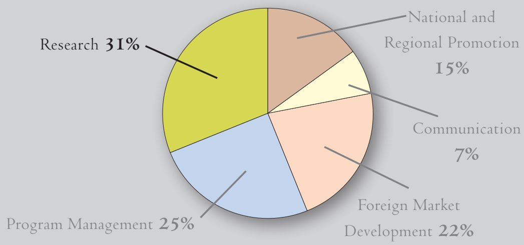
2004 Dry Bean Research Update

2004-2005 Budget by Category



Dry Bean Research

North Dakota and Minnesota dry bean growers who volunteer their time to serve on the Northarvest Bean Growers Association board, the North Dakota Dry Bean Council and the Minnesota Dry Bean Council have decided to target dry bean checkoff funds where they believe there is the greatest opportunity for the greatest return for the greatest number of dry beans growers.

They devoted the largest portion of the 2004 budget – 31% – to research.

In the pages that follow is a progress report on these projects.

Jim Percich

Effects of Nitrogen Fertilization and the Liming of Acid Soils on Kidney Bean Root Rot Severity and Yield in Minnesota.

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Objectives

1. Determine the effect of tillage and liming on Kidney bean root rot.
2. Determine the impact of nitrogen fertilizer and *Bacillus*/*Rhizobium* seed inoculation on root rot.

Research method

To meet the first objective, the experiment evaluated the interaction between tillage, sub-soiling (14-16 inches) and reduced tillage (6 inches), agricultural lime, applied at 0 or 4 tons/A (increased pH to 6.5), and seed inoculation with *B. subtilis* and *R. tropici*. Each treatment was 40 x 1000 ft., irrigated, and replicated six times on two farms having an average soil pH of 5.4. No nitrogen was applied.

To meet the second objective, nitrogen was applied as ammonium nitrate at different rates: 0, 30 lb/A (sowing or at pre-bloom), 30 lb/A (sowing) plus 30 lb/A (pre-bloom), and at 30 lb/A (sowing) and 60 lb/A pre-bloom). The nitrogen treatments were compared to seed inoculated with *Rhizobium tropici* +*Bacillus* *subtilis*, Maxim/Apron + Lorsban, and untreated seed. All treatments, except the seed treated with *R. tropici* + *B. subtilis* and the untreated seed contained Maxim/Apron + Lorsban.

Results

Sub-soiling vs. reduced tillage resulted in average yield increase of 29 and 10% at site 1 and 2, respectively. Site 1 was more severely compacted than site 2. (Figure1)

The use of lime and treated seed compared to no lime plus treated seed resulted in yield increases of 14% and 11% at site 1 and 2, respectively.

Sub-soiling, liming, and treated seed together resulted in increases in *Rhizobium* nodulation, root development, and yield at both sites (Fig 2).

However, the only significant effect at either site was deep tillage in increasing yield. Liming and biological seed treatment, with or without deep tillage resulted in no significant yield increases.

Seed treated with *B. subtilis* + *R. tropici* in two different soils (pH 5.4 and pH 6.7), and highly infested with the root rot pathogens, and not fertilized with nitrogen, resulted in yields that did not significantly differ from any of the nitrogen treatments.

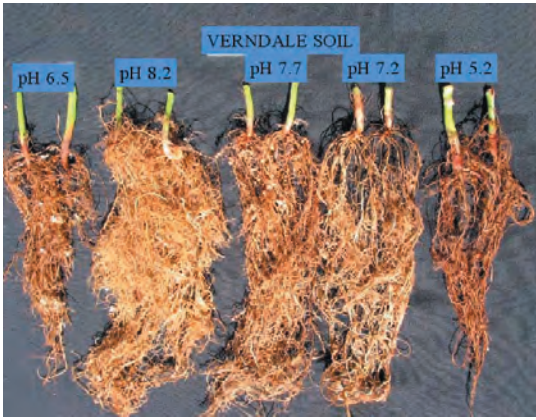
Specifically, when nitrogen was applied as ammonium nitrate at the highest fertilization rates, 30 lb/A at sowing, then followed by an additional 30 or 60 lb/A at pre-bloom, there were no significant yield increases when compared to seed treated with *B. subtilis* and *Rhizobium* alone without nitrogen.

White mold was observed to be more severe in the nitrogen treatments in 2004.

