The Effects of Cultivar on Nodulation, Seed Yield and Dinitrogen Fixation of Dry Bean (*Phaseolus vulgaris* L.)

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Introduction

Dry bean (*Phaseolus vulgaris*) is the most important pulse crop in the world. Export markets for the numerous commercial classes of the crop exist all over the world. In recent years, dry bean production has steadily increased in western Canada. In the year 2000, 433 100 acres of dry bean were grown in western Canada. Manitoba was the largest producing province, accounting for 235 000 acres of dry bean. Alberta followed with 50 000 acres. In Saskatchewan, 10 000 acres of dry bean were grown in the year 2000 and it is predicted that well over 20 000 acres will be grown in 2001. With this expansion comes the need to develop improved production packages for the dry bean crop.

While dry bean is a legume, it is generally believed to be a poor N_2 fixer in comparison to other legumes and application of N fertilizers has been recommended in bean production. Dry bean cultivars are classified into four main groupings based on growth habit (Kelly et al. 1987) and recent evidence suggests that the success of the inoculation process may depend on the growth habit of the host cultivar. Substantial genotypic variability exists within dry bean cultivars for N_2 fixation (Hardarson et al. 1993; Pena-Cabriales et al. 1993). Dinitrogen fixation may vary widely depending on growth habit of the bean genotype (Graham 1981). This study, therefore, investigated the impact of dry bean cultivar on the success of the inoculation process using granular inoculant.

Materials and Methods

The study was conducted at two locations in the year 2000; Saskatchewan Pulse Growers (SPG) farm (Dark Brown Chernozemic soil) and Seager Wheeler Farm near Rosthern (Black Chernozemic soil). The soil at SPG had 20 kg/ha available N at the 0-30 cm depth while the soil at Rosthern had 29 kg/ha available N at the same depth.

Twelve bean cultivars representing different commercial classes and different growth habits (Table 1) were used in the study. The treatments consisted of a control with no inoculant application and an application of granular inoculant placed in the seedrow. Triple superphosphate (0-45-0) at the rate of 20 kg/ha P_2O_5 was applied in the furrow at planting. No nitrogen fertiliser was applied. The study was arranged in a randomised complete block design with four replications. Each plot consisted of seven rows (six bean, one flax), 12 m long and 15 cm apart. Flax was used as a reference crop for the assessment of percent nitrogen derived from the atmosphere (%Ndfa).

Table 1. Characteristics of Dry Bean Cultivars Used in the Study

Name of cultivar	Commercial class	**Growth habit**
CDC Camino	Pinto	Type I, determinate
CDC Pintium	Pinto	Type I, determinate
CDC Pinnacle	Pinto	Type III, indeterminate
CDC Altiro	Pinto	Type III, indeterminate
CDC Bianca	Great Northern	Type I, determinate
L 93E101	Great Northern	Type II, indeterminate
CDC Crocus	Great Northern	Type III, indeterminate
US 1140	Great Northern	Type III, indeterminate
CDC Expresso	Black	Type I, determinate
L 96F101	Black	Type II, indeterminate
CDC Nighthawk	Black	Type II, indeterminate
UI 906	Black	Type II, indeterminate

At early pod filling, five plants were dug out from each plot to determine nodule dry mass and shoot dry mass. At harvest, seed yield was determined from a square metre quadrant from the centre of each plot and converted to kg/ha. Percent nitrogen derived from the atmosphere for the seed was determined from a 1 mg subsample of 100 g finely ground seed sample from each plot. Nitrogen fixation was determined by the natural abundance method (Bremer and van Kessel 1990). The $\delta^{15}N$ of dry bean grown in N-free medium was considered to be 0.00 (de Silva 1998). Data from the two locations were combined together and analysed using a mixed model analysis of variance performed using the GLM procedure of SAS (SAS Institute Inc. 1987). Plant stands for CDC Bianca and US 1140 were extremely poor hence seed yield data for the two cultivars were excluded from the analysis.

Results and Discussion

The inoculation treatment produced similar results for all genotypes at both locations hence data were combined over locations. Nodule dry mass was significantly higher for the inoculated plots than for control plots for all bean cultivars (Figure 1). Type II and Type III (indeterminate) cultivars had higher levels of nodulation compared to Type I (determinate) cultivars. Nodule dry mass varied little within each group.

Applying granular inoculant increased shoot dry mass significantly compared to the control for bean cultrivars with a Type III growth habit but had little effect on Type I and Type II cultivars (Figure 2). Differences in shoot dry mass were greater within Type I cultivars than within Type II or Type III cultivars.

