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AGRONOMY | ORIGINAL ARTICLE

The Growth and Yield Response of Dry Beans (*Phaseolus vulgaris* L.) Varieties to Planting Date in Bela-Bela, the Limpopo Province, South Africa

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ABSTRACT

Dry bean (*Phaseolus vulgaris* L.) is a significant leguminous crop owing to its elevated protein levels. A field experiment was carried out to assess the influence of planting date on growth, dry bean yield, and yield components during the 2017/2018 and 2018/2019 planting periods at Towoomba research station, Bela Bela, South Africa. Two varieties of dry beans were planted: Kranskop (indeterminate, red speckled) and Pan 123 (determinate, small white). The planting dates consisted of 14 December 2017, 31 January 2018, 15 November 2018, 20 December 2018 and 17 January 2018. The experiment was set up in a randomized complete block design with three replications. The chlorophyll content, leaf area index (LAI), plant height, number of pods per plant, number seeds per pod, number of seeds per plant, hundred seed weight and grain yield were significantly influenced by interaction relationship between planting date and varieties. Planting Pan 123 in November 2018 resulted in the highest number of pods per plant (52) and number of seeds per plant (198). The highest grain yield (3.85 t ha^{-1}) for Pan 123 was produced when planted in December 2018. Planting Kranskop in December resulted in high LAI (3.51), number of seeds per pod (4.28) and grain yield (4.97 t ha^{-1}). December seems to be the best planting time for both varieties in bela-bela.

1. Introduction

Dry bean (*Phaseolus vulgaris* L.) is considered the most significant legume for direct human consumption (Uebersax *et al.* 2022). Dry bean (*Phaseolus vulgaris* L.) is an important protein grain crop in South Africa (Mathobo *et al.* 2017). The production of dry bean is around 78% of the total amount required for consumption in South Africa (Mathobo and Mathobo 2024) the deficit is met by imports. Dry beans' nutritional makeup and advantages for human health are widely acknowledged (Didinger *et al.* 2022). Dry bean is a good source of proteins, complex carbohydrates including fibre, minerals, and vitamins (Ocampo *et al.* 2018). The high nutritional characteristics of dry bean make it a potential crop for improving nutritional security and preventing malnutrition for resource poor communities (De Paula *et al.* 2024). Three dry bean types are grown in South Africa: large white (kidney), small white, and red speckled beans with small white dedicated for canning and red speckled commanding the biggest market in the country (Department of Agriculture, Forestry and Fisheries (DAFF, 2012). Limpopo province is the second following Free State in dry bean production in South Africa (Mathobo and Mathobo, 2024).

The average yield production of dry bean in South Africa is very low (1003 kg ha^{-1}) (Mathobo and Mathobo 2024) compared to Sudan (2983 kgha^{-1}) (FAOSATA, 2020). The highest yield of dry beans can be attained by maintaining a suitable equilibrium between plant and environmental factors throughout the crop growth cycle (Fageria and Santos 2008). In many developing nations, climate change has shown to have a negative impact in the agricultural industry and future climate change predictions suggests further crop yield reductions (Mohammed and Feleke, 2022). The predictions indicated that climate

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change will result in warmer temperatures and less precipitation in South Africa (Calzadilla et al., 2014). Approximately 73% of Africa's bean-producing regions are impacted by climate change, which is most often mentioned in relation to the risk of drought (Farrow & Muthoni-Andriatsitohaina, 2020). Dry beans require 400–500 mm of moisture per season for optimum growth and maximum seed yield, with the rain falling evenly over the first 10–12 weeks of growth (Farrow & Muthoni-Andriatsitohaina, 2020). Several studies have indicated that leaf area index, dry matter production, number of seeds per plant, number of pods per plant, hundred seed weight, and grain yield were all decreased by drought stress (Mathobo *et al*., 2017; Ghassemmi-Golezani and Lotfi, 2012; Gohari, 2013). Dry bean grows optimally at temperatures between 18 and 24 ºC and should not exceed 30 ºC during flowering (Department of Agriculture, Forestry and Fisheries 2010). Beans are generally sensitive to high temperature specifically during reproductive growth stage (Uebersax *et al.* 2022). Grain legumes exposed to temperatures below 10-15 ºC or 30ºC resulted flower abortion and reduced seed filling, leading to serious reduction in grain yield (Gogoi *et al.* 2018). High temperature led to flower shedding and pod abortion leading to low grain yield (Tene *et al.* 2023). High temperature (>30ºC day or 30ºC night) during anthesis or seed setting, severely reduces bean production (Pathania *et al.* 2014).