Nitrogen costs are considered by many growers to be an expensive input. Also, ground and surface water nitrate contamination is a serious concern on irrigated sandy soils.

We recommend that after an additional large-scale nitrogen rate evaluation trial in 2005 the nitrogen fertilizer recommendations in the “Dry Bean Production Guide” be revised to reflect the effects of nitrogen fertilization on *Rhizobium* inoculants, diseases and yield.

Comparing deep and shallow tillage on root growth and development. Left, deep tillage; center, shallow tillage; and right, no tillage (Site 1).



The combined use of deep tillage, biological seed treatment, and liming on root growth and development, nodulation, and root rot severity.

Current members of the Northarvest Bean Growers Association's research committee are:

Mark Myrdal, Edinburg, N.D.
Gary Paur, Gilby, N.D.
Gary Friskop. Wahpeton, N.D.
Kevin Anderson, East Grand Forks, Minn.
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Jim Sletten, Northwood, N.D.
Paul Schulz, Washburn, N.D.
Mike Beltz, Hillsboro, N.D.
Brian Love, Euclid, Minn.
Mike Beelner, Park Rapids, Minn.
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Dry bean improvement for the Northern Plains

Principal Investigator
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NDSU

Greenhouse lights simulate summer sunshine through winter to grow another generation in the plant breeding programs.

Objective

Develop high yielding, high quality bean genotypes adapted to the northern Great Plains.

Methods

Breeding and disease nurseries, and yield trials were grown at nine locations in North Dakota and Minnesota [Prosper, Hatton (2), Forest River, Johnstown, Fargo, Carrington, Perham, and Park Rapids] in 2004. A white mold nursery was conducted at Carrington, which also had advanced yield trials and preliminary yield trials for pinto, navy, black, great northern, and pinks and reds. Two sites near Hatton were utilized, one for the variety trial and the other for the breeding nursery. Sites at Perham and Park Rapids were to test 774 lines for root rot resistance.

Pinto (P), navy (N), and miscellaneous (M) bean class variety trials were grown near Prosper (P, N, & M), Hatton (P, N, & M), Forest River (P & N) and Oakes (P & N); Preliminary and advanced yield tests were grown at Prosper, Hatton, Johnstown, and Park Rapids.

Flor de Mayo and Flor de Junio beans (two preferred bean classes in Mexico) and Central American reds (preferred in many countries in Central America as well as by immigrants from these countries in the U.S.) were grown in the field near Hatton as part of a program to identify new dry bean classes that may be adapted the northern Great Plains.

Results

In 2004, the NDSU breeding program:

- Released the black bean line ND9902621-2 with the name ‘Eclipse’. Eclipse has excellent yield potential across a wide range of environments, combined with good disease resistance, erect growth habit, and excellent drydown. In North Dakota environments, Eclipse consistently outperforms T-39 black bean and is uniform for plant structure and maturity. Seed is similar in all respects to T-39, but Eclipse has slightly better canning quality, based on tests performed by the USDA-ARS bean quality lab in East Lansing, MI.
- Jointly released germplasm derived from an NDSU navy bean breeding line, ND88-106-04, which consistently scored well in reduced white mold damage when evaluated in field conditions.
- Tested 78 pinto, 67 navy, 39 black and 22 great

Long-term Effort

"The dry bean breeding program at North Dakota State University is a long-term research effort to develop high yielding, high quality bean genotypes adapted to the northern Great Plains. Activities and procedures remain relatively similar from year to year, providing consistency in development and evaluation of material that is suited to the production systems and environment of the Northarvest production region. Hybridizations are made between parents possessing desirable traits during the winter of each year. Our first priority remains pinto improvement, and more than 40 percent of all crosses made are to improve this market class. The remaining crosses involve the navy, black, dark and light red kidney, small red, great northern and pink market classes. 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, anthracnose, virus, and bacterial blights. Off-season nurseries are used to speed the breeding process and provide initial seed increases of lines that may be considered for release." *– Ken Grafton*

Ken Grafton plants bean seeds in the pots for a greenhouse evaluation.

northern and red bean lines in advanced yield trials.

- Harvested approximately 800 plots for the variety trials alone (20 pinto entries, 23 navy, 23 miscellaneous and 13 kidney entries).
- Harvested 2,472 test plots of preliminary and advanced yield trials.
- Harvested other yield trials that increase anthracnose resistant material (54 entries) and Flor de Mayo trials (12 entries).
- Made and harvested more than 7,000 single plant selections from breeding trials, plant nurseries and other sites.

