Field Survey of Kabuli Chickpea and Dry Bean Plant Spacing Uniformity

L. Zyla[1], A. Vandenberg[2], T. Warkentin[2]

[1]Agricultural Engineering Consultant, Box 8043, Saskatoon SK, S7K 4R7
[2]Crop Development Centre, University of Saskatchewan, Saskatoon SK, S7N 5A8

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Abstract

In an effort to reduce capital expenditures, dryland growers of kabuli chickpea and dry bean in Saskatchewan have been seeding their crops with conventional seeding equipment rather than precision planters. Intra-row plant spacing has been non-uniform, and this project was undertaken to quantify that non-uniformity. Data on within-row plant spacing were collected from twenty-nine commercial growers of dry bean and kabuli chickpea in Saskatchewan during the 2000-growing season. Plant spacing was non-uniform, but the need for equipment modifications to improve plant spacing uniformity is uncertain. Preliminary experiments by the Crop Development Centre have shown a yield advantage for dry bean seeded with more uniform spacing. However, little scientific work has been done on the effect of spacing uniformity on chickpea, and the literature reveals conflicting information among crop types. It is speculated that more uniform plant spacing will improve seed quality and reduce weed competition.

Background & Objectives

Current area production of dry bean in Saskatchewan is approximately 10,000 ha but could potentially reach 650,000 ha (Minogue 1996) with most of this growth occurring under dryland conditions. Chickpea production meanwhile has grown from 10,500 ha in 1997 to 280,000 ha in 2000. Minogue (1996) has estimated that area production of chickpea could potentially reach 970,000 ha in Saskatchewan.

A majority of dry bean production in the irrigation district of Saskatchewan is seeded with row-crop precision planters that employ single seed metering technology. Under dryland conditions, dry bean and chickpea is sown with conventional seeders that employ bulk seed metering technology. Growers, and people working in the industry, have observed that plant spacing within the seed row of commercial fields seeded with conventional equipment is not always uniform. However, this non-uniformity has not been measured, or quantified in any way.

Robinson et al. (1982) report that a reduction in row spacing and an accompanying greater uniformity of plant spacing have been a trend for the major cultivated row crops of the north central USA for the last forty years. Saskatchewan growers of dry bean and chickpea currently have the opportunity to adopt these crops, and avoid the capital cost of row-crop equipment. Although the narrow row spacing of conventional equipment tends to produce more equidistant plant spacing by nature, a low-cost add-on singulator that would minimise the extremes in plant spacing may be beneficial.

This project was initiated to determine the within-row plant spacing uniformity of commercial kabuli chickpea and dry bean production fields in Saskatchewan. The data is used to determine the need for development of a low-cost, add-on singulator that would improve the seed spacing of conventional seeding equipment.

Literature Review

A non-uniform plant spacing has the potential to reduce yields when closely spaced plants compete for light, moisture, and nutrients, while plants spaced far apart have poor utilisation of soil area. Preliminary tests conducted in 1999 by the Crop Development Centre, University of Saskatchewan showed a reduced yield for two varieties of pinto bean when seeded non-uniformly. A review of the literature revealed similar results for other crops such as snap bean pod yield (Wahab 1982), vining pea (Davies et al. 1985), soybean (Parvez et al. 1989), field bean (Heege 1993), and corn (Krall et al. 1977, Randall et al. 1985). Halderson (1983), without experimental data, states that certain varieties of edible bean have shown yield advantages when plant spacing within the row was the same as spacing between rows.

It is difficult to draw definitive conclusions from the literature, since some crop types have the ability to compensate for variability in plant spacing, and other factors influence yield. For example, Auld (1983) did not discover a yield advantage when spring wheat and durum were seeded on a precise geometric spatial arrangement. Krall et al. (1977) found that two locations showed a decrease in corn seed yield as variability of spacing increased, while a third field showed no correlation with yield. Davies et al. (1985) reported a yield advantage for vining pea, but the advantage disappeared when the crop matured and was harvested dry. Kahn et al. (1995) found that precision planting did not produce a yield advantage in cowpea. Robinson et al. (1982) reported a yield reduction in sunflower of 0 - 31% for uneven spacing. Wiggans (1939) concluded that soybean plants, like many others, could make wide adjustments to space and recommended that optimum rates and spacing need to be determined for each variety and location.

