

Northarvest Bean Grower Association

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Research Report, 1999

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Breeding Dry Beans For The Northern Plains, 1998

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The long-term objective of the dry bean breeding program at North Dakota State University is to develop high yielding, high quality, adapted bean cultivars for production in the Northarvest region. More than 500 unique, controlled hybridizations are made in the greenhouse each year to reach this objective. Parental germplasm consists of adapted cultivars grown in the Northern Plains, breeding lines developed at NDSU, and germplasm possessing desirable traits from other breeding programs. Unadapted germplasm lines from other sources are evaluated for desirable traits and introgressed into adapted material (e.g., pre-breeding). Each year, the breeding program evaluates material from around the world as possible sources of resistance to white mold, rust, root rot, and bacterial blights.

Pedigree method

The breeding scheme used in the breeding program is known as the pedigree breeding method. The steps involved in the breeding process vary depending on the stage of development of the population or line. We depend heavily on single plant selection for easily identified traits, such as plant maturity, architecture, pod load, lack of diseases, and appropriate seed characteristics. Single plants that are selected for these desirable traits are harvested, and the seed is grown in an off-season nursery in Puerto Rico for seed increase. At the same time, evaluation of these lines for disease resistance continues in the greenhouse. Superior lines are harvested in bulk and the resultant lines are planted in progeny rows at several locations in North Dakota or Minnesota.

Superior families and rows identifed at these locations are selected and the best plants in those rows are harvested. Seed from these plants are again planted in an off-season nursery, with superior rows identified and harvested. These lines are then evaluated in a preliminary yield test (2-3 reps at each of 3 locations, depending on seed availability) for one year. If a line performs well, it is single plant selected to begin pure line develop-

Continued on page 4

ment and also entered into advanced yield tests (3 reps/ location; 4 locations). A selection pressure of 10-15% is placed on materials entered into plant rows and yield tests, ensuring that only superior lines will be selected. Elite lines that perform well in the advanced yield trials are then entered into variety trials for three years (years 7, 8, and 9). The time required to release a variety after the initial cross is made is usually 10-12 years, although it may be reduced considerably if off-season nurseries are used.

Winter nurseries

Off-season nurseries are used to reduce the number of years needed for experimental lines to reach near-homozygosity, allowing yield tests to begin earlier in the breeding cycle. Several years can be eliminated from cultivar development if winter nurseries are used.

As in past years, a winter nursery will be conducted in Puerto Rico. The 1998-99 winter nursery consisted of over 4,100 rows, almost twice as large as last year s nursery of 2,800 rows. More than 1,500 pinto bean lines were grown in this year s nursery.

Variety trials

The breeding program has yield tests and/or breeding nurseries at nine locations in North Dakota and Minnesota (Erie, Hatton, Forest River, Johnstown, Page, Carrington, Crete, Park Rapids, and Perham). In 1998, pinto (P) navy (N), and miscellaneous (M) bean class variety trials were grown near Erie (P,N, &M), Hatton (P,N, &M), Forest River (P&N), Crete (P&N), Perham (M), and Park Rapids (M); preliminary yield tests were grown at Erie, Hatton, Johnstown, and Perham (kidney and crans only). Approximately 1,000 variety trial plots were harvested, in spite of the fact that about 400 plots were abandoned because of severe flood damage. An additional 4,500 plots from yield trials and breeding nurseries were harvested in 1998.

Breeding nurseries were located at Erie, Hatton, Johnstown, and Perham (irrigated). Germplasm evaluation nurseries were at Erie and Perham; the Midwest regional Performance Nursery (a four state trial coordinated by NDSU) and the Cooperative Dry Bean Nursery (12 states and provinces, coordinated by the University of Idaho) also were at Erie. Disease nurseries were at Page (white mold), Hatton (rust), Erie(common blight), and Perham (root rot). Breeding nurseries, yield trials, and other trials will total more than 7,000 plots planted on over 45 acres.

1998 season

The 1998 growing season was, for the most part, good early on, except for areas that received excessive rainfall. The growing season was conducive to white mold, which was reported as early as July 20 in some production fields. Late July and August were, for the most part, dry, which minimized white mold damage. Common bacterial blight was particularly evident throughout much of the region. The breeding project lost a yield trial at Perham because of excessive rainfall. Breeding nurseries were good to very good, and with the sites at Erie and Hatton, over 7,000 single plant selections of pinto, navy, pink, black, dark red kidney, light red kidney, and cranberry market classes were made. These single plant selections were evaluated in the seed lab for seed quality traits, with the lines having the best traits entered in the 1998-99 winter nursery.