Thousands of plants were evaluated in the field this year.

New Market Class Initiative

A new initiative has been started in the dry bean program to help growers diversify into other market classes, thereby increasing the possibility of further exports. As indicated, breeding programs for dark and light red kidney, pink, small red, black, and great northern bean market classes also are underway. Pink, small red, and great northern market classes are closely related to pinto bean, while black is similar to navy bean; materials used to improve the two major market classes may also be used to improve these other, minor classes. In addition to these market classes, we also have a small effort placed on developing Flor de Mayo and Flor de Junio beans (two preferred bean classes in Mexico) and Central American reds (preferred in many countries in Central America as well as by immigrants from these countries in the U.S.). The first lines from this program were evaluated in the field near Hatton, ND for adaptation and yield in 2004. – Ken Grafton.

Field Evaluations of Four Dry Bean Populations For White Mold Resistance

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Objective

Identify white mold resistance in four new dry bean populations.

Benefits to North Dakota and Minnesota dry bean producers

White mold is a persistent and economically damaging disease of dry beans in the Northarvest production area. Disease susceptibility is common in accepted cultivars, so the potential for serious economic damage in the future is high. Genetic resistance is the most efficient way to control any disease. The objective of this research is to identify new sources of genetic resistance to white mold in dry bean and to move that resistance into germplasm adapted to the Northarvest region that can be used by the breeding program for future cultivar development.

Research methods

This project was initiated with greenhouse experiments that identified dry bean lines from Mexico, Central America and South America with potentially new and useable white mold resistance. These dry bean lines, collected, maintained, and obtained from the USDA, are genetically different from our varieties. Collectively, they may contain valuable sources of genetic resistance for the Northarvest production area. Included in this genetic variability may be new sources of resistance to white mold. Four of the best lines identified from these screens were crossed with Othello, a disease-susceptible Pinto bean cultivar adapted to this region.

> ***White mold is a persistent and economically damaging disease of dry beans in the Northarvest production area.***

A population of approximately 100 to 125 lines was developed in the greenhouse from each of the four lines by crossing them to Othello pinto bean. Each population was advanced to the F6 generation. F6 lines are genetically stable, like a cultivar. This stability will permit the increase of large amounts of seed of each population that can be used in multiple replicated tests in the field and greenhouse as we screen the populations for resistance to white mold. Also, since they are genetically stable, F6 lines that show promise for white mold resistance can be expected to contribute genetic resistance to the breeding program in a predictable fashion.

To our surprise, CNC/Othello progeny exhibited a high level of white mold resistance in addition to rust resistance.

Each line from each cross (nearly 500 lines in total) were evaluated in the greenhouse for white mold resistance. Last summer, the best 20 to 30 lines from each population, as determined by the greenhouse tests, were evaluated in the field for reaction to white mold. The field trials were performed at Carrington, ND in inoculated plots that were misted. Disease pressure was extremely high in these plots.

A fifth population was evaluated for resistance to white mold in the greenhouse. This population had the dry bean line CNC as a parent. CNC, a black bean from Central America, was originally of interest to us because it is resistant to all North American races of bean rust. We had previously crossed CNC to the Othello (because it is also rust susceptible) and developed the progeny into 100 F6 lines to analyze rust resistance in CNC

Results

Several lines developed from the crossing South American lines with Othello showed good levels of resistance in replicated plots and may be of value for breeding purposes. Additional experiments are needed to confirm this.

To our surprise, CNC/Othello progeny exhibited a high level of white mold resistance in addition to rust resistance. This resistance segregated in the population, as determined by greenhouse tests. We are now in the process of identifying individual lines from the CNC/Othello population that may have novel white mold resistance and novel rust resistance for the breeding program.

Weed Control in Dry Beans

Principal investigator
Richard Zollinger
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NDSU

Research Goals

Conduct research that will help answer dry bean growers question pertaining to weed control and herbicide use issues and problems.

Objectives

1. Evaluate weed control and dry bean tolerance to Sandea (halosulfuron).
2. Evaluate dry bean tolerance to Spartan (sulfentrazone).
3. Evaluate adjuvant enhancement of Valor (flumioxazin) for dry bean desiccation.