The literature seems to show that plant spacing uniformity more significantly influences yield as plant population increases. Hoff and Mederski (1960) showed this to be true for corn. Heath and Hebblethwaite (1987) discovered that plant density of combining pea had a greater influence on yield than spatial arrangement for 10-cm rows. Precision drilling was not likely to increase yield provided the crop was sown at sufficient density to ensure satisfactory photosynthetic area index during pod fill. Heyns (1989) reports that yield of maize will not be noticeably affected by uneven spacing patterns, provided the seed distribution is reasonable, with no undue drop in seed population.

Other reasons for improving plant spacing uniformity may include a more uniform maturity and seed size, improved quality, lower disease pressure, reduced weed growth, and lower seed costs. It is noted that uniformity of maturity may be a more significant issue for northern latitudes such as Saskatchewan. Furthermore, if yield is improved with uniform spacing, it presents an opportunity to reduce seed costs for growers. Heath and Hebblethwaite (1987) found that uniform plant spacing reduced seed costs while maintaining yield for pea.

Methodology

Twenty-nine fields from the Redvers, Rosthern, Outlook, Saskatoon, Rosetown, and Elrose areas were included in the study. A sample size of 300 spacings was chosen (ISO 1984, Kachman and Smith 1995), and four locations representative of the field were selected for data collection at each site. Portions of the field where turning was likely to have occurred, and areas of poor emergence were avoided. A string was stretched across the seed row at each location, and data collected by ticking off 75 plant locations with a marker. The strings were brought back to the laboratory for subsequent analysis.

ISO (1984) provide guidelines for plotting histograms and data analysis. A theoretical spacing is first determined, and spacings less than 0.5 times the theoretical spacing are deemed to be multiples (MULT), while spacings greater than 1.5 times the theoretical spacing are reported as misses (MISS). A quality of feed index (QFI) is calculated by subtracting MISS and MULT from the total number of spaces. All three of these parameters are expressed as a percentage of the total number of spacings. Halderson (1983) and PAMI (1984) chose 95% as an acceptable QFI for laboratory tests of planters.

Results & Discussion

A visual analysis of the histogram charts showed that all fields had non-uniform plant spacing. Figure 1, as represented by the solid bars, is a typical example. An indication of uniform spacing would be multiple peaks in the histogram. For example, if a seeder is seeding uniformly at a target intra-row spacing of 100 mm, the largest distribution would be around 100 mm, as represented by the hollow bars of Fig. 1. If, as one would expect, misses (MISS) occurred there would be a subsequent smaller distribution around 200 mm and perhaps an even smaller distribution around 300 mm. Kachman and Smith (1995) also provide examples of uniform and non-uniform histograms for planters.

Histograms do not lend themselves well to data analysis. Therefore, calculations to objectively quantify the non-uniformity were completed according to ISO (1984). Overall mean QFI was 37% (s.d. 4.9%), substantially lower than the 95% considered acceptable for laboratory testing of planters. MULT was 30% (s.d. 6.1%), and MISS was 33% (s.d. 8.2%). Figure 2 provides an overview of the uniformity data for the chickpea fields; the dry bean chart, although not provided, is similar. Even though these calculations have been provided, conclusions cannot be reliably drawn from them due to the following data limitations:

- Target seed rate – Many co-operators based their seeding rate on the recommended bulk weight of seed per ha (acre), but did not know individual seed weight. Thus, the target plant population was based upon an estimate only.
- Germination estimates – Some co-operators were able to provide only estimates of germination.

