	29.1
Coronado	1	17	80	120	7-6	105	145	34.1
Dal	23	22	85	143	30	106	102	28.3
Elan	4-29	12	85	135	30	85	90	31.8
Garland	19	13	90	93				
Ga. 7199	10	20	90	127	30	103	129	24.6
Goodland	12	20	90	138	27	43	89	29.9
Irwin	4-23	22	90	136	21	82	44	32.3
Jaycee	10	13	90	116				
Sure. bc	29	15	85	157	7-5	98	73	29.8
Swan	4-23	13	90	208	21	81	61	39.4
TAM 301	28	15	75	125	7-6	94	99	28.0
TAM 312	9	15	80	120	7-3	88	86	37.0
Tx 64C 4194-2	30	15	80	125	7-6	102	172	30.6
Wright	19	21	100	160	30	114	93	28.9
Fla Ab 113	4	14	85	145	7-8	100	131	23.6
FLA Q1R113	5	14	90	132				
" 70Q1093	4-30	12	80	137	28	81	126	28.6
" 70Q1153 strigosa	9	13	95	20	7-2	112	99	21.5
" 68Q2912	4	14	100	255				
CDA 28	5	20	70	87	7-6	107	107	32.3
" 139	5	20	75	115	7-6	104	133	31.2
" 286	30	19	80	185	7-7	100	101	32.3
" 1812	9	20	80	147				
CI 6965	18	20	110	234				
" 7010 strigosa	11	20	80	12				
" 7172	2	15	100	92	7-20	110	26	15.6
" 8150	22	22	90	150				
" 8234	30	17	90	82	7-6	108	146	30.3
" 8235	23	20	93	216	7-6	118	117	35.0
" 8360	26	26	95	187	7-2	108	142	31.3

Variety or selection	Amman, Jordan				Madison, Wisconsin			
	Head date May (Apr)	Ripe date June	Plant height cm	Grain yield grams	Head date June (July)	Plant height cm	Grain yield 1 m gm	Kernel wt mg
X1273-4-1	25	16	70	30	21	109	--	--
X1309-1-1-1	5	21	100	194	25	101	79	32.9
X1385-1	19	18	90	44	7-5	108	118	30.4
X1552-1	19	16	90	172	27	85	95	28.7
X1573-1	11	21	85	120				
X1656-4-1	18	23	80	80	7-1	97	86	32.1
X1656-4-2	22	23	75	93				
X1667-4	25	23	80	99	27	101	132	36.8
X1764-2	18	22	90	104	30	106	71	28.0
X1772-2	17	22	82	146	30	112	117	31.6
X1779-2	19	23	85	166	7-1	100	128	27.9
X1824-1	19	23	95	84				
X1913-3	21	18	85	104	7-1	90	89	31.7
X1922-2	9	24	100	170				
X1933-1	21	24	95	100				
X1983-2	20	19	90	114				
X1985-1	10	16	100	195				
X1985-2	12	16	95	110				
X1986-1	22	24	95	148				
X1987-1	15	19	90	218				
X2028-4	17	22	85	105				
X2028-8	19	22	80	100				
X2051-1	4-24	12	120	71	25	120	50	29.2
X2051-2	1	14	110	15	24	106	58	24.1
X2051-6	3	12	105	126	26	114	146	34.0
X2052-1	11	12	110	40				
X2055-1	10	12	95	50	24	100	106	28.7
X2060-5	30	12	95	105	26	90	99	30.2
X2067-2	19				26	92	-	--
X2078-1	23	24	85	230				
X2080-1	18	24	90	80				
X2082-1	23	21	90	144				
X2082-2	21	21	90	65	30	96	104	31.2
X2159-1	11	24	95	140				
X2185-1	11	17	100	125	26	118	151	31.9
X2185-2	17	24	105	95	24	115	90	32.9
X2186-1	2	16	120	48	30	121	77	28.7
X2188-3	16	20	100	127				
X2194-2	22	24	95	111	25	114	72	32.4
X2200-1	25	26	85	115				