Adjusting planting date has been recognized as one of the successful approaches of mitigating the negative impact of climate change (Ma et al., 2024). The entire plant growth cycle is impacted by the time of planting including seed germination, seedling emergence, vegetative plant growth, flowering, pod formation, grain filling, and crop maturity (Hussain *et al.* 2022). Planting date significantly influences the timing and duration of vegetative and reproductive stages, yield and its components and seed quality (Abido and Seadh 2014). The planting time plays an important in determining the final seed yield and is an important agronomic practice as indicated in other leguminous crops like cowpeas (Shiringani and Shimelis 2011), Bambara groundnut (Ngwako *et al.* 2013).

The interaction between soybean varieties and planting dates resulted in a significant variation in seed yield, plant height and plant biomass (Shahin *et al.* 2023). Grain yield, plant height, number of pods per plant and hundred seed weight were significantly affected by planting date, variety, planting date x variety interaction in Soybeans (Ibrahim 2012). The highest chlorophyll content was found in faba bean planted late October (El-Metwally *et al.* 2013).

Controlling the timing of planting time is crucial considering shifting climate conditions in order to give plants the best possible circumstances for growth, physiology, and yield development (Hussain *et al.* 2022). Most of the farmers in Limpopo province plant their beans in November while the recommended time is from January, it was then decided that it is necessary to compare the production within the three months (November, December and January) Therefore, with all the findings and changing climatic conditions, it is very important to study the effect of planting date under different climatic conditions. The objective of the study was to determine the effect of planting date on growth, yield and yield components of dry bean varieties in Bela-Bela, Limpopo province.

2. Materials and Methods

2.1. Experimental site and treatments

Field experiments were conducted at Towoomba research station, approximately 4km southeast of Bela-Bela town in Waterberg District, Limpopo Province, South Africa. (28º21'E, 24º25'S; 1184 m above sea level). Towoomba receives an average annual rain fall of 650-750 mm and the temperature ranging from 19 ºC to 38 ºC. Two varieties of dry bean which are Kranskop (Indeterminate, red speckled) and Pan 123 (determinate, small white) were used for this study. The planting dates consisted of 14 December 2017, 31 January 2018, 15 November 2018, 20 December 2018 and 17 January 2018. The November 2017 planting was disturbed by rain received on the week of planting resulting in the soil too wet to work on. The trial was arranged in a randomized complete block design (RCBD) consisting of three replications. The plot consisted of 4x5 m^2 with an intra- row spacing of 7.5 cm and inter- row spacing of 90 cm. The plant population of 150 000 plant ha^{-1} was used. Seeds were placed 5cm below the soil. Topdressing was done using Lime ammonium nitrate (LAN) 28%N. Weeding was done manually at days after planting (34DAP) and harvesting was done manually at harvest maturity (between 115-120 DAP). The trial was irrigated once a week with 30 mm.

2.2. Growth and agronomic data

The effect of planting date on dry bean was monitored by collecting the following data: measuring the plant height, chlorophyll content and Leaf area index (LAI) at vegetative 34 days after planting (DAP) and reproductive stage 68 DAP). Plant height was recorded as the measurement from ground level to the apex of the growing point using tape measure. Chlorophyll content was assessed using a portable chlorophyll content meter (CCM-200, Opti Sciences, USA). The readings were taken from the highest fully developed leaf (3 leaves per plot). Leaf area index was measured using ACCUPAR Ceptometer model LP-80. Yield data (seed yield, 100 seed mass) was gathered from 1 m^2 (2 central rows) located in the center of the plot. The count of pods per plant and the count of seeds per plant were assessed from 10 randomly chosen plants per plot. The following data was collected at harvest: number of pods per plant, number of seeds per plant, 100 seed weight and seed yield, yield expressed at 10% moisture content. The daily average rainfall, minimum and maximum temperature were measured using an automatic weather station located at Towoomba Research station.

2.3. Statistical analysis

The analysis of variance was performed using General linear models of the Statistical Analysis System software (SAS, 2010). Means were compared using the Tukey's least of significance differences (LSD) test at 5% probability level. Correlation analysis was done using SAS to determine the relationship between parameters.

