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Research Paper

Response of common bean (*Phaseolus vulgaris* L.) genotypes to varying planting dates in Botswana

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Abstract. A field study was conducted at the Department of Agricultural Research, Sebele, Gaborone, at 24°35′S, 25°56′E, and altitude 993 meters, over the summer/winter planting seasons of 2017/18 irrigated conditions. The experiment was laid out in a split-plot arrangement of randomized complete block with three replications. The main plot consisted of two common bean genotypes, DAB 564 and DAB 520, and subplots comprised of five planting dates treatments, being 10th October, 10th November, 10th December, 10th February and 10th March. Results showed that Planting date significantly increased number of pods per plant, pod length, 100 SW, and seed yield. Highest seed yield of 2424 kg/ha was from genotype DAB564 during March date of planting. The genotypes were stable for seed yield, 100SW, pod length and number of pods per plant, which implies these characters are amenable for selection during any of five planting dates.

Keywords: Bean, planting date, seed yield.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is a warm season annual legume crop grown primarily for its protein and energy-rich dry seeds. Beans are also good source of zinc and iron (Buruchara *et al*., 2011). They are considered to be the most important grain legume for human consumption; and comprise 50% of the grain legumes consumed worldwide (Broughton *et al*., 2003; Graham *et al*., 2003). Dry beans seeds contain 22% protein, 2% fat, 61% carbohydrate (including 5% fibre) as well as adequate levels of all vitamins and minerals (DAFF, 2010).

Common beans grow in subtropical and dry tropical zones, so it does well in warm climates with average temperatures ranging between 18 and 24°C. Temperatures exceeding 30°C during flowering, might cause flower abortion (Stephen *et al*., 2014). The crop performs well in the tropics at an altitude of about 1,250 m with rainfall ranging from 400 to 650 mm. Beans grow well in deep (100 cm), well–drained soils with a pH of 5.8 to 6.5. The crop takes between 85 to 115 days to mature depending on cultivar and season, while the yield potential ranges between 1.5 to 2.5 tonnes ha^{-1} in South Africa (DAFF, 2011).

Planting date is considered as one of the major agronomic factors in crop production as it influences the balance between vegetative and reproductive growth period (Dube *et al*., 2014). Planting common bean early can enable the crop set and fill before the onset of chilling. Early planting can also provide the potential for producing a larger crop canopy, which can better utilise solar radiation for photosynthesis (De Bruin *et al*., 2010). On the other hand, late planting causes the reproductive growth stages of the crop to face the full chilling, which results in lower yields.

Table 1. Effect of genotype and planting date on phenology of common beans during 2017/2018 season.

Treatment	Emergence (DAS)	Flowering (DAS)	Physiological maturity (DAS)
February	5.50[a]	39.17[b]	79.00[b]
March	5.50[a]	41.67[a]	87.67[a]
DAB564	5.33[a]	40.67[a]	84.00[a]
DAB520	5.67[a]	40.17[a]	82.67[b]
Mean	5.50	40.42	83.33
CV	7.42	1.89	0.92
LSD	0.54	1.02	1.02
October	4.83[b]	41.67[b]	87.17[b]
November	5.67[a]	46.33[a]	91.50[a]
December	5.83[a]	39.83[c]	78.00[c]
DAB564	5.20[b]	42.89[a]	86.67[a]
DAB520	5.70[a]	42.33[a]	84.44[b]
Mean	5.44	42.61	85.56
CV	7.49	1.56	0.67
LSD	0.42	0.68	0.59

The time of sowing a crop is a critical factor in determining the environmental conditions at planting, anthesis, pod-filling and drying. Therefore, sowing date can be important in determining the success of the crop and in maximizing seed yield. Also it has been observed that planting at an appropriate planting date has an advantage over climatic conditions temperatures, humidity and day length (Mirzaienasab and Mojaddam, 2014). Hence, there is the need to determine the optimum sowing time for the newly introduced common beans in Botswana so as to minimize farming risk, for farmers.

MATERIALS AND METHODS

A field study was conducted at the Department of Agricultural Research - Horticulture Field, Sebele, Gaborone, at 24°35′S, 25°56′E, and altitude 993 m, over the summer and winter planting seasons of 2017/2018 irrigated conditions.

The experiment was laid out in a split-plot arrangement of randomized complete block with three replications. The main plot consisted of two common bean genotypes, DAB 564 and DAB 520, and subplots comprised of five planting dates treatments, being 10th October, 10th November, 10th December, 10th February and 10th March. The nitrogen fertilizer applied was urea (46.5% N) at the rate of 125 kg/ha, on plot size of 2.25 m × 2 m and intra-row spacing of 0.3 m, and inter-row spacing of 0.75 m. The planting was done at two seeds per hole manually, and thinned to one after two weeks after emergence. Data collected included number of days to emergence (de), days to flowering (da), number of days to maturity (dm), number of pods per plant (Pod/Plant), pod length (PodL), 100 seed mass (100SW), and seed yield (Yield/Ha).