Benefits to ND/MN dry bean growers

Sandea will registered on dry bean soon. A data base of weed control and dry bean safety will help growers determine if this tool can be used in their weed control efforts.

There is concern that Spartan may injure dry beans in certain soil conditions, like high pH. Subjecting several dry bean types to varying rates of Spartan in high pH soils across the state will help determine the risk of injury.

Valor will be registered as dry bean desiccant within a couple of years. Valor responds to adjuvants. Adjuvant research will help determine those products that will enhance Valor the greatest.

Results

Sandea effectiveness

Sandea is a preemergence and postemergence herbicide that controls many large-seeded broadleaf weeds, like wild mustard, common cocklebur, common ragweed, and marshelder, but is weak on redroot pigweed, common lambquarters. Applying Sandea with a soil applied grass herbicide like Outlook, Dual Magnum or with Spartan can provide near complete broadleaf weed control. Sandea has no grass activity.

Dry bean tolerance to Spartan

Experiments were conducted to evaluate the tolerance of six dry bean types to Spartan. 'T-39' Black bean, 'IU465' Great Northern bean, 'Vista' Navy bean, '312' Pink bean, 'Maverick' Pinto bean, and 'Garnett' Small Red bean were seeded in 2004 to soils with a pH between 7.8 to 8.3, and organic matter between 2.5 and 5.5%.

Sandea is a preemergence and postemergence herbicide that controls many large-seeded broadleaf weeds... but is weak on redroot pigweed, common lambquarters.

Spartan was applied at rates from 2 to 8 oz/A immediately after seeding. At Buffalo, Thompson, and Oakes, N.D., none of the bean types exhibited significant injury symptoms from rates of 4 oz/

A or less. Treatment rates from 5.33 oz/A and 8 oz/A treatments caused slight to moderate injury symptoms early in the growing season, but symptoms declined as the season progressed. Primary injury symptoms included stunted growth, wrinkling of leaf tissue, necrotic leaf spotting, chlorosis, and veinal discoloration. In this experiment, injury appeared to be correlated most strongly to Spartan rate than any other factor. Injury increased as Spartan rate increased.

Spartan injury appears to be more strongly correlated to soil pH than any other factor. Spartan injury was more severe in high pH plots than low pH plots.

At Minot, visible injury symptoms were most observed on Black and Navy. Primary injury symptoms included stunted growth, slow emergence, leaf wrinkling, chlorosis, and necrotic leaf spotting. Spartan injury was most severe in the Navy bean type, as significant injury occurred at all treatment rates. Order of susceptibility from most to least tolerant is Navy bean, Pink, Black, Small Red, Pinto, and Great Northern. Spartan injury appears to be more strongly correlated to soil pH than any other factor. Spartan injury was more severe in high pH plots than low pH plots. Spartan injury increased as soil pH increased because the Spartan was more soluble in the soil solution. Additionally, Spartan injury decreased as soil organic matter increased because the herbicide was adsorbed to the organic matter.

Valor

Valor has shown activity as a dry bean desiccant and enhancement from primarily oil based adjuvants. Methylated seed oil (MSO) and MSO & Basic Blend (BB) adjuvants with Valor gave the greatest and most rapid dry bean desiccation. Superb HC (high emulsifier concentration petroleum oil), which is used at half the rate of most petroleum oil adjuvants plus InterLock (deposition aid + drift retardant), also gave high and rapid bean desiccation. Organosilicone surfactants that reduce surface tension of spray droplets to increase canopy penetration did not improve desiccation. These data support previous research, which indicated oil adjuvants improve dry bean desiccation with Valor.

3 days after treatment

Dry Bean Response to Nitrogen Fertilizer

Principal investigator

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NDSU Carrington Research and Extension Center

Objectives

1. Determine the optimum level of nitrogen fertilizer for dry bean yield and quality.
2. Compare dry bean performance with N fertilizer to that with inoculant.
3. Evaluate the effect of split N application.
4. Study the response to N management strategies in contrasting plant types.
5. Disseminate the results to appropriate user groups.

Benefits to North Dakota and Minnesota dry bean growers

The results of this project will assist growers, crop consultants, extension personnel and researchers in determining the most effective and economically viable strategy for managing N in dry bean to achieve high yields and quality.