Approximately 90-95% of the breeding effort is placed on pinto bean and navy bean improvement.

Resistance screening

Breeding lines were evaluated in the greenhouse for the presence of BCMV resistance genes I, bc2[2], and bc3 during the winter. Incorporating adequate levels of BCMV resistance into pinto bean breeding lines improves the overall desirability of experimental lines because of the threat of virus infection in western seed producing states. Lines also were evaluated for rust resistance, using a composite of isolates collected from North Dakota. High levels of resistance were identified in lines from a number of market classes. Given adequate funding and greenhouse space, the breeding program would prefer to supplement field inoculation of both rust and white mold with greenhouse evaluations.

Canning evaluation

Canning trials of pinto bean and navy bean breeding lines are conducted for all advanced and some preliminary trials, depending on seed supply, in collaboration with Dr. Sam Chang, Department of Food and Nutrition. In these canning trials, experimental lines are rated on overall appearance, on a subjective scale of 1 = superior to 7 = poor appearance (4 = average), relative to released commercial cultivars. These cultivars also serve as yield and agronomic checks in the yield trials. We are currently canning the 1998 trials and anticipate evaluating about 800 samples. The objective of these canning tests is to identify both potentially superior genotypes, which would be advanced for further evaluation, as well as inferior genotypes, which would be eliminated from the breeding program.

White mold nursery

White mold continues to be a serious management problem for dry bean growers and is ranked as the disease of most concern to producers. The potential for improved genetic resistance as a control measure has been demonstrated. Two major mechanisms of genetic resistance to white mold exist: 1) avoidance - usually associated with improved plant architecture; and 2) physiological - associated with biochemical functions at the cellular level. Generally, greenhouse and laboratory methods screen solely for physiological resistance, whereas field plantings screen for both physiological and avoidance mechanisms. Thus, greenhouse and laboratory resistance may not correlate well to field resistance. The breeding project has relied on evaluating material in the field, and also evaluates material from other programs entered in the National White Mold Nursery. This national nursery is grown in Michigan, New York, Nebraska, Colorado, North Dakota, and Ontario, Canada. In the 1994-96 nurseries, an NDSU navy bean breeding line, 88-106-04, had the lowest score of any adapted navy experimental line or cultivar when averaged over all test locations, indicating that progress is being made to minimize white mold damage. In the 1997 nursery, a navy line, ND 97-076-01, was one of the most resistant lines evaluated in North Dakota

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and Michigan. In 1998, very little white mold was observed due to the dry weather conditions that prevailed throughout flowering and seed fill. We have continued to evaluate materials for resistance to white mold and are collaborating in evaluating materials from the USDA Plant Germplasm collection for reaction to white mold. Several lines showed promising levels of resistance in the greenhouse. We need to verify our results and test the lines in the field. One problem with field evaluation, however, may be that the lines might be completely unadapted.

Rust

Rust has, at times, been a severe disease problem, particularly for pinto bean producers. This fungal pathogen is composed of many races (at least 80 in the United States and over 200 worldwide) and has the capability to increase in variability, since it can complete its entire life cycle on the bean plant. Resistance usually is controlled in a single gene fashion, whereby one gene in the plant imparts resistance to one specific race of the pathogen. Often, this type of vertical resistance is short-lived, because the selection pressure placed on the rust race forces a change in the rust population. As a result, a new rust race is developed, and the former resistant variety becomes susceptible. This was observed in the pinto variety Olathe which, when first grown in North Dakota, was completely resistant, but is now susceptible to at least one component of the rust population.

The dry bean breeding program currently is involved in determining the inheritance of broad-based rust resistance genes that were found in tropical germplasm. This resistance may be the result of one gene conferring resistance to more than one race, or a tight (linked) cluster of genes. By understanding the mechanism of inheritance, we will be better able to develop an efficient breeding strategy to utilize this new source of resistance.

The breeding program has cooperated extensively with USDA-ARS and other state scientists to incorporate high levels of rust resistance into the major bean market classes. To date, this collaborative relationship has resulted in the release of 14 rust resistant pinto lines and 12 navy lines. These lines provide unique sources of resistance to both public and private bean breeders. This year, approximately 90 lines were evaluated at the rust nursery site near Casselton to identify those lines with desirable agronomic traits.