The agronomic data was analysed by using the analysis of variance technique using STATISTICA package, version 13.1 and Least Significance Difference (LSD) was used to compute the difference of treatment means at $P \leq 0.05$.

RESULTS

Genotype and planting date had no effect on number of days to emergence of beans during February and March planting dates (Table 1). However, there was a significant difference in emergence of beans during the summer months of October, November, and December and for the two genotypes. Planting date also significantly influenced number of days to flowering during the February and March months, with crops planted in February reaching flowering quicker (39.17 days). In November crops took longer (46.33 days) to reach flowering than the December months. According to Table 1, planting date significantly influenced number of days to physiological maturity of beans. Crops planted in March took longer days (87.67) to mature compared to the February planting date (79.00 days). During the summer trial the November planting date crops took maximum days (91.50) to reach physiological maturity compared to the October and December dates.

According to Table 2 planting date and genotype significantly influenced number of pods/plant, pod length, 100SW and seed yield. March planting date produced more yield (2631.2 kg/ha) than the February date (1678.2 kg/ha). Genotype DAB564 produced significantly higher

Table 2. Effect of genotype and planting date on yield and yield components of common beans during 2017/18 season.

Treatment	No. pods/plant	Pod length (cm)	100 pod mass (g)	Yield (kg/ha)
February	9.90[b]	9.72[b]	36.23[a]	1678.2[b]
March	12.17[a]	10.33[a]	37.75[b]	2631.2[a]
DAB564	11.67[a]	10.75[a]	37.85[a]	2424.80[a]
DAB520	10.40[b]	9.30[b]	36.13[b]	1884.50[b]
Mean	11.03	10.03	36.99	2154.67
CV	6.51	4.47	1.45	8.48
LSD	0.96	0.59	0.71	243.39
October	9.27[a]	9.80[a]	38.53[a]	1495.45[b]
November	9.73[a]	8.80[b]	37.30[a]	1722.96[a]
December	7.85[b]	8.80[b]	37.20[a]	1288.28[c]
AB564	9.26[a]	9.74[a]	38.74[a]	1758.27[a]
DAB520	8.64[a]	8.58[b]	36.61[b]	1246.20[b]
Mean	8.95	9.16	37.68	1502.23
CV	6.82	7.36	3.66	9.13
LSD	0.63	0.69	1.41	40.93

Means separated using the Least Significant Difference (LSD) at P = 0.05; Means with the same letter(s) are not significantly different.

Table 3. Mean square analysis of variance for yield and related traits of two common bean varieties evaluated for five planting dates during 2017 – 18 season.

Source	df	YieldHA	100SW	Avepod	PodL	Pod/Plant	da	de	dm
Genotype	1	2054335***	29.008***	1.63333***	12.2880***	5.7203***	2.1333**	1.2000***	26.1333***
Date	4	1589196***	4.227**	0.46613***	2.7488***	14.5517***	47.0500***	0.8667***	207.7500***
Genotype × Date	4	48690ns	0.668ns	0.06923***	0.1788ns	0.6417ns	1.8833**	0.3667**	1.2167**
Residual	18	20760	1.263	0.01460	0.2504	0.4308	0.4519	0.1148	0.4333
Rep		59789	1.225	0.1569	1.2763	0.4263	0.9333	0.6333	0.4333
Grand mean		1763	37.40	2.212	9.507	9.78	41.73	5.467	84.67

*** Highly significant at 0.001; ** highly significant at 0.05

yield (2424.80 kg/ha) than DAB520 (1884.50 kg/ha). Summer planting dates of October, November, and December significantly influenced all the above studied parameters, except for 100SW. Maximum seed yield (1722.96 kg/ha) was recorded during the November planting date, followed by October, and lastly December (1288.28 kg/ha).

The results for a combined analysis of variance for all examined traits are summarised in Table 3, it shows that both the genotypes and the planting dates were highly significantly different for all the characters. The mean square of variance of genotype x environment (planting date) was highly significant only for average pod weight, days to flowering, days to emergence and days to maturity. The genotypes were stable for yieldHa, 100SW, podL and pod per plant, which implies these characters are amenable for selection during any of five planting dates.

Figure 1 showed that the interactive effect of genotype and planting date significantly increased seed yield of common bean, with genotype DAB564 planted during November recording highest yield (1961.84 kg/ha).

Figure 2 shows a significant interaction between planting date and genotype towards seed yield of common beans grown in February and March. The highest seed yield was produced during March across genotypes, however the response of genotypes DAB564 or DAB520 did not significantly differ in the two months of study (Figure 2).