Description of research

Field trials were conducted at the NDSU Carrington and North Central (Minot) Research Extension Centers to evaluate nitrogen (N) management of dry bean. Seven levels of N were evaluated without inoculation with *Rhizobium*, as well as a comparison with and without inoculation at the lower N levels and an evaluation of the response to split applications of N (pre-plant and side-dressed prior to flowering). Soil test data (0-24") indicated 15 lbs NO_3^--N in Carrington and 51 lbs in Minot. Urea (Carrington) or ammonium nitrate (Minot) was broadcast to the desired levels of total N and incorporated in the 10' x 22-25' plots prior to planting on 14 June in Carrington and 28 May in Minot. Plots consisted of four 30" rows and were arranged in a randomized complete block design with 4 replicates. Cultivar 'Maverick' (pinto) was evaluated at both sites. At Carrington, cultivar 'Vista' (navy) was also included and a split-plot arrangement was used with cultivar as the main plot factor and N treatment as the subplot factor. Weeds were controlled with herbicide, cultivation, and hand rouging. Significant insect and

Table 3. Dry bean response to N treatments, NDSU Minot, 2004.

Treatment (lbs total N /	Days to Flower	Height	Vigor	Plant Stand	Vine Length	Pods	Seed Damage	Plant Weight	Seed Weight	Test Weight	Yield 2004
	DAP[1]	inches	0-9[2]	PFR[3]	cm	#	%	grams	g/1000	lb/bu	lb/A
Control (no fert, no inoc.)	52	15	7.3	7.6	39	151	1.3	297.3	356.7	60.4	1803
50 lbs N (soil test+fert) /a	53	14	7.8	8.0	34	150	1.5	283.2	379.4	60.8	1810
75 lb N/a	52	16	8.8	7.4	40	136	1.3	259.5	366.9	60.2	1987
100 lb N/a	52	15	9.0	9.4	38	151	1.8	288.0	365.0	59.9	1914
125 lb N/a	53	17	9.0	8.0	43	130	1.8	229.2	364.4	60.3	1948
150 lb N/a	53	16	9.0	9.1	40	163	2.0	304.5	369.4	60.2	1976
200 lb N/a	53	16	9.0	7.3	41	159	1.8	310.2	363.7	60.5	2022
Inoculant (No Fert)	52	16	7.5	7.5	40	143	1.5	253.8	375.1	60.4	1969
50 lb N/a + Inoculant	52	18	7.8	9.3	45	158	1.8	286.5	370.7	60.7	1891
100 lb N/a + Inoculant	52	15	8.8	8.8	39	147	1.3	262.0	356.1	59.9	1960
50 lb N PPI + 50 lb Post	52	16	8.8	8.3	40	138	1.5	260.3	355.9	60.0	2053
Mean	52	16	8.4	8.3	40	148	1.6	275.8	365.74	60.3	1939
C.V.%	1.4	9.4	5.6	15.7	9.4	13.7	36.1	15.2	1.9	0.7	8.3
LSD 5%	NS	NS	0.7	NS	NS	NS	NS	NS	NS	NS	NS

[1]Days after planting
[2]0 = very low vigor, 9 = very high vigor
[3]Plants / linear foot of row

disease pressure was not observed at either site. Slight hail damage occurred on 6 June and 25 August in Minot and a light frost on 20 August at both sites.

Outcomes and findings

The 2004 growing season was exceptionally cool. Maverick reached physiological maturity at both sites, while Vista was killed by frost before achieving maximum yield. However, no significant cultivar x N treatment interactions were observed in Carrington and the navy bean data is included as recorded.

In Carrington, the yield of Maverick was superior to that of Vista (Table 1). The failure of Vista to reach physiological maturity before frost was undoubtedly a key factor in this difference. Across cultivars, yield peaked at 100 lbs total N / acre and all treatments with less than 75 lbs total N / acre yielded significantly less than the 100-lb treatment. Across cultivars and inoculation treatments, incremental yield increases were observed as total N increased from 15 to 50 to 75 lbs / acre (Table 2). Inoculation resulted in slight yield decreases at all 3 N levels tested. Side-dressing N treatments showed no advantage over applying 100 lbs pre-plant.

In Minot, no statistically significant ($P < 0.05$) yield differences were observed (Table 3). However, 75 lbs total N / acre or higher tended to increase yield over the lowest N treatments. Yield was numerically highest with 200 lbs PPI and the split application. Inoculation resulted in a slight yield increase at each N level tested.