Root rots

A nursery composed of 160 entries was evaluated in a root rot infested field near Perham, MN. Lines were evaluated for root health by digging five random plants from a row and recording the amount of root damage using a rating scale of 1 = no damage to 5 = severe damage. As expected, the susceptible cultivar Montcalm had the highest average rankings, while some lines, such as FR 266, Wisc. RRR-36, and G 122, continued to show little damage, in spite of severe conditions. We also were able to evaluate some populations derived from these resistant sources and Montcalm, and were pleased to see that the level of resistance was good to very good. In addition to the root rot evaluation nursery, F2 populations were grown in a nearby field where root rot infection was less severe, and root

Canning Quality Evaluation of Dry Edible Bean, 1998 Report

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Canning is the major method of processing dry beans for human consumption in the United States and other Western countries.

A great majority of the Northarvest bean was either used in the U.S. or shipped to the European countries. The factors influencing food quality differences among dry bean cultivars are not fully understood. Cultivar, production environment, harvesting methods, handling and storage conditions can affect canned bean quality

Studying food quality attributes in dry bean cultivars is important. Cultivars developed without considering food quality attributes may not meet the requirements of the canners and consumers. Ideally cultivars developed should give a high drained weight and good sensory quality after canning without undue breakage or clumping. Therefore, the objective of our study is to collaborate with Dr. Ken Grafton s breeding project in identifying genotypes with desirable yield, agronomic traits, good disease resistance and acceptable canning quality.

Methodology

Approximately 600 bean samples -- including navy, pinto, cranberry, and kidney beans -- from various test plots were obtained from Dr. Grafton. These beans were equilibrated to 16% moisture content in a humidity chamber prior to canning. The beans were soaked, blanched and packed in a brine solution in metal cans, which were retorted at 240 degrees F for 45 minutes, and cooled to room temperature. After storing for a period of at least two weeks, the cans were opened and beans scored for characteristics, including integrity of the beans, clumping and starchy nature of the liquid brine, drained weight and textural properties.

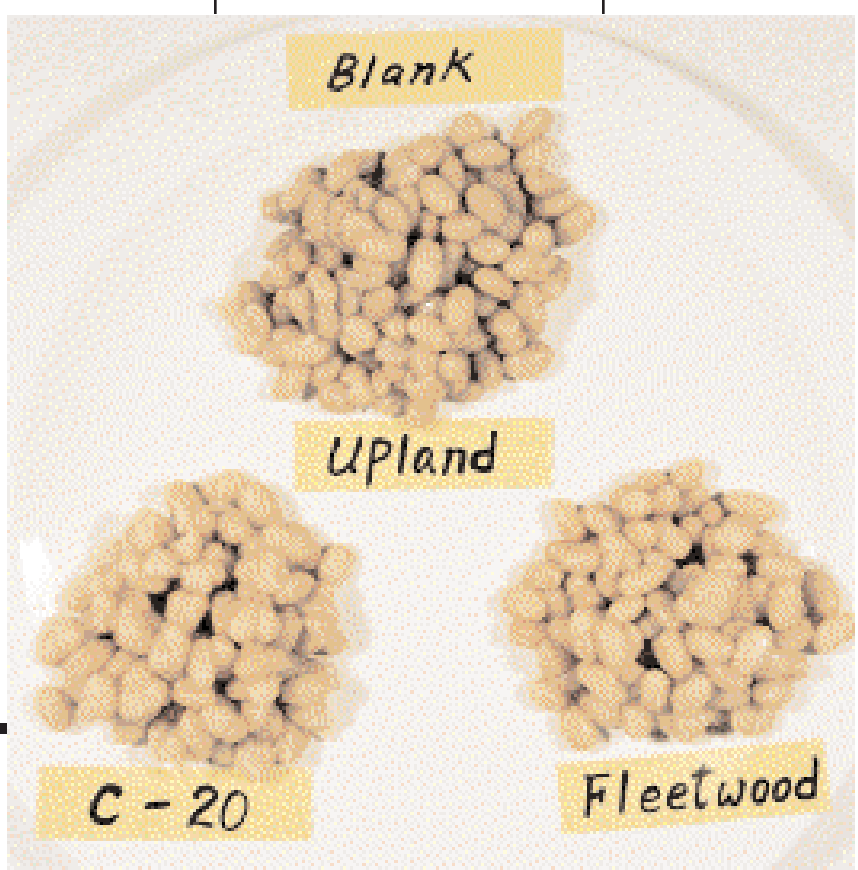
Results

Among navy bean preliminary yield trials, nine out of 17 lines from Hatton gave good canning quality attributes (little breakage, little clumping, low degree of starchiness), whereas none out of the 17 lines from Erie exhibited good canning quality attributes.