3. Results

3.1. Weather data

The average daily weather is presented in figure 1-3. The temperature data collected indicated that during both seasons (2017/2018 and 2018/2019) the average maximum temperature between 38 and 42 days after planting (DAP) was above the recommended which is below 30°C. Those are the times for effective flowering in dry beans. For 2017/2018 average maximum temperature was 30.7 and 32.4°C for the December and January treatments respectively. For 2018/2019 season the average maximum temperature was 31.8, 30.9 and 33.9 °C for the November, December and January treatments respectively. Several reports have indicated that dry bean is very sensitive to above 30°C during flowering (Omae *et al.* 2012; Gogoi *et al.* 2018). During 2017/2018 the January treatment received about 56 mm of rainfall during pod development which might have influenced higher grain yield (1.16t ha^{-1}) compared to December. December planted treatment received the rainfall of about 57 mm just after 90 DAP which was a little bit too much which might influence pod damage as it was towards the end of the growing season.

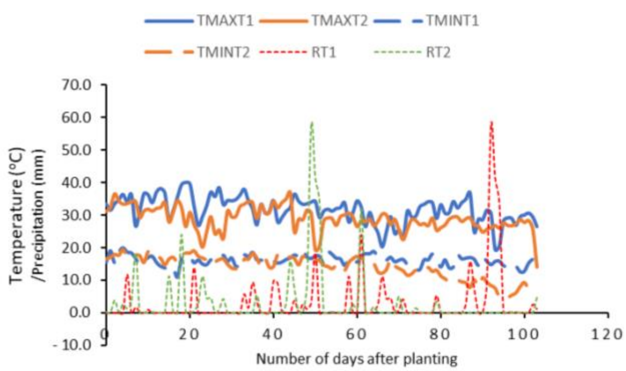

Figure 1. Daily average maximum and minimum temperature and rainfall data for 2017/2018 season. TMAX: Average maximum temperature, TMIN: Average minimum temperature, T1: December planting date, T2: January planting date, R: rainfall

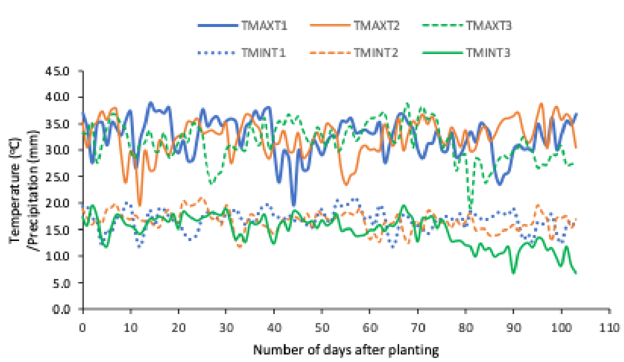

Figure 2. Daily average maximum and minimum temperature data for 2018/2019 season. TMAX: Average maximum temperature, TMIN: Average minimum temperature, T1: November, T2: December planting date, T3: January planting date, R: rainfall

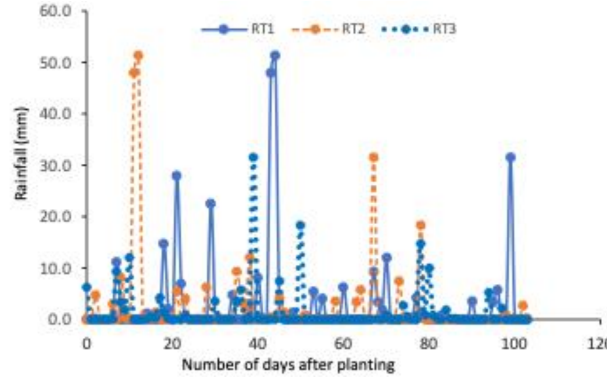

Figure 3. Dail average rainfall data for 2018/2019

3.2. Chlorophyll content

The chlorophyll content at 34 and 68 DAP was highly influenced by interaction relationship between dry bean varieties and planting time at P≤0.01 for 2017/2018. The highest chlorophyll content was found in Pan 123 planted in January (25.75) and the lowest from Kranskop planted in December (14.60) (Table 1) at 34 DAP. This could be due to a good rainfall received during vegetative stage for the treatment planted in January. During 68 DAP the highest chlorophyll content was found in Pan 123 planted in January (26.28) which was not significantly different from Kranskop planted in December (25.5). This might have resulted to good climatic conditions favouring increased photosynthetic rates.