Summary

The 2004 results of this trial are inconclusive. The current recommendation of 100 lbs total N / acre for a 2000-lb yield goal seems appropriate. However, yields at both sites may have been reduced by environmental stresses (cool weather, frost, hail), which may have prevented better expression of treatments. The consistent slight response to inoculation at Minot is interesting, since this field did not have a previous history of dry bean production, whereas the Carrington site did. The lack of cultivar x N treatment interaction at Carrington is encouraging, in that it suggests that the results of this research may apply to a broader range of cultivars and market classes.

Table 1. Dry bean response to soil nitrogen level, NDSU Carrington, 2004.

Treatment	Yield	Test Weight	Seed Weight
	(lbs/acre)	(lbs/bushel)	(g/250)
Variety			
Maverick	1851	59.4	75.7
Vista	1458	60.9	37.1
P-value	0.0571	0.0013	<0.0001
N Treatment (lbs total N / acre)			
N15	1480	60.4	56.1
N50	1642	60.2	55.7
N75	1736	60.2	55.7
N100	1839	60.1	56.5
N125	1703	60.1	55.8
N150	1743	60.0	56.3
N200	1663	60.3	58.3
N15-In	1455	60.3	55.5
N50-In	1546	60.1	55.8
N75-In	1610	60.1	58.1
N50-In+50	1618	60.0	56.2
N100-In+50	1815	60.0	56.6
P-value	0.0007	0.3811	0.4577
LSD (0.05)	184	NS	NS
LSD (0.01)	245	NS	NS
Mean	1654	60.1	56.4
C.V. (%)	11.1	0.6	4.6

Table 2. Main effects of the lowest 3 N rates with and without inoculation, NSDU Carrington, 2004..

Treatment	Yield	Test Weight	Seed Weight
	(lbs/ac)	(lbs/bu)	(g/250)
N Level (lbs total N/acre)			
15	1468	60.3	55.8
50	1594	60.2	55.7
75	1673	60.2	56.9
P-value	0.0036	0.2993	0.3059
LSD (0.05)	115	NS	NS
LSD (0.01)	155	NS	NS
Inoculation			
- Inoculant	1619	60.3	55.8

Studies to Minimize Seed Coat Color Darkening in Pinto Beans

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Research Goals

Evaluate factors affecting the seed coat color of pinto beans in a second year study.

Objectives

1. Determine the effect of the harvest date on seed coat color.
2. Determine the effect of nitrogen fertilization on seed coat color.
3. Determine the effect of the relative humidity on seed coat color in a controlled environment.

Benefits to North Dakota and Minnesota Bean Growers

Seed coat color is an important trait in pinto beans. Consumers prefer pinto cultivars with bright and shiny mottle colored seed coat. Dark seed coat on pinto beans results in lost of market value. The results obtained in these studies will give the growers additional management practices to reduce the darkening of pinto bean seed coat.

Research methods

Effects of harvest date: Twenty varieties of pinto beans (Apache, Aztec, Bill-Z, Burke, Buster, Chase, Elizabeth, Fargo, Focus, GTS-900, Kodiak, Maverick, Montrose, Othello, Rally, Remington, Topaz, UI114, UI320, and Winchester) were planted at two locations in ND: Prosper on June 4 and Fargo on June 10. Fargo location was lost due to excessive rainfall. Prosper was harvested at four different dates Sept. 17, Oct. 1, 15, and 29. Seed color was evaluated for each sample using an Agtron Color Quality Meter (calibration: black = 0, white = 90).

Effect of Nitrogen fertilization: Three pinto bean varieties (Maverick, Montrose, and Othello), were planted at Hatton, ND on June 5th. Four rates of nitrogen were used (0, 35, 70, and 105 lb/a) to determine the effect of nitrogen fertilization on the seed coat color of pinto beans. The full rate of nitrogen was applied on July 12th at V4 stage. The experiment was harvested on October 11th (four months after planting). Seed color was evaluated using an Agtron

Color Quality Meter.

Effect of Relative Humidity (Growth Chamber): Ten varieties of pinto beans (Bill-Z, Buster, Chase, GTS900, Maverick, Montrose, Othello, Remington, UI114, and Winchester) were used to evaluate the effect of relative humidity. Plants were grown in a growth chamber at relative humidities (RH) of 45, 75, and 85% at 25 °C, with a regime of 12 hours of light and 12 hours of dark.