In navy advanced yield trials, 16 out of 30 lines from Hatton, 11 out of 28 lines from Erie and one out of 20 lines from Johnstown gave good canning attributes.

Among pinto bean preliminary yield trials, eight out of 17 lines from Erie and 10 from Hatton had good canning characteristics.

Location had an effect



The color and texture of beans after canning is part of the evaluation trials in NDSU s dry bean breeding program.

Molecular Markers Linked To CNC Rust Resistance Gene, 1998

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Bean rust is a serious disease in the Northarvest region. In a recent survey of the region s dry bean growers, rust was identified as the second most serious disease behind white mold. Rust reduces dry bean yield and quality by causing premature senescence of leaves and by directing nutrients away from the developing pod and toward the diseased leaf. Fungicides are registered for control of bean rust, but applications are expensive and reduce profit margins. The most economically-efficient and environmentally-friendly means to control rust is through genetic resistance.

The Central American black bean Compesto Negro Chimaltenango possesses a rust resistance gene, designated CNC, that is effective against all known races of bean rust in the Northarvest region. Further, CNC has not been widely used in breeding programs anywhere in the United States. Thus, CNC is an underutilized rust resistance gene that has great potential value to Northarvest producers. Our objective is to combine the CNC rust resistance gene with other resistance genes in future cultivars as a means to obtain durable rust resistance. Combining rust resistance genes into a common background is a difficult task. However, the process can be simplified by the use of molecular markers linked to the gene of interest, in this case, CNC. Molecular markers permit identification of progeny that possess the desired gene without the use of virulent rust races.

Last year, the Northarvest Bean Growers Association funded our proposal aimed at identifying molecular markers linked to the CNC rust resistance gene in dry edible beans. Progress to date includes the development of dry bean populations that segregate for CNC. These populations were developed from crosses of PI527310, a pinto bean with CNC, and the rust-susceptible pinto bean UI-114. Crosses were made and F2 and F3 populations were produced in greenhouses at North Dakota State University. These populations, composed of F3 families, are currently being

Dry Bean Weed Control & Herbicide Evaluations, 1998

Editor s note: Weed control research consisted of three separate projects:

* Evaluation of postemergence herbicides.
* Evaluation of dry bean variety tolerance to various herbicides applied preplant, preplant incoprorated or post-emergence.
* Evaluation of adjuvants with Pursuit and Raptor.

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Experiments were conducted, at NW-22 and Hatton, ND to evaluate dry bean tolerance from herbicides applied post emergence.

NW-22 – Portions of the study were affected by excessive rainfall and standing water. Unaffected areas in each plot were evaluated if available. Generally, small difference in dry bean response was observed between varieties with most treatments.

Dry bean response did not differ with adjuvant type used with Raptor applied alone, but injury usually increased as Raptor rate increased.

Addition of UAN to Raptor + NIS increased dry bean injury at the 2 and 3 fl oz/A rates of Raptor.

Addition of Basagran to Raptor at 4 fl oz/A + NIS tended to reduce dry bean injury as compared to Raptor + NIS applied alone.

Hatton -- FirstRate and Expert injured dry bean varieties tested and dry beans did not recover.

Pursuit at 4 oz/A with different classes of adjuvants did not injure dry beans.

Dry bean injury was less than 14% from Raptor at different rates and with different adjuvants. At the last rating, dry beans recovered from most treatments causing injury. Raptor with Scoil or Quad 7 did not cause greater injury than surfactant or surfactant + UAN fertilizer.

Variety Tolerance

Experiments were conducted at NW-22 and Hatton, ND to evaluate dry bean tolerance to herbicides applied PPI, PRE, and POST.

NW-22 -- Most of the study was affected by excessive rainfall and standing water.

Hatton --All soil applied herbicides gave unacceptable dry bean injury. Sonalan + Python severely injured dry bean varieties tested.

Dry beans showed little response to Sonalan + Authority early but injury increased over time.

Herbicides applied PRE caused less dry bean injury PPI. Norstar navy bean was injured more by soil-applied herbicides than other dry bean varieties tested. Pursuit applied after Sonalan + Python did not cause further injury to dry beans.

General environmental conditions were excellent during the growing season. Adequate rainfall occurred throughout the growing season and dry bean growth in untreated areas was lush.

No information can be given to explain the serious dry injury observed considering all herbicides, except FirstRate had been shown to be relatively safe in previous studies.

Adjuvant Use

Experiments were conducted in Casselton, ND to evaluate weed control from Pursuit and Raptor applied with different adjuvants.