Variety or selection	Amman, Jordan				Madison, Wisconsin			
	Head date May (Apr)	Ripe date June	Plant height cm	Grain yield grams	Head date June (July)	Plant height cm	Grain yield 1 m gm	Kernel wt mg
X2219-3-1	20	21	85	43	7-6	101	105	32.6
X2220-1	20	26	85	60				
X2220-2	17	20	90	124				
X2221-2	12	16	80	160				
X2221-3	23	17	85	83				
X2221-5	10	17	100	87				
X2222-3	27	26	80	80	7-5	114	95	27.3
X2223-1	19	20	90	127	7-4	101	116	24.6
X2225-2	19	26	100	67				
X2225-3	18	20	100	120				
X2255-1	18	20	110	143	26	112	131	35.6
X2286-2	5	13	120	145	24	108	71	20.3
X2295-2-1	13	13	90	131				
X2299-3	28	12	110	105	25	102	102	28.0
X2300-2	17	12	90	108	26	94	80	30.6
X2300-4	19	12	90	155	30	94	131	30.7
X2300-5	19	13	90	135	27	101	83	32.2
X2305-2	30	12	115	117	7-6	132	87	25.3
X2305-3	18	13	110	57				
X2309-2	16	12	90	98				
X2309-7	4-29	12	100	84				
X2317-1	4-22	12	115	146	24	90	75	24.4
X2317-3	4-22	12	105	122	24	100	120	26.6
X2341-1	15	12	125	136	7-3	111	124	25.0
X2343-1	4-26	12	115	160	25	121	111	27.2
X2347-1	19	21	105	195				
X2357-1-1	10	20	100	95	27	102	135	28.0
X2357-2	5	18	110	92	7-2	110	122	28.9
X2360-1	10	14	110	75				
X2365-1	12	13	115	135	7-3	112	168	24.8
X2379-6	11	14	105	57				
X2379-8	6	12	100	176	25	91	100	32.8
X2379-9	5	12	110	95	27	101	122	33.5
X2390-1	20	20	85	110				
X2423-1	20	26	100	185				
X2426-1-1	16	12	80	151	26	96	136	27.9
X2426-4	15	12	80	170				
X2426-6	17	20	90	192				
X2427-4	17	20	95	130				
X2437-1	19	20	110	197				

Variety or selection	Amman, Jordan				Madison, Wisconsin			
	Head date May (Apr)	Ripe date June	Plant height cm	Grain yield grams	Head date June (July)	Plant height cm.	Grain yield 1 m gm	Kernel wt mg
X2438-4	11	17	100	226				
X2456-2	24	21	75	80	29	110	160	28.4
X2456-3	21	26	95	175				
X2456-6	19	26	100	220				
X2459-1	17	21	105	122				
X2459-2	18	19	80	107	26	94	133	31.1
X2459-6	19	20	80	100				
X2470-1	5	19	80	105	22	98	82	37.5
X2471-1	10	19	120	100				
X2471-2	17	19	100	42	26	105	111	31.5
X2480-2	4-30	20	115	31	22	103	48	29.0
X2480-4	12	16	120	142				
X2503-1	9	19	105	85	25	108	136	27.7
X2503-2	10	20	110	53	26	117	105	28.9
X2503-3	10	19	110	32	26	115	95	28.4
X2505-2	18	16	105	65				
X2505-3	10	14	80	40	22	88	107	30.5
X2505-4	4	14	105	152	23	95	126	25.2
X2506-3	11	14	115	85	30	115	130	26.3
X2507-1	12	14	90	172				
X2508-1	18	14	100	124	30	105	118	36.8
X2509-1	12	12	90	128	7-5	120	39	24.6
X2510-2	10	12	90	83	27	92	141	31.2
X2529-2	19	20	100	98	7-3	102	137	31.2
X2590-1	17	20	100	79	25	108	125	26.5
X2616-1	10	14	90	83	30	92	106	25.7
X2638-1	10	14	90	115	23	80	87	24.2
X2638-4	10	12	90	87	24	87	72	23.3
X2638-5	10	12	90	12	25	82	75	25.3
X2642-1	9	15	110	70	23	97	89	27.4
X2664-2	19	20	110	130				
X2666-3	4	14	90	117				
X2670-1	19	20	85	82	7-2	100	51	28.6
X2670-2	19	20	90	142	7-4	104	149	30.5
X2678-1	10	12	90	147	22	86	87	35.8
X2681-1	26	26	80	131	7-6	105	126	30.8
X2682-1	12	15	100	189	30	98	142	31.4
X2684-1	20	19	85	87				
X2684-2	18	20	95	97				
X2687-1	21	20	80	58				