- Estimate of percent emergence – Emergence estimates were obtained by subtracting measured plant population from the target plant population. With target plant population estimated, emergence is also an estimate.
- Plants that emerge, but do not survive to produce seed – Disease or other factors may kill a plant in the seedling stage leaving only remnants of a plant. During data collection, these plants were counted when seen, but some may have been missed.
- Spread pattern of the seeder – One seeder employed an opener with a wide spread pattern making identification of the seed row difficult during data collection.

Other factors point to the need for an improved uniformity of plant spacing. These include:

- A potentially more uniform maturity at harvest with subsequent improvement in seed quality. Seed quality is an important consideration for chickpea and bean varieties sold into the salad market. Uniform maturity may also be difficult to obtain in northern latitudes with shorter growing seasons.
- A reduced incidence of disease by minimising the number of plants spaced close together.
- A reduced weed pressure when the number of large spacings between plants is reduced.
- A reduced seed cost if yield can be maintained while using less seed.

The data also show an interesting trend for fields seeded to large seed bean types. As seed size increases, the weight of seed per ha (acre) needs to increase if plant population is to be maintained. Many of the seeding rates for one cultivar (cv. Camino) appeared to have fallen short of the recommended plant population. This, coupled with emergence rates that averaged 62% (s.d. 14%) for dry bean, likely resulted in low plant populations and potentially reduced yield. Additional extension work may be necessary to ensure that growers of the large-size bean varieties achieve the recommended plant populations.

Conclusions

1) Within-row plant spacing data was non-uniform for the bean and kabuli chickpea fields sampled. The measure of non-uniformity was based upon a subjective, but skilled observation of histogram data for each field, rather than an objective calculation of degree of non-uniformity.
2) A low-cost, add-on singulator could be developed to improve plant spacing uniformity of dry bean and kabuli chickpea. Development should only proceed after considering the recommendations below.
3) The literature revealed a trend to narrower rows, with an accompanying equidistant plant spacing, for the major row crops of the North Central USA. Saskatchewan growers have the opportunity to capitalise on this trend by adapting their equipment for these crops. Without the need to purchase costly row crop equipment, a competitive advantage is possible.
4) Extension work may be needed to ensure that growers of larger sized bean seed varieties achieve recommended plant populations.

Recommendations

1) Arrange, in order of priority, the factors that indicate the need for more uniform plant spacing. Industry stakeholders and scientists could participate in this.
2) Review the literature to determine the need for additional scientific research work on the factors of the previous recommendation.
3) Completion of equidistant plant spacing trials, specific to varieties of dry bean and chickpea expected to be grown in Saskatchewan. The trials could be designed to verify a yield response to uniform spacing, or the importance of the factors of the first recommendation.
4) Recognising that the research required above would be costly, an alternative would be to use the funding for actual development of the singulator. A manufacturer of the device would then have the opportunity to market it for all crops that benefit from uniform plant spacing. This would spread the development costs beyond the pulse industry.

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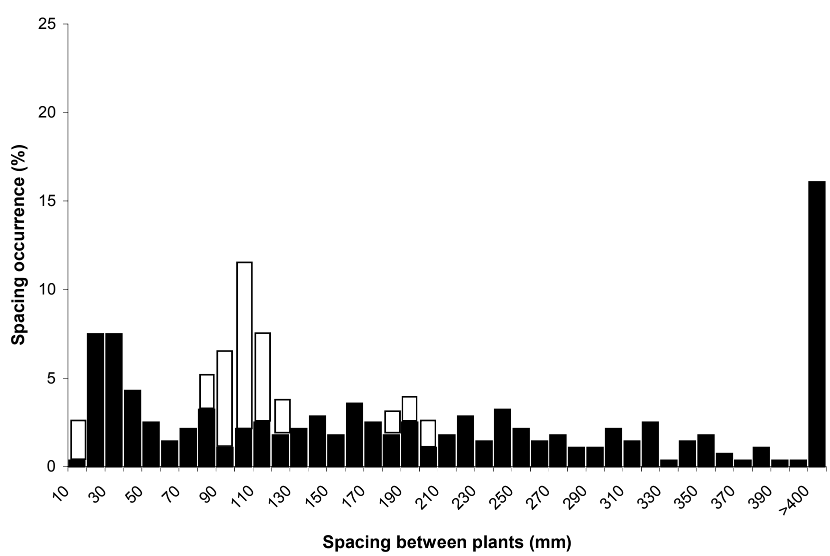