Pursuit at 0.72 oz/A is registered for use on dry beans in North Dakota. Few differences in weed control were observed at the July 10 evaluation. However, at the July 21 evaluation, foxtail control ranged from 53 to 80% and common cocklebur control ranged from 43 to 82%.

Calcium in White Mold Management, 1998

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White mold, caused by the fungus Sclerotinia sclerotiorum, is still the most serious disease on dry beans in North Dakota and Minnesota. The Northarvest Grower survey for the 1997 crop indicated nearly 3/4ths of the growers had white mold, and over 60% of their acres were affected (Lamey and others, 1999).

The disease was not so serious in 1998, primarily because of less mid-season rainfall. In 1997, strip trials in growers fields, and replicated tests at experiment stations indicated that calcium sprays could reduce damage from white mold.

Attempts to repeat those field trials in 1998 with cooperating growers in Traill, Steele, and Griggs counties of North Dakota provided no new information, simply because white mold did not develop to any appreciable extent. In irrigated trials in 1998, white mold developed three weeks after fungicides and nutrients were applied, had a distinct bidirectional gradient, and did not reach serious proportions. Only plants sprayed with benomyl [Benlate] had significantly less disease and only plants sprayed with combined calcium sulfate and benomyl had significantly greater yield.

In six greenhouse trials, low rates of calcium (600 to 700 ppm) reduced bean blossom infections an average of 21%. High rates of calcium (2000 ppm) reduced infections 27% and fungicide (benomyl or thiophanate methyl [Topsin M] at 1.5 lb/A) reduced infections 46%. In laboratory tests, Sclerotinia was inoculated onto bean leaf disks that had been treated with calcium compounds, fungicide, or left untreated. Sclerotinia caused soft rot of the leaf tissue, and when the rotted tissues were immersed in water for 1 hour, cellular contents and other materials exuded into the water.

The amount of exudation was measured by conductivity, and conductivity was correlated with the area of decay measured by traditional methods. Only leaf disks treated with fungicide (thiophanate methyl) or with calcium sulfate (2000 ppm) had significantly less conductivity, and only the fungicide significantly reduced decay.

Both field and greenhouse observations indicated that some calcium formulations were not tenacious and removal of the calcium by irrigation/misting may have reduced their activity. So in a second laboratory study, a spreader-sticker was added to the fungicide and calcium treatments.

Again, the disks with fungicide or with calcium sulfate (2000 ppm) had significantly lower conductivity, and only the fungicide significantly reduced the area of decay.

In summary, calcium compounds can suppress white mold development in beans. In some conditions, folair-applied calcium may have substantial value in disease management. Additional studies are needed to understand the environmental and biological conditions that affect

Airborne ascospores of Sclerotinia sclerotiorum, 1998

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In dry bean, Sclerotinia sclerotiorum epidemics result almost exclusively from ascospore infections. Little is known about the aeroecology of ascospores. In field trials in Traill County, assays of airborne ascospores were made with 6-stage viable particle samplers onto a selective medium. The pattern of spore collection showed Sclerotinia-infested grain fields were sources of ascospores.

In field assays, 90% of the spores were deposited in stages 1 and 2 of the Andersen sampler, indicating that the spores had an aerodynamic size of >5 micro meters. Particles of this size have a settling rate of about 0.04 in./sec, and spores at 21 ft would have a settling time of about 2 hours; so in a 15 mph wind, spores could be transported 30 miles. The mean distance between dry bean fields in the county where these studies were made is less than 1.5 miles.

By implication, the distance between a source and a bean field would be less than 0.8 mile, and the time for spore transport would be 2.5 min.

Viability tests were made on microthreads. Individual Dacron polyester yarn strands were wound around steel frames, then loaded with spores in a specially designed chamber. Threads were examined microscopically. When spores were collected at 68 degrees F, 8% of the spores were in clumps of 2 to 4 spores. In contrast, collections at 50 degrees F yielded a single 2-spore clump and collections at 86 degrees F had no clumped spores. Clumped spores probably settle from the airstream quickly and are deposited near the source. Colony counts from plated threads were used to determine survival. At relative humidity of 88% to 98% at 72 degrees F, survival was inversely proportional to the relative humidity, but was less than survival of control spores held at 33% RH.

Viability of spores on microthreads exposed to the open air in sunlight declined as represented by the equation: % survival = 92.3*0.902^ time in hours, and half-life was approximately 6 hours.

When spores were exposed to open-air in the shade of a shelterbelt, the viability increased (% survival = 99.1*0.964 time in hours) and the half life was extended to 18 hours.

Considering that the

An enlargement of white mold fruiting bodies.