The chlorophyll content during vegetative growth was influenced by interaction relationship between dry bean varieties and planting time at p≤0.01 for 2018/2019. The highest chlorophyll content was recorded on Pan 123 planted in January (20.73) followed by Kranskop planted in December (19.37) which was statistically similar to Kranskop planted in November (19.23) and Pan 123 planted in December (19.13) (Figure 4). The lowest was recorded from Kranskop planted in January (14.20) (Figure 3). The chlorophyll content during reproductive stages was highly influenced by the interaction relationship at P≤0.01 for 2018/2019. During reproductive stage, the highest chlorophyll content was found from Kranskop planted in December (26.37) and it was not significantly different from Pan 123 planted in November (25.07). The lowest chlorophyll content was found in Pan 123 planted in January (20.55) and it was not significantly different from Kranskop planted in January (20.83). There was a tendency of Kranskop producing higher chlorophyll content than Pan 123 throughout all the planting dates. The highest chlorophyll content on late planting dates was also reported in faba bean (El-Metwally *et al.* 2013). The chlorophyll levels during the reproductive phase were positively related to grain yield (0.845***), LAI (reproductive stage) (0.818***), number of seeds per pod (0.650**) and number of seeds per plant (0.534*).

3.3. Leaf area index

The LAI during both vegetative and reproductive stages was influenced by interaction relationship between dry bean varieties and planting time at p≤0.01 for 2018/2019. The highest LAI was found in Kranskop planted in

December (2.42) followed by Pan 123 planted in December (2.21). Pan 123 planted in December was statistically similar to Pan 123 planted in November (2.11). The lowest LAI was found from Kranskop planted in November (1.89) and it was statistically similar to Pan 123 planted in January (1.94) (Figure 5). During reproductive stage the highest LAI was found in Kranskop planted in December (3.51) and was statistically similar to Pan 123 planted in December (3.42) and Pan 123 planted in November (3.10). The lowest LAI was found in Kranskop planted in January (2.24) and it was statistically similar to Kranskop planted in November (2.36) (Figure 2). An opportunity for greater leaf area was presented by the December planting date's optimal conditions and temperatures, which encouraged cell division, expansion, and elongation. The significant variation in LAI have been reported in Maize (Hasson and Ahmed, 2025). LAI during vegetative stage was positively correlated with grain yield (0.931***), number of seeds per pod (0.716***) and number of seeds per plant (0.496*). LAI during reproductive stage was positively correlated with grain yield (0.787***) and number of seeds per pod (0.684**) (Table 3). LAI is correlated to yield and its parameters because is an important parameter responsible for intercepting solar radiation determining photosynthesis and final yield (Fageria and Santos 2010).

3.4. Plant height

The plant height during 34 DAP and 68 DAP for 2017/2018 was influenced by interaction relationship between dry bean varieties and planting time at P≤0.01 and P≤0.05, respectively. The results for 34 DAP plant height indicated that planting Kranskop and Pan in December reduced plant height by 37.22 and 14.82%, respectively (Table 1). This could be due to good rain received during vegetative stage for treatment planted in January. The plant height for 2018/2019 during vegetative and reproductive stage was highly influenced by interaction relationship between dry bean varieties and planting time at p≤0.01. Pan and Kranskop planted in November resulted in a 32 and 10% reduction in plant height during vegetative stage respectively (Figure 3). Planting Pan 123 and Kranskop in December also reduced plant height during vegetative stage by 56 and 49% respectively compared to January planting. For 2018/2019 planting Pan 123 in November and December resulted in a 21 and 5% reduction in plant height during reproductive stage respectively compared to Pan planted in January. On the other hand, planting Kranskop in November and December resulted in a 17 and 34% increase in plant height during reproductive stage respectively compared to Kranskop planted in January (Figure 6). During vegetative stage there was a tendency of increased plant height with delayed planting time for both seasons. Significant interaction between planting date x varieties on plant height have been reported in common bean (Nwadike and Terkimbi 2015), in soybean (Matsuo *et al.* 2016). The absence of planting date x varieties interaction was reported for plant height in tepary bean (Molosiwa and Kgokong 2018). Early planting date resulted in taller plants than later planting in groundnut (Arslan *et al.* 2022), green beans (Bala *et al.* 2022) and in dry beans (Bayrak *et al.* 2022; İpekeşen *et al.* 2022).