Applying granular inoculant increased seed yield significantly over the control plots. This increase in seed yield was higher for Type III cultivars (29.6%) compared to Type I (18%) or Type II (19%) cultivars (Figure 3). The response to inoculant application varied within Type I and Type III cultivars but was the same within Type II cultivars

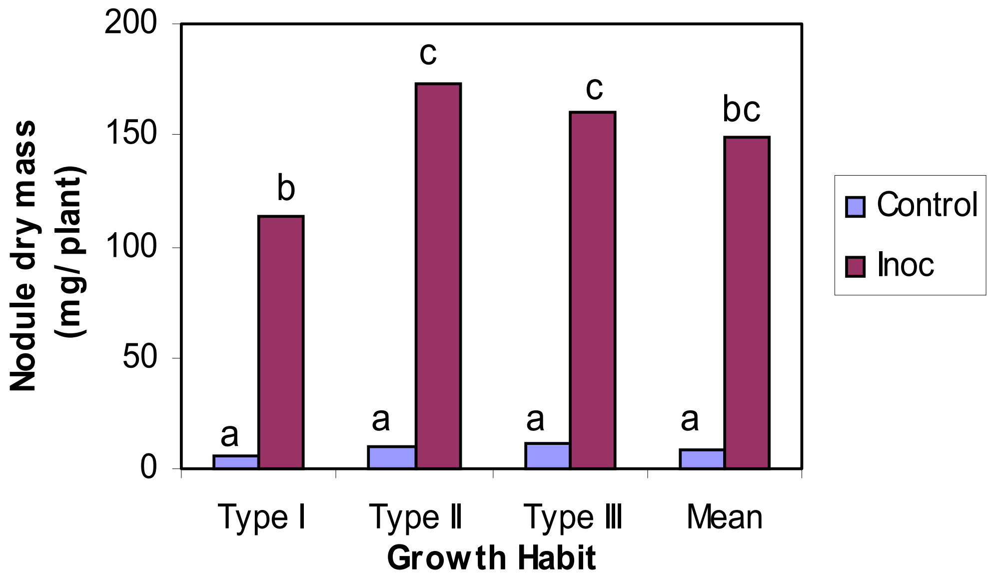

Figure 1. Effect of growth habit and *Rhizobium* inoculant on nodule dry mass

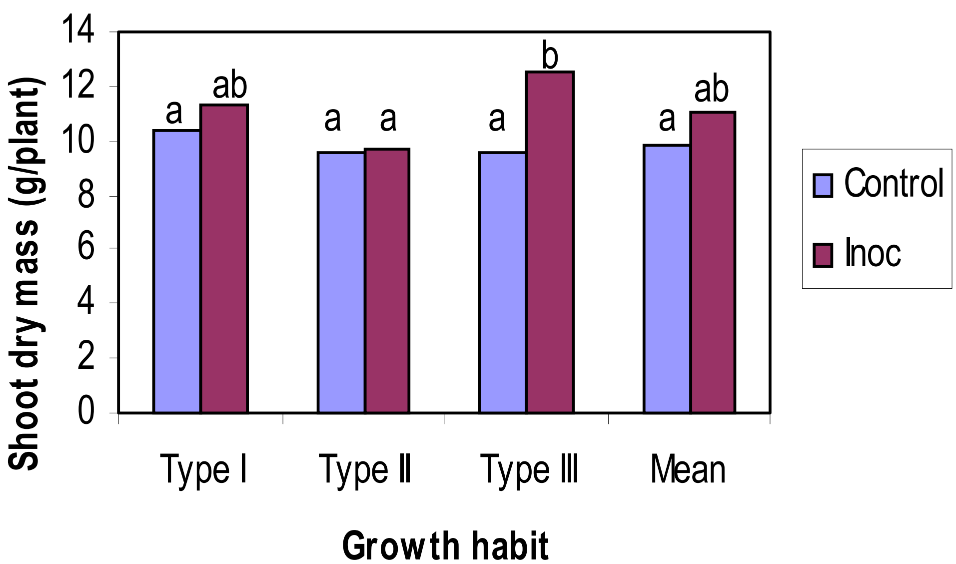

Figure 2. Effect of growth habit and *Rhizobium* inoculant on midseason shoot dry mass

Granular inoculant application increased the amount of N fixed by bean plants significantly compared to control plots (Figure 4). The Type III cultivars fixed significantly greater amounts of N compared to Type II cultivars. The amount of N fixed in inoculated plots ranged from 21.4 to 35.8 kg $ha^{-1.}$ The Type III cultivars were at the upper range whereas the Type II cultivars were at the lower range.