Dry Bean Grower Survey, 1998

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A survey of 1997 grower pest problems and pesticide use was conducted at the Northarvest Bean Day on January 23, 1998.

Dry bean growers reported that weather was the worst production problem on 46% of Minnesota respondents acres and 30% of North Dakota respondents acres.

The survey also revealed that 3% of Minnesota and 5% of North Dakota respondents acres were lost due to weather-related problems. The second worst production problem was disease, reported on 18% of Minnesota and 19% of North Dakota respondents acres. This contrasts to 1996 when disease was the worst production problem in both states.

Table 6. Worst disease problem[a] in 1997 in Minnesota and North Dakota.

Worst Disease Problem	Respondents[b] Number	Respondents[b] %	Acres Reported[c] Number	Acres Reported[c] %
Minnesota				
White mold	40	74.1	15,517	63.3
Root rot	6	11.1	2,526	10.3
Bacterial blight	2	3.7	1,330	5.4
Rust	2	3.7	770	3.1
None	4	7.4	1,194	4.9
North Dakota				
White mold	88	71.0	42,134	62.0
Rust	11	8.9	4,665	6.8
Bacterial blight	10	8.1	4,140	6.1
Root rot	5	4.0	2,780	4.1
Alternaria	1	0.8	400	0.6
None	9	7.3	4,850	7.1
Northarvest				
White mold	128	71.9	57,651	62.4
Bacterial blight	12	6.7	5,470	5.9
Rust	13	7.3	5,435	5.9
Root rot	11	6.2	5,306	5.7
Alternaria	1	0.6	400	0.4
None	13	7.3	6,044	6.5

[a] Ranked as No. 1 disease problem by respondents.

[b] Based on 54 responses from Minnesota and 124 responses from North Dakota.

[c] Respondents' acres only.

The white mold fungicides Benlate and Topsin M were used on 52% of Minnesota and 28% of North Dakota respondents acres, up slightly from 1996. These fungicides were broadcast-applied more commonly than band-applied, as was the case in 1996.

The worst weed in Minnesota in 1997 was redroot pigweed. It was the worst weed on 28% of Minnesota respondents acres, up substantially from 1996. Foxtail was the worst weed problem on 18% of Minnesota respondents acres and nightshade was the worst on 14%. The worst weed in North Dakota in 1997 was nightshade. It was the worst weed on 19% of North Dakota respondents acres, up substantially from 1996. Foxtail was the worst weed problem on 15% of North Dakota respondents acres.

Inter-row cultivation was used on 81% of Minnesota and 85% of North Dakota respondents acres. Rotary hoe was used on 33% of Minnesota and 20% of North Dakota respondents acres.

Bentazon (Basagran, others) was the most commonly used herbicide, applied on 52% of Minnesota and 48% of North Dakota respondents acres. Spring applied trifluralin was used on 30% of Minnesota and 28% of North Dakota respondents acres.

Spring applied Sonalan was used on 34% of North Dakota respondents acres.

Fall applied Sonalan was used on 26% of Minnesota and 19% of North Dakota respondents acres.

Pursuit was used on 26% of North Dakota respondents acres.

Assure II was used on 22% of Minnesota and 18% of North Dakota respondents acres.

Spring applied Eptam was used on 19% of Minnesota respondents acres and Lasso was used on 14%.

A desiccant was applied to dry beans on 33% of Minnesota and 25% of North Dakota respondents acres. The most commonly used desiccant was Gramoxone Extra, applied on 24% of Minnesota and 22% of North Dakota respondents acres.

Grasshoppers were the worst insect problem on 14% of Minnesota and 15% of North Dakota respondents acres.

Mineral Nutritional Problems With Dry Beans, 1998

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Zinc Deficiency in Beans

Zinc deficiency is the most common micronutrient deficiency likely to affect detrimentally dry edible bean production in our region. Factors which accentuate zinc deficiency in beans include calcareous soils, low available soil zinc, and high levels of soil nitrate and available phosphorus. Use of excess nitrogen fertilizer can also accentuate zinc deficiency in beans. Zinc deficiency causes leaf chlorosis, reduced vine growth, increased flower abortion, and delayed pod maturity in beans.

While zinc deficiency has been observed in pinto and kidney beans in this region, certain cultivars of navy bean are particularly susceptible to zinc deficiency. Plant breeders currently have no easy way to select for genetic resistance to zinc deficiency. We have observed that high seed-zinc concentration appears to be a characteristic of zinc-efficient navy bean cultivars. Part of our research in 1998 was to determine if seed-zinc concentration could be used to select for the zinc-efficiency trait.