Table 1. Effect of the interaction between dry bean varieties and planting date on plant height , chlorophyll content, yield and yield componets for 2017/2018

Treatment	Plant height (34 DAP) (cm)	Plant height (68 DAP) (cm)	Chlorophyll content (34 DAP)	Chlorophyll content (68 DAP)	No. of pods $plant^{-1}$	No. of seeds $plant^{-1}$	Hundred Seed weight (g)	Grain yield ($t\ ha^{-1}$)
Pan Dec	33.50c	46.00b	17.55b	21.41b	15.00c	118c	29.0c	0.60c
Krans Dec	28.67c	55.67a	14.60c	25.5a	23.83b	114c	51.3b	0.54d
Pan Jan	39.33b	44.50b	25.75a	26.28a	29.83a	151a	26.0d	1.12b
Krans Jan	45.67a	52.83a	16.73bc	21.05b	11.00c	65d	61.5a	1.14a
Cv	11.82	9.7	11.71	2.7	20	0.9	2.66	1.43
LSD	5.35**	6.44*	2.69**	0.844**	4.99**	1.37**	1.151**	0.015**

Means of values in a column with the same letter are not significantly different, *: significant at p ≤ 0.05 **: significant at p ≤ 0.01; Pan: Pan 123; Krans: Kranskop; Dec: December; Jan: January; DAP: Days after planting

Table 2. Effect of dry bean variety and planting date on yield components and yield for 2018/2019 season

Treatment	Total dry matter	Harvest Index	Pods $plant^{-1}$	Seeds pod^{-1}	Seeds $plant^{-1}$	Shelling %	Hundred seed weight (g)	Yield ($t\ ha^{-1}$)
Pan Nov	73.33b	0.470c	52.17a	3.80b	198.33a	69.33b	19.67c	2.07d
Krans Nov	92.50a	0.601a	21.87c	3.46c	75.50c	66.00b	40.00b	3.59b
Pan Dec	41.50c	0.484c	30.93b	4.14a	128.33b	72.67b	18.67c	3.85b
Krans Dec	71.17b	0.382d	21.83c	4.28a	92.00c	80.67a	52.67a	4.97a
Pan Jan	39.17c	0.538b	26.23bc	3.63bc	92.67c	70.00b	19.67c	2.61c
Krans Jan	70.83b	0.560ab	11.43d	3.59bc	40.83e	70.00b	51.33a	1.28e
$LSD_{0.01}$	2.64	0.049	4.94	0.324	20.39	7.68	6.43	0.281

Means of values in a column with the same letter are not significantly different, LSD: Least significant difference, Pan Nov: Pannar 123 planted in November, Krans Nov: Kranskop planted in November, Pan Dec: Pannar 123 planted in December, Krans Dec: Kranskop planted in December, Pan Jan: Pannar 123 planted in January, Krans Jan: Kranskop planted in January.

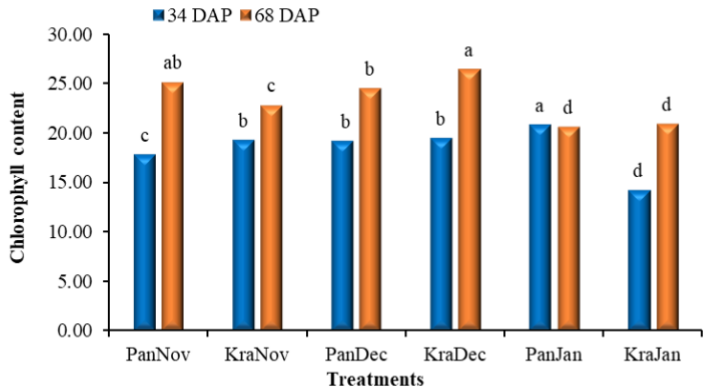

Figure 4. Effect of dry bean variety and planting date on chlorophyll content. Means of bars of the same number of days after planting with the same letter are not significantly different. PanNov: Pannar 123 planted in November, KraNov: Kranskop planted in November, PanDec: Pannar 123 planted in December, KraDec: Kranskop planted in December, PanJan: Pannar 123 planted in January, KraJan: Kranskop planted in January

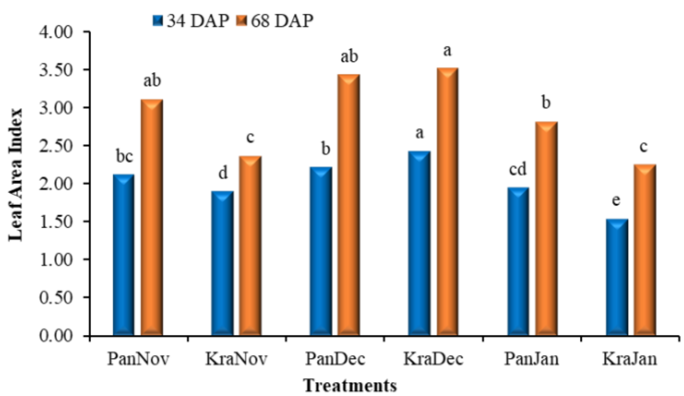

Figure 5. Effect of dry bean variety and planting date on Leaf Area Index. Means of bars of the same number of days after planting with the same letter are not significantly different. PanNov: Pannar 123 planted in November, KraNov: Kranskop planted in November, PanDec:Pannar 123 planted in December, KraDec:Kranskop planted in December, PanJan:Pannar 123 planted in January, KraJan:Kranskop planted in January.