Variety or selection	Amman, Jordan				Madison, Wisconsin			
	Head date May (Apr)	Ripe date June	Plant height cm	Grain yield grams	Head date June (July)	Plant height cm.	Grain yield 1 m gm	Kernel wt mg
X2687-2	19	20	100	158				
X2738-1	23	26	100	133	29	100	145	26.5
X2739-2	30	26	75	164				
X2760-1	22	20	80	133	30	121	121	30.4
X2780-1	19	20	80	118				
X2795-1	25	21	85	97	7-1	110	84	24.7
X2795-2	24	21	70	130	7-1	107	148	26.5
X2803-1	4	18	90	111	7-12	145	96	26.7
X2822-2	20	20	75	40	26	98	120	29.7
X2832-1	16	18	110	111	25	95	107	27.2
X2833-1-1	20	20	82	157				
X2851-1	7	20	95	215	26	95	119	27.3
X2851-2	9	19	100	175				
X2851-3	9	18	100	135				
X2852-1	5	18	90	187				
X2853-1	10	15	90	150				
X2876-5	11	14	85	95	25	104	75	26.5
X2876-6	17	12	82	125				
X2876-7	15	20	90	138	30	100	51	30.6
X2881-1	12	18	105	170	21	91	63	22.5
X2882-4	14	12	100	194	7-1	105	163	25.1
X2887-8	15	20	100	165				
X2887-10	17	19	100	135	7-1	109	108	34.3
X2895-5	15	20	120	185				
X2907-1	11	14	90	138	26	104	117	29.0
X2907-2	10	21	85	160				
X2908-1	20	22	105	202	29	110	147	31.0
X2909A-2	17	19	80	100	25	98	70	26.2
X2909 A-6	16	19	90	65	27	80	84	27.8
X2914B-1	23	26	80	150	28	100	111	26.5
X2977-1	24	26	80	135	28	112	156	29.4
X3004-1	26	26	90	135				
X3005-1	22	26	70	190				
X3025-1	28	26	85	35				
X3056-1	19	26	110	124	29	114	121	29.2
X3056-2	19	26	90	135	30	115	82	28.6
X3056-3	20	26	90	155	29	108	87	24.8
X3060-1	24	27	95	120	7-4	134	147	31.4
X3060-2	31	27	80	77				
X3086-1	22	20	80	140	7-2	105	143	26.8

Variety or selection	Amman, Jordan				Madison, Wisconsin			
	Head date May (Apr)	Ripe date June	Plant height cm	Grain yield grams	Head date June (July)	Plant height cm	Grain yield 1 m gm	Kernel wt mg
X3119-1	4	18	100	140				
X3128-1	1	19	100	144	7-6	120	79	25.4
X3138-1	9	19	90	36	7-5	120	56	25.6
X3139-1	21	18	80	119				
X3183-3	22	21	85	135	26	91	97	27.7
X3184-1	18	17	95	113	25	106	174	26.9
X3189-1	19	18	95	117	26	92	114	25.8
X3189-2	23	22	80	175				
X3194-1	11	19	100	100				
X3212-1	21	21	90	117	27	94	132	29.0
X3216-1	18	12	85	122	27	85	115	28.3
X3217-1	18	22	95	195	28	101	89	32.8
X3236-1	10	17	95	71	25	91	83	27.2
X3236-2	15	17	90	105				
X3246-1	14	20	110	163	7-1	116	96	27.1
X3271-1	14	16	100	85				
X3277-1	13	16	95	123	27	89	109	31.5
X3279-1	16	16	105	141	28	106	124	29.7
X3304-1	11	16	70	173				
X3308-1	18	15	100	50				
X3314-1	4	26	105	183				
X3320-1	19	14	100	134	26	112	100	29.2
X3334-1	9	14	80	51	23	104	-	-
X3337-1	17	16	100	78				
X3351-1	11	20	90	129	25	-	92	31.3
X3441-1	18	26	90	150				
X3443-1	17	20	95	131	26	93	149	29.9
X3443-2	17	20	90	125				
X3444-1	19	21	90	113	28	96	173	26.6
X3444-2	23	26	75	180				
H427	19	22	90	105				
H432	11	17	100	140	26	102	73	22.4
H432	13	20	110	180				
H543	18	20	105	80				
H543	15	20	110	187				
H544	9	18	120	194				
H545	4	18	125	30				
H546	1	13	120	125	25	114		
H547	4-30	13	125	60				
H548	4	13	110	180				
H549	7	26	95	88	25	100	57	23.3