Two zinc-efficient navy bean cultivars (Norstar and Voyager) and four suspected zinc-inefficient cultivars (Avanti, Albion, Huron and Seafarer) were grown in replicated experiments at two diverse field sites. Seed of Avanti, Albion and Huron was appreciably lower in zinc than was seed of Norstar and Voyager. However, seed of Seafarer, an old cultivar which is now rarely grown, was not low in seed zinc. We are currently checking whether the Seafarer seed used in 1998 was true-to-type.

Marsh Spot of Cranberry Bean

Cranberry bean is primarily grown for export, and production of high quality seed is essential for this crop to be economically viable in North Dakota and Minnesota. A discoloration and necrosis of cotyledons in some cranberry seed grown in the region have been observed. Although all varieties show the abnormality under some conditions, the severity of this non-pathogenic problem, called marsh spot , is variety dependent. The problem is so-named because of its resemblance to marsh spot in peas, a disease known to be caused by manganese deficiency in the seed cotyledons.

We were able to grow Cardinal cranberry bean in the greenhouse and field in 1998, and harvest seed with the marsh spot symptoms. Our initial research indicates that manganese deficiency is not the cause of the problem. Also, we have identified a genotype that is resistant to the abnormality. The problem will be studied in detail in 1999.

Iron-Deficiency Chlorosis in Beans

Iron-deficiency chlorosis is a major production problem affecting bean-seed yields under irrigation in the Great Plains. Two kidney bean cultivars (RedKloud and Sacramento) and one great northern bean (Beryl) are reported to be very susceptible to iron-deficiency in Nebraska. We grew these varieties, two navy bean cultivars (Norstar and Voyager) and one pinto bean cultivar (Othello) at

Below: Avanti growing on a soil high in available zinc had retarded stem grown.

Below left: Avanti growing on the same soil with added zinc. (Note increased stem growth.)

Control of Kidney Bean Root Rot in Minnesota, 1998

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Kidney bean root rot is a serious concern for Minnesota farmers, particularly when wet and cold conditions persist during the first stages of plant development. For three consecutive years our research project has studied this problem by examining kidney bean plots grown in Park Rapids, Perham and Staples, Minn. Three fungi -- Fusarium oxysporum f. sp phaseoli, Fusarium solani f. sp. phaseoli and Rhizoctonia solani -- were commonly found in infested fields in this region.

F. solani isolates collected from these fields account for the highest disease severity observed in artificially inoculated Montcalm beans.

R. solani always occurs in infested fields. The AG-4 group identified in the study areas produce significant damage in cultivars Montcalm, Diacol Calima, Rogers 312 and Bill-Z.

F. oxysporum is the most prevalent isolate and it produces mild infections.

The combination of the three pathogens considerably increases disease severity and can produce plant death.

This disease complex has received limited attention compared to foliar diseases. It is widespread and, under stress conditions, can significantly reduce bean yields.

Fusarium solani is the primary pathogen involved in bean root rot in the Perham, Staples and Park Rapids areas. These organisms are important in areas of intensive bean cropping. Continuous rotation of beans increases root rot, as observed Staples. Growing potatoes in a rotation with beans may contribute to the increase of R. solani as observed in 2 fields. Crop rotation influences root rot incidence and severity and probably determines the pathogen succession and patterns of interaction between the soilborne pathogens.

Control of bean root rot using two antagonistic microbes, Bacillus subtilis (Kodiak) and Thrichoderma harzianum (T-22) seed treatment, was successful in infested pasteurized soil, resulting in an increase of plant growth and a decrease in disease severity (DS). In a highly infested field soil at Staples, most seed treatments, when used with the antagonists, decreased DS and increased yield compared to plants grown from untreated seed. Plant yields from seed treated with Kodiak and Captan + Kodiak outperformed all other treatments (Fig. 1). Kodiak suppressed disease and increased yield when compared to the untreated control. Its performance was consistent at both Staples and Verndale. This suggests that Kodiak has the potential for protection against bean root rot.

Rhizobium tropici strain UMR 1899 also showed to benefit plant growth and yield. T-22 alone, or in combination with Vitavax also had a positive influence on yield compared to the untreated control. In 1998 at Verndale, the DS decreased and plant dry weight increased when Montcalm seed was treated with Vitavax + Kodiak and Captan + Kodiak; Vitavax + Kodiak or Kodiak alone (Figure. 2). Untreated plants developed slowly and matured earlier than healthy plants. Kodiak and Captan + Kodiak maintained a healthy taproot.