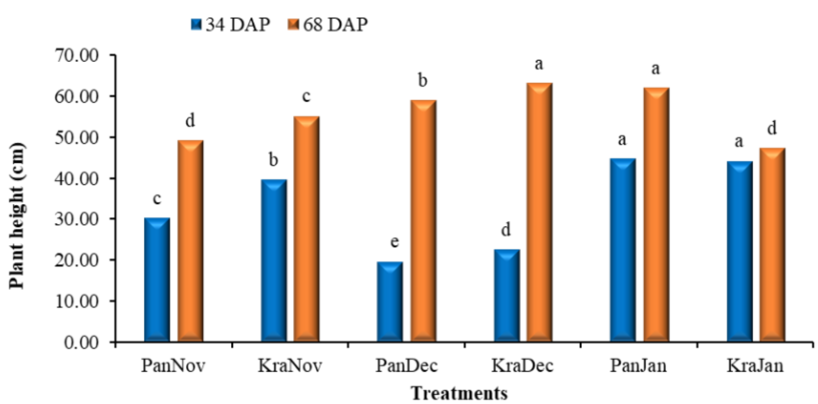

Figure 6. Effect of dry bean variety and planting date on plant height. Means of bars of the same number of days after planting with the same letter are not significantly different. PanNov: Pannar 123 planted in November, KraNov: Kranskop planted in November, PanDec:Pannar 123 planted in December, KraDec:Kranskop planted in December, PanJan:Pannar 123 planted in January, KraJan:Kranskop planted in January.

3.5. Dry matter yield

The results revealed that during 2018/2019 dry matter yield was highly influenced by the interaction relationship between dry bean varieties and planting time at p≤0.01. When Pan and Kranskop were plated in November dry matter yield was increased by 87 and 30% respectively compared to when planted in January (Table 2). The results also indicate that planting Pan 123 and Kranskop in December resulted in a non -significance difference in dry matter yield compared to January planting. Higher dry matter yield with early planting was reported in lentil (Maphosa *et al.* 2023), faba bean (Ghareeb *et al.* 2023) and chickpea (Richards *et al.* 2022).

3.6. Harvest Index (HI)

The HI for 2018/2019 was influenced by interaction relationship between dry bean varieties and planting time at p≤0.01. The results revealed that planting Pan 123 in November and December significantly reduced the HI by 13 and 10% respectively compared to when planted in January (Table 2). Planting Kranskop in November resulted in HI statistically similar to January planting. When Kranskop was planted in December HI was reduced by 31%. High HI may be due to the leaves and aborted pods that abscise and fell to the ground and was not collected (Pinto Junior *et al.* 2018). Early planting resulted in low harvest index in chickpea (Richards *et al.* 2022).

3.7. Number of pods per plant

The interaction between timing of planting and the dry bean varieties had a significant impact on the number of pods on each plant at p≤0.01 during both seasons 2017/2018 and 2018/2019. The highest number of pods during 2017/2018 was produced by Pan 123 planted in January (29.83) followed by Kranskop planted in December (23.83) (Table 1). The highest number of pods during 2018/2019 was found in Pan 123 planted in November (52.17) followed by Pan 123 planted in December (30.93) which was statistically similar to Pan 123 planted in January (26.23) (Table 2). The number of pods per plant for Kranskop planted in November (21.87) and December (21.83) were not significantly different. The lowest number of pods per plant was produced by Kranskop planted in January (11.43). The combined analysis indicated that the highest number of pods per plant were produced by Pan 123 planted during November 2018 (52) (Table 3). The results suggest that earlier planting increased the number of pods per plant for all varieties. Number of pods positively correlated with number of seeds per plant (0.974***). Earlier planting resulted in the highest number of pods per plant in bush bean (Subedia *et al.* 2024), French bean (Datta *et al.* 2023) and soybean (Mandić *et al.* 2020; Jarecki and Bobrecka-Jamro 2021).