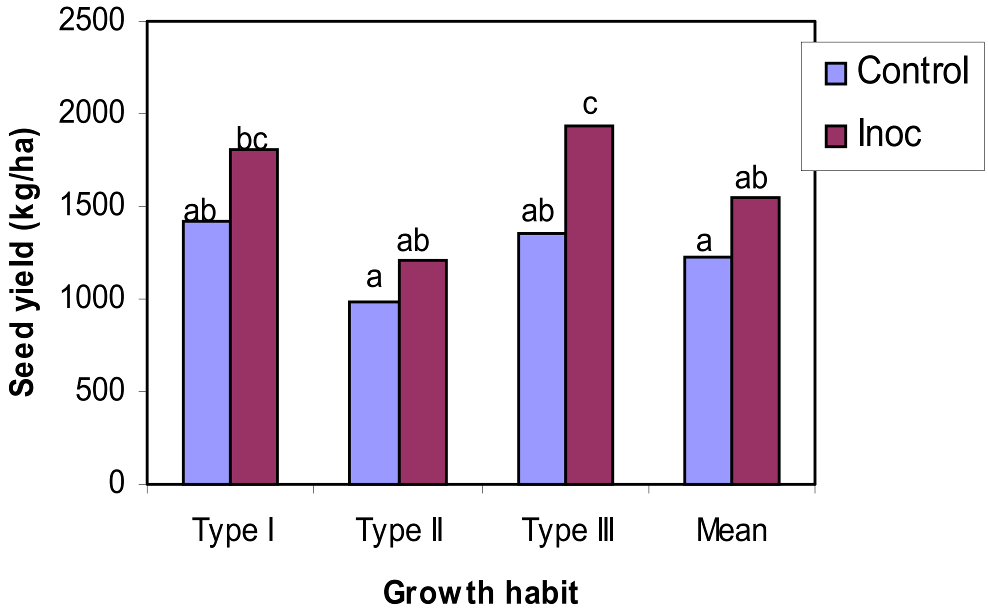

Figure 3. Effect of growth habit and Rhizobiun inoculant on seed yield

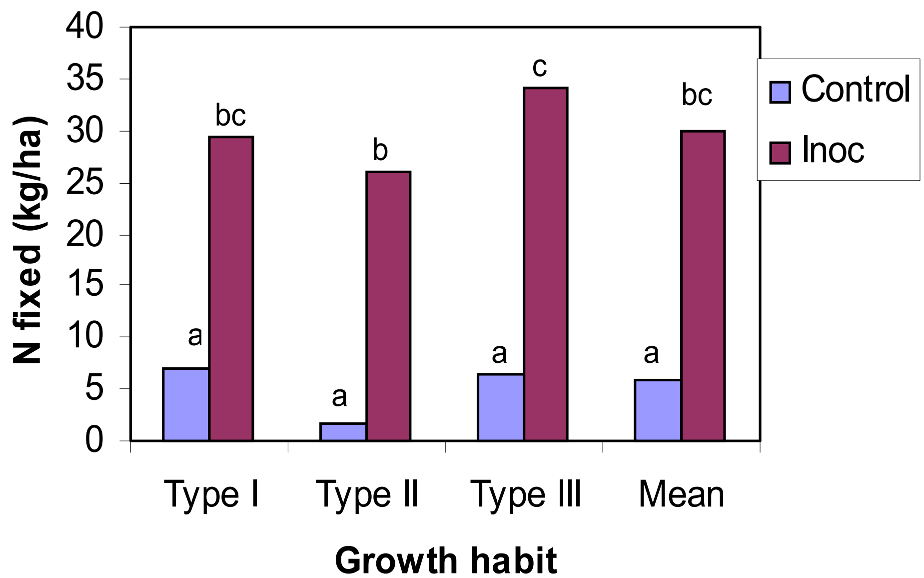

Figure 4. Effect of growth habit and *Rhizobium* inoculant on amount of N fixed by dry bean plants

Discussion

First year results of this study show differences among dry bean cultivars for nodulation and N_2 fixation. Differences in N_2 fixation were associated with growth habit, with Type III cultivars showing a greater response to inoculant application compared Type I and Type II cultivars. The actual amount of N fixed ranged from 21.4 kg ha^{-1} to 35.8 kg ha^{-1} depending on the cultivar. This is lower than has been reported by other researchers (Rennie and Kemp 1983 a, b) who reported a fixation range of 40 kg ha^{-1} to 125 kg ha^{-1} depending on cultivar. This study is ongoing and will be repeated in the year 2001 to test the effect of growing season conditions on N_2 fixation.

Acknowledgments

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