Results

Effects of harvesting date: Results from 2004 growing season at Prosper, ND show that harvest dates significantly affect seed coat color on pinto beans (Chart 1). Significant differences were observed among varieties. UI-320 and Winchester presented the darkest color on Sept. 17 and Oct. 29 respectively, Montrose presented the lightest color across all harvest dates. The higher the score the lighter the color of the seed coat.

In general late harvest had a negative effect on seed coat color across all varieties. Beans harvested on the first harvest date (Sept 17) had the lightest (higher score) color. Beans harvested on the last harvest date (Oct 29) had the darkest (lower score) color. On average, color score was reduced 6 points between the first and the last harvest date. The data obtained in 2004 season agree with the results from 2003 study.

This year differences among varieties were not consistent with the data obtained in 2003 growing seasons, with the exception of Montrose (Fig. 1), which showed an acceptable seed coat color at the last harvest date in both seasons. For instance, the variety Winchester, the best from 2003 data, resulted to be one of the darkest varieties this growing season (Fig. 2). The variety Kodiak which scored as the darkest seed coat color last year is in the middle range in seed coat color this season. As a general recommendation pinto beans should be harvested as early as possible, since the longest the beans are in the field exposed to the environment the darker the color of the seed coat.

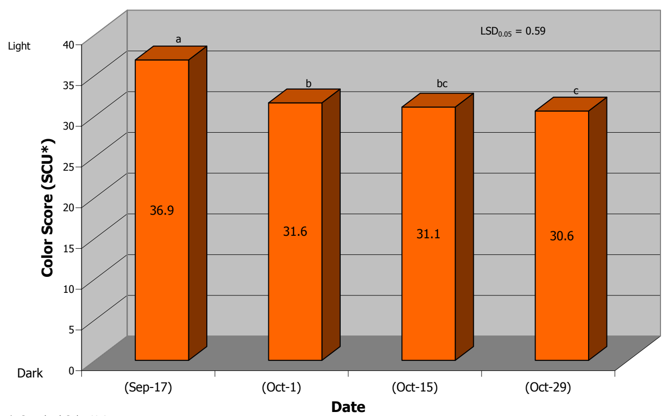
Effect Nitrogen fertilization: Results in this study shown that nitrogen fertilization did not affect seed coat color at any rate. Similar results were observed in 2003 where no differences were found.

Fig. 1: Seed color samples of Montrose of four harvest dates from Prosper, ND 2004

Fig. 2: Seed color samples of Winchester of four harvest dates from Prosper, ND 2004

Effect of Relative Humidity (Growth Chamber): Relative humidity had a significant effect on seed coat color of pinto beans. Significant differences were found among varieties and relative humidities. Variety GTS-900 had the lower color score (darker color) and was the only one significantly different from all the rest. In general, seed gown under the 85% relative humidity treatment had the darkest color and was significantly different from the 45% relative humidity treatment, which had the lighter color.

Chart 1. Effect of Harvest Date on Seed Coat Color, Prosper ND 2004



* Standard Color Unit

High-Selenium Pinto Beans as a Value-Added Product

Principal investigator
John Finley, Ph.D.
Research Chemist, USDA/ARS

Objectives

1. Determine the Selenium (Se) content of field-grown pinto beans from the vicinity of Jamestown, North Dakota.
2. Quantify the contributors to variation of the Se content in pinto beans.
3. Develop a map of the Jamestown area that predicts the feasibility of growing high-selenium beans in that area.

Benefits to North Dakota/Minnesota bean growers

A recent conference hosted by the Grand Forks Human Nutrition Research Center highlighted the potential benefits to human health of enhancing the food supply with the essential trace element selenium (Se). Selenium is needed in moderate amounts (55 micrograms per day) for nutritionally essential functions such as producing enzymes that guard against oxygen stress in cells. However, a clinical study conducted in humans found that consumption of an additional 200 micrograms of selenium per day reduces the incidence of cancer, especially prostate and colo-rectal cancer. A large study (approximately 32,000 subjects) is currently being conducted in an attempt to confirm the previous finding of selenium-mediated reduction of cancer.