Variety or selection	Amman, Jordan				Madison, Wisconsin			
	Head date May (Apr)	Ripe date June	Plant height cm	Grain yield grams	Head date June (July)	Plant height cm	Grain yield gm/m	Kernel wt mg
H550	8	13	100	43				
H554	4-30	16	105	103				
H555	4-30	14	110	52	22	84	50	21.1
H555	4-30	14	110	107				
H556	1	14	110	118	24	94	90	22.8
H558	4	13	120	108				
H441-R-28	4-29	13	125	104	22	104	37	22.6
H443-4	4-30	13	90	65				
Markton (check)	22	26	95	167	7-1	110	123	29.1

Table 9. Production of forage and grain.
Guaiba, Brazil (near Porto Alegre).
J. M. Scholl et al. in 1973.

Variety	Production of forage DM (Kg/ha) 1 cutting	2 cuttings	3 cuttings
Coronado	1705	3000	5190
TAM 301	1665	3040	5034
Cortez	1689	2835	4457
Nora	1422	2931	4230
Fla. 501	1399	2809	3912
Elan	1341	2568	3491
CI8235	1184	2370	2713
Byzantina	1527	2445	3715

Variety	Production and Quality (test wt.) of Grain: D.M. Kg/ha 0 cutting	1 cutting	2 cuttings	lbs/bu 0 cutting	1 cutting	2 cuttings
Coronado	3289	1630	1275	38	39	37
TAM 301	3905	2280	1665	36	37	35
Cortez	2912	2114	520	34	38	31
Nora	1115	400	114	36	33	25
Fla. 501	1542	1457	360	37	41	32
Elan	3314	1437	699	36	34	32
CI 8235	2129	1665	442	33	34	23
Byzantina	1017	602	490	34	31	28

Table 10. Parents of rising F_3 populations distributed September 1975 after F_2 production 1975, and weight of grain from 3 meter row.

1975 source	Parents Female	Parents Male	Weight of 3 meter row g
1	PR76	X2357-1-1	211
2	PR76	Sur. bc	166
3	X2309-2	Cok. 234	159
4	X2503-1	Cok. 234	205
5	X2185-1	Cok. 234	260
6	X2185-2	Sur. bc	228
7	X2638-1	Cor.	130
8	X2426-1-1	Sur. bc	204
9	X2379-7	Sur. bc	210
10	X3119-1	TAM 312	126
11	64C4914-2	X2357-1-1	228
12	64C4914-2	X2379-9	220
13	64C4914-2	X2309-2	194
14	X2185-1	X3138-1	261
15	X2185-1	X3128-1	263
16	X2185-1	X2873-1	274
17	X2185-2	X2060-5	159
18	X3212-1	X2185-2	201
19	X2185-2	X2357-1-1	178
20	X2185-2	X2908-1	275
21	X2286-2	X2357-1-1	137
22	X2286-2	Sur. bc	117
23	X2287-1-1	X2295-2-1	171
24	X2505-3	X2185-2	185
25	X2505-3	X2357-1-1	150
26	X2505-3	X2888-2	236
27	X2508-1	X2887-12	290
28	X2616-1	X3236-1	194
29	X2638-4	X1309-1-1-1	166
30	X2638-4	X3119-1	148
31	X2908-1	X2309-2	277
32	X2908-1	X2876-7	234
33	X3119-1	X2078-1	201
34	X3138-1	X2379-9	152
35	X3138-1	64C4194-2	274
36	X3189-1	X2379-9	242
37	X3189-1	X2638-1	195
38	X3189-1	X2687-1	147
39	X3212-1	X2426-1-1	290
40	X3212-1	X3056-2	212

Plump grains of oat spikelet