3.8. Number of seeds per pod

The results presented in Table 2 indicates that the number of seeds per pods was highly influenced by interaction relationship between dry bean varieties and planting time at p≤0.01 for 2018/2019. Planting Kranskop and Pan 123 in December increased number of seeds per pod by 19 and 14% respectively. For both Kranskop and Pan 123 the January plantings produced number of seeds per pod which was not significantly different from the November plantings. The number of seeds per pod (2018/2019) positively correlated with grain yield (0.819***), LAI vegetative stage (0.716***), LAI reproductive stage (0.685**), chlorophyll content reproductive stage (0.651**) and plant height vegetative stage (0.595**) (Table 3). The results suggest that higher number of pods resulted from higher leaf area which allows for high photosynthetic rates leading to high number of seeds per pod.

3.9. Number of seeds per plant

The number of seeds per plant for both seasons (2017/2018 and 2018/2019) was highly influenced by interaction relationship between dry bean varieties and planting time at p≤0.01. The highest number of seeds per plant was produced by Pan 123 planted in January for both seasons. The highest number of seeds per plant during 2017/2018 was found in Pan 123 planted in January (151), followed by Pan 123 planted in December (118) (Table 1). The highest number of seeds per plant during 2018/2019 was found in Pan 123 planted in November (198.33), followed by Pan 123 planted in December (128.33) (Table 2). The lowest number of seeds per plant was produced by Kranskop planted in January (40.83). The combined analysis indicated that The highest number of seeds per plant were produced by Pan 123 planted during November 2018 (198). This might be due to increased photosynthetic activity indicated by high chlorophyll content. The number of seeds per plant during 2018/2019 was positively correlated with number of pods per plant (0.974***), chlorophyll content (reproductive stage) (0.534*), grain yield (0.530*) and LAI (vegetative stage) (0.493*) (Table 4). The previous reports indicated that the earlier planting produced the highest number of seeds per plant in dry beans (İpekeşen *et al.* 2022) and marigold (Mohanty *et al.* 2015).

3.10. Hundred seed weight

The hundred seed weight was highly influenced by interaction relationship between dry bean varieties and planting time at p≤0.01 for both seasons (2017/2018 and 2018/2019). Planting Kranskop in January resulted in the highest hundred seed weight (61.5g) during 2017/2018 (Table 1). Planting Pan 123 in November, December and January resulted in a statistically similar hundred seed weight during 2018/2019. On the other hand for 2018/2019, planting Kranskop in November resulted in a 22% reduction in hundred seed weight compared to January planted (Table 2). Planting Kranskop in December resulted in a statistically similar hundred seed weight to January planted Kranskop. The highest hundred seed weight was produced by Kranskop planted in January 2018 (61.50) and the lowest by Pan 123 planted in December 2018 (18.67) (Table 3). Previous reports indicated that hundred seed weight was significantly affected by planting date x variety interaction in soybean (Ibrahim, 2012; Matsuo *et al.* 2016), common bean (Nwadike and Terkimbi 2015). Varieties x planting date interaction was not significant for hundred seed weight in tepary bean (Molosiwa and Kgokong 2018). Planting during December reduced hundred seed weight as compared to January plantings in tepary bean (Molosiwa and Kgokong 2018).

3.11. Grain yield

During 2017/2018 the grain yield was influenced by the interaction relationship between dry bean varieties and planting time at P≤0.01. The highest grain yield was found in Kranskop planted in January (1.14t ha^{-1}) and the lowest by Kranskop planted in December for 2017/2018 (Table 1). Planting during December reduced seed yield as compared to January plantings in tepary bean (Molosiwa and Kgokong 2018). Previous report has indicated that early planting increased soybean grain yields (Ibrahim 2012). Cultivar yield was influenced by planting date in soybean (Robinson et al. 2009). The grain yield was highly influenced by interaction relationship between dry bean varieties and planting time at p≤0.01 in 2018/2019. The highest grain yield was found in Kranskop planted in December (4.97t ha^{-1}) followed by Pan 123 planted in December (3.85t ha^{-1}) which was statistically similar to Pan 123 planted in November (3.59t ha^{-1}) (Table 2). The lowest grain yield was produced by Kranskop planted in January (1.28t ha^{-1}). The combined analysis indicated that the highest grain yield was produced by Kranskop planted in December 2018 (4.97) and the lowest was produced by Kranskop planted in December 2017 (Table 3).