R. solani AG-4 was highly virulent to bean cultivars Montcalm, Imbabello and Sanilac, and moderately virulent to alfalfa, canola, soybean, red clover, sugarbeet, peas and infected common lambsquarter and quackgrass.

F. oxysporum from kidney beans infected the three bean cultivars tested and produced symptomatic infection on alfalfa, canola and peas. Asymptomatic infection was found on corn, wheat and the weeds (common lambsquarter yellow, and green foxtail,quackgrass, wild mustard and ragweed).

F. solani was only found to infect beans and soybeans. Sunflower, rye, oats and buckwheat were not infected by any of the pathogens. This suggests that rotations with these crops may be beneficial in lowering root rot in subsequent bean crops. However, sunflowers should be avoided because of white mold potential. More research is needed to determine the importance of these crops in maintaining or increasing the pathogen population in the soil. Infection of weeds may increase and maintain the pathogen during the growing season.

Breeding lines

At Staples, 164 NDSU F3 lines that Dr. Ken Grafton obtained from crosses between Montcalm and G-122 were evaluated and selected for resistance to root rot. A high proportion of the F3 lines evaluated showed susceptibility to root rot. Twenty seven of the 164 breeding lines showed tolerance to root rot (lower DS average 3) compared to the commercial susceptible variety Montcalm.

During the second evaluation 19 additional lines were outstanding and were selected for tolerance to root rot. These selections will be further screened in different sites and selected for generating new cultivars.

In Staples, application of Kodiak to the seed of four advanced lines showed decreased DS. Of the four lines evaluated, 92-198-02 expressed the least root rot. All lines when treated with Kodiak showed a decrease in DS. These results indicate that yields of cultivars or lines with some resistance to bean root rot can be improved with the application of an effective biocontrol.

Pathogen survival studies

In Staples a refuge of potato, sunflower, bean, canola, pea and soybean is being studied to determine the winter survival of the pathogens. In this study

Fig. 1 -- Effect of two biocontrol agents and seed protectants on bean yields -- 1997

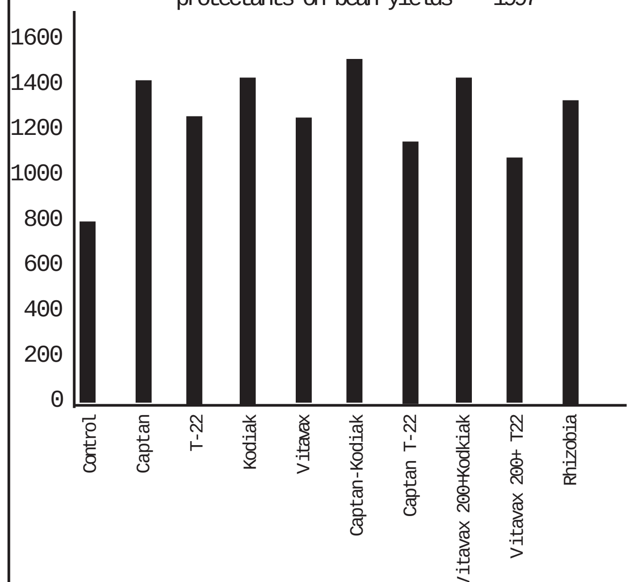
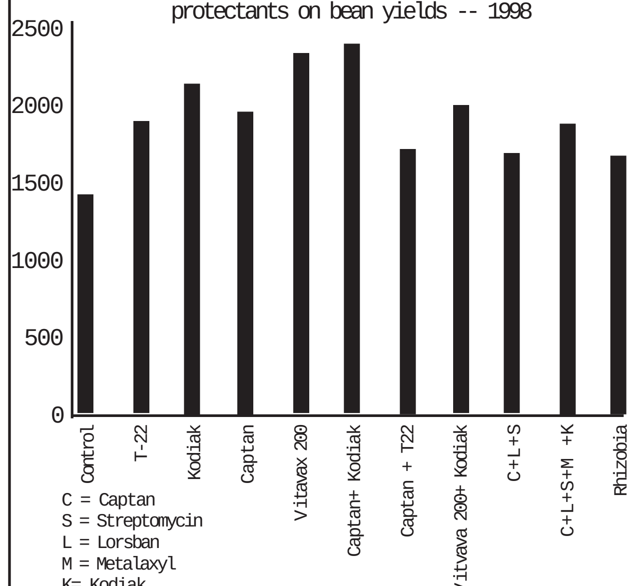


Fig. 2 Effect of two biocontrol agents and seed protectants on bean yields -- 1998



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