DISCUSSION

Results from Table 1 showed that crops under October planting date emerged earliest (4.83 days) than the November and December planting dates and that is attributed to warmer temperature which promoted

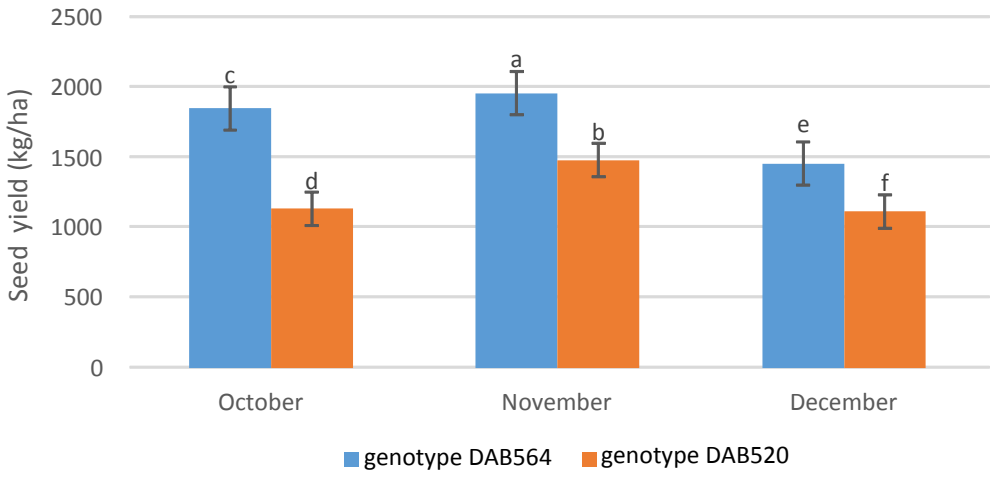

Figure 1. Effect of genotype and planting date on seed yield of common bean the October, November and December dates.

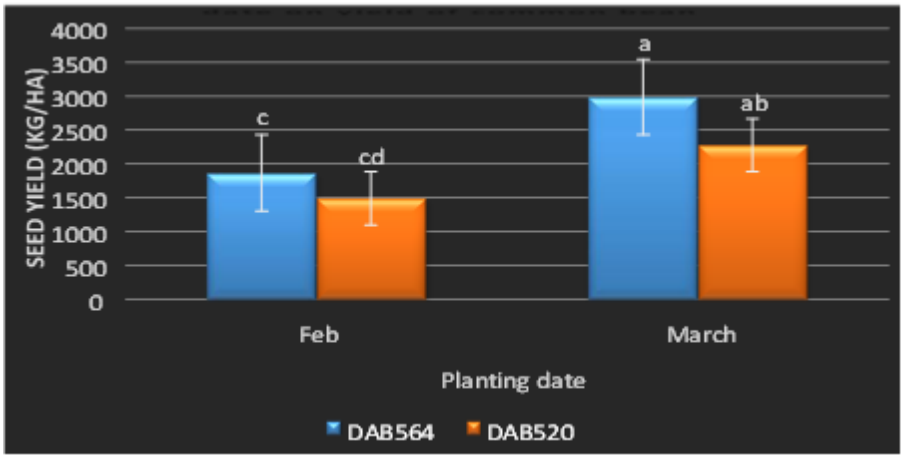

Figure 2. Effect of genotype and planting date on seed yield of common bean during February and March dates.

germination, hence quicker emergence. Crops planted in November took longer to reach flowering than the December months and this may be attributed to more grain filling of photosynthates as a results of lower temperatures in November compared to December. Crops planted in March took longer days to mature compared to the February planting date and this is attributed to more grain filling period as influenced by colder temperature.

Data presented in Table 2 depicted that planting date and genotype significantly influenced number of pods/plant, pod length, 100 pod mass and seed yield. Increased seed yield in March planting date compared to February was attributed to longer grain filling period due to more days to maturity as more photosynthesis were accumulated. These results corroborate with those of Ewas (2010) and Ramirez *et al*. (2008) who reported increased green pod yield and quality during the winter period in Sudan. Genotype DAB564 produced significantly higher yield than DAB520 and this might be attributed to its genetic potential. Werber *et al*. (2007) reported similar results due to cultivar differences.

The November planting date produced higher seed yield than the October and December planting dates. During November planting, the crop developed a large canopy cover early in the growing season, thus maximising on transpiration, solar radiation interception, and hence high biomass accumulation (Esmaeilzadeh and Aminpanah, 2015), which resulted in higher seed yield. Similar results of increased grain yield at an appropriate planting date were reported by Mirzaienasab and Mojaddam (2014). Significant positive effects of sowing date on pod yield were also confirmed by Amer *et al*. (2002) who reported improvement of both quantitative

and qualitative traits of bean dependent on appropriate sowing date.

Results from Figure 1 showed that in summer the interactive effect of genotype and planting date significantly increased seed yield of common bean, with November planting date and genotype DAB564 recording highest yield. Maximum yield was attributed to higher number of pods/plant and longer pod size.

CONCLUSIONS AND RECOMMENDATIONS

During the winter months March planting date increased seed yield of common bean by 36.22% compared to the February date. Genotype DAB564 produced more yield (22.88%) than genotype DAB520 under the same dates of February and March. April planting is not suitable to grow beans as the plants aborted flowers, hence no seed yield. For summer season, November month produced highest seed yield (1722.96 kg/ha) than the October and December, which is an increase of 27.67% compared to the lowest yield of December.

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