The high yield produced by Kranskop planted in December was due to higher chlorophyll content reproductive stage (0.845***), number of seeds per pod (0.818***), LAI vegetative stage (0.787***), LAI reproductive stage (0.787***) and number of seeds per plant (0.531*) (Table 4). Previous reports indicated that grain yield was significantly affected by planting date x variety interaction in common bean (Nwadike and Terkimbi 2015) and in soybean (Matsuo *et al.* 2016). Early planting increased yield in canola (Ahmadi and Sarhangi 2025), dry bean (Mashiqa *et al.* 2019), French bean (Datta *et al.* 2023) and faba bean (Sellami *et al.* 2021; Manning *et al.* 2020). The high LAI results in high transpiration and solar radiation interception leading to high photosynthetic rates resulting in high yield (Mashiqa *et al.* 2019).

Table 3. Effect of dry bean variety and planting date on yield components and yield for the combined analysis of 2017/2018 and 2018/2019 season

Treatment	No. of pods $plant^{-1}$	No. of seeds $plant^{-1}$	Hundred seed weight (g)	Grain yield (t ha^{-1})
Pan Dec 2017	29.83b	118.33c	51.33b	0.603g
Krans Dec 2017	23.83c	114.00c	29.00d	0.548g
Pan Jan 2018	13.00d	151.00b	26.00d	1.12f
Krans Jan 2018	11.00d	65.17e	**61.50a**	1.14f
Pan Nov 2018	**52a**	**198.33a**	19.67e	2.07e
Krans Nov 2018	22.17c	75.50d	40.00c	3.59c
Pan Dec 2018	30.67b	128.33c	18.67e	3.85b
Krans Dec 2018	22.00c	92.00d	52.67b	**4.97a**
Pan Jan 2019	26.17bc	92.67d	19.67e	2.61d
Krans Jan 2019	11.67d	40.83f	51.33b	1.28f
$LSD_{0.01}$	4.614	15.11	4.62	0.20
Cv	16.37	12.07	7.28	5.44

Means of values in a column with the same letter are not significantly different, LSD: Least significant difference, Pan Nov: Pannar 123 planted in November, Krans Nov: Kranskop planted in November, Pan Dec: Pannar 123 planted in December, Krans Dec: Kranskop planted in December, Pan Jan: Pannar 123 planted in January, Krans Jan: Kranskop planted in January.

Table 4. Correlation analysis results for 2018/2019

	Yield	PHV	PHR	CHLV	CHLR	LAIv	LAIr	TDM	HI	PODS	SEEDS	Seedpod	HSW
Yield	1.000												
PHV	0.311	1.000											
PHR	-0.286	-0.350	1.000										
CHLV	-0.510	-0.254	**0.814**	1.000									
CHLR	**0.845**	0.150	0.020	-0.335	1.000								
LAIv	**0.930**	0.216	-0.197	-0.412	**0.817**	1.000							
LAIr	**0.787**	0.330	-0.209	-0.250	**0.663**	**0.864**	1.000						
TDM	-0.209	-0.446	0.289	-0.109	0.195	-0.171	-0.341	1.000					
HI	0.275	**0.814**	-0.203	-0.023	0.131	0.081	0.236	-0.575	1.000				
PODS	0.415	-0.513	0.275	0.205	0.450	0.398	0.382	-0.084	-0.130	1.000			
SEEDS	**0.530**	-0.405	0.261	0.162	**0.534**	**0.493**	0.457	-0.128	-0.043	**0.974**	1.000		
Seedpod	**0.819**	**0.595**	-0.281	-0.409	**0.651**	**0.716**	**0.685**	-0.298	**0.480**	0.097	0.274	1.000	
HSW	-0.126	0.330	-0.312	-0.491	0.035	-0.181	-0.246	**0.585**	0.016	-0.692	-0.678	0.008	1.000

PHV: Plant height during vegetative stage, PHR: Plant height during reproductive stage, CHLV: Chlorophyll content during vegetative stage,CHLR: Chlorophyll content during reproductive stage, LAIv: Leaf area index during vegetative stage, LAIr: Leaf area index during reproductive stage, TDM: Total dry matter, HI: Harvest index, PODS: number of pods per plant, SEEDS: number of seeds per plant, Seedpod: number of seeds per plant, HSW: Hundred seed weight

4. Conclusion

The planting time plays an important role in dry bean production. There was a significant effect of variety x planting date interaction relationship on plant height, chlorophyll content, number of pods per plant, number of seeds per plant, hundred seed weight and grain yield. The results indicated that the highest number of pods per plant (52) and number of seeds per plant (198) were produced by Pan 148 planted in November while the highest grain yield was produced by Kranskop (4.97 t ha^{-1}) planted in December 2018. The best planting date for both varieties (Pan 123 and Kranskop) can be suggested to be December looking at the results of the present study.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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