Figure 1. Typical frequency histogram, as represented by the solid bars, showing no clear spacing pattern. The hollow bars show what a uniform spacing pattern might look like.

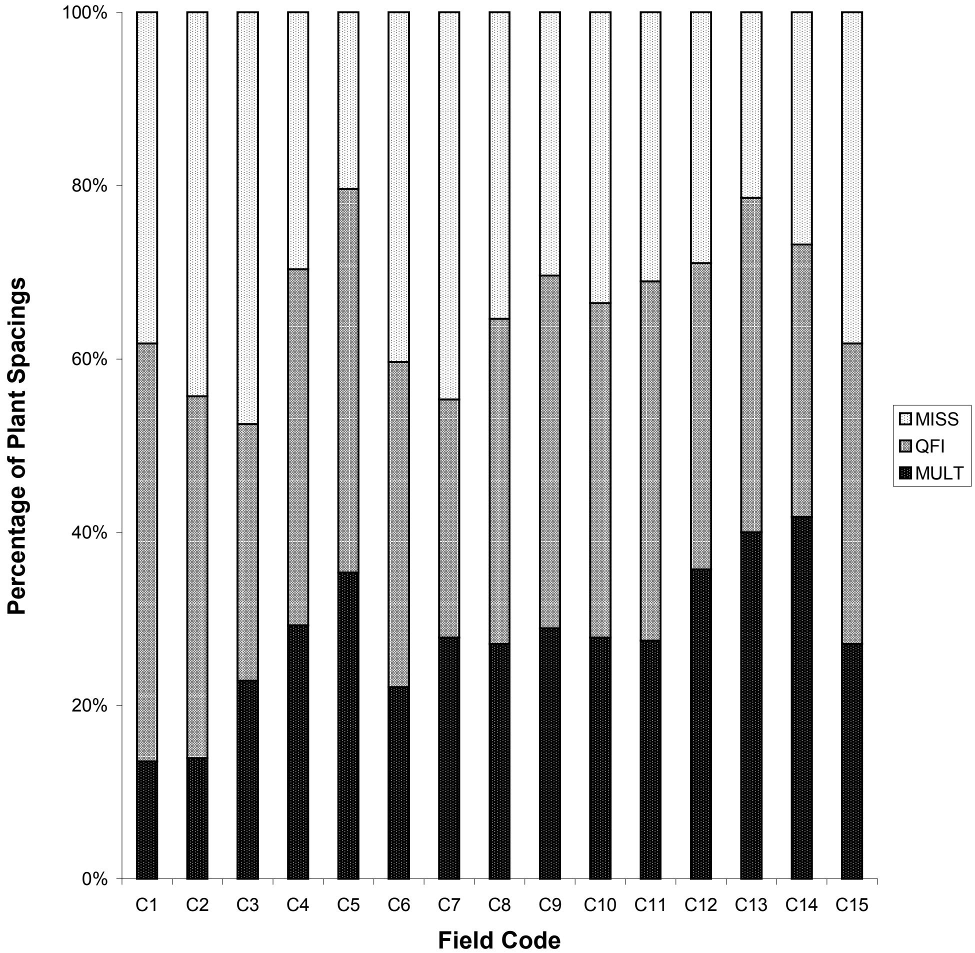

Figure 2. Overview of uniformity data for chickpea fields.

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