The implications of these studies for agriculture are substantial; a demand is developing for selenium-enriched foods, and this demand will certainly increase if the present prostate cancer trial yields positive results. Plant foods accumulate selenium partially in direct relationship to the selenium concentration of the soil, so soils enriched in selenium may produce selenium-enriched crops. North Dakota has areas with very high concentrations of selenium in the soil, and many of these areas are in regions where pinto beans are produced. Consequently, pinto beans from North Dakota are a potentially valuable source of supplemental selenium; this attribute could be used to produce a value-added product and/or help to market pinto beans from North Dakota.

Research methods

Pinto beans were collected from 78 different fields and 37 different producers broadly organized into five different geographical regions across North Dakota (Figure 1). Dried beans were crushed, dissolved in acid and analyzed for total selenium concentration (by hydride generation atomic absorption spectroscopy).

Findings

Results are shown in Table 1.

The mean selenium concentration of all samples was 486 nanograms selenium/g (or 0.49 micrograms per gram), but there was wide variation (136 to 983 nanograms per gram; standard deviation of 253ng/g). Samples were analyzed as five distinct geographic clusters; selenium concentrations in 4 of the 5 clusters were similar while the Gilby area was lower than the rest (however, there were only 4 samples from this area). Wide variation was noted in all areas except Gilby.

These results are what we predicted based on our understanding of selenium accumulation in plants.

Study Results

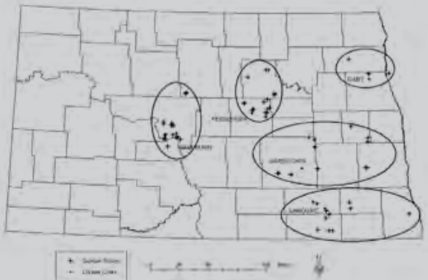


Figure 1. *Locations of pinto bean samples collected in North Dakota in 2004.*

Figure 2. *General trends in selenium concentration throughout the 2004 study area*

Location	Number samples	Selenium (micrograms per gram)	Standard deviation	Minimum	Maximum
Fessenden	18	494	167	257	941
Gilby	4	250	77	182	380
Jamestown	14	545	278	223	983
Lamoure	11	505	192	136	834
Washburn	18	459	245	185	970
Overall average		**486**	**253**	**136**	**983**

Table 1. *Selenium concentrations in pinto beans from various locations within North Dakota.*

First, as expected beans grown on North Dakota soils had selenium concentrations well above average. The USDA nutrient database gives average nutritional values for many foods, including canned pinto beans; the selenium content is listed as 71 nanograms per gram. Because canned beans are ~ 75% water, this corresponds to a dry bean selenium concentration of ~ 280 nanograms per gram (0.28 micrograms per gram). By comparison, 4 of the 5 regions in North Dakota had selenium concentrations almost twice that.

The second expected result is the extreme variation in selenium concentrations. High selenium soils occur where a selenium-rich rock layer reaches the surface and becomes weathered, consequently high and low selenium soils may occur within a few miles of each other.

The geographical origination of the samples was determined by having producers record field coordinates using either the Public Land Survey System (PLSS) or global positioning system (GPS); this information was converted to latitude/longitude coordinates using a program developed by the North Dakota State Water Commission. This procedure allowed the results to be mapped to specific geographical points in North Dakota and development of a preliminary map of average selenium concentrations in pinto beans (Figure 2).

There are no doubt many other geographical factors that may contribute to the selenium concentration of pinto beans. An excellent tool for assessing other geological and geographical factors is the Geographic Information System (GIS), a database that allows analysis of extensive environmental data for a specific geographic coordinate. As a first step in this analysis, the present data have been entered into a mapping program, allowing development of a preliminary contour map of selenium concentrations (Figure 2). Information regarding topography, precipitation, soil type, and planting history, among other factors is being incorporated into the GIS to develop a model that may then be used to more accurately predict spatial patterns of selenium concentration.

The data collected thus far demonstrate that pinto beans grown in North Dakota do accumulate sufficient selenium to make them, *on average,* an excellent source of dietary selenium. However, the initial data also show a large degree of variation in selenium concentrations. Additional analyses of a greater number of samples collected during a second growing season is needed to determine factors that result in this variation, and such information will allow bean growers to predict with more accuracy where and under what conditions high-selenium crops may be grown.

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