GROWTH AND YIELD RESPONSE OF CHICKPEA TO PLANTING DATE UNDER DIFFERENT WATERING REGIMES

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Abstract

This study aimed at assessing the effect of planting date on the growth and yield of chickpea. Two field experiments were undertaken using a split plot design with planting dates (1, 14 and 28 May 2014; early, medium and late, respectively) as main plots and chickpea cultivar (Range 1, Range 3, Range 4 and Range 5) as subplots. Experiment I was well watered (weekly irrigation) while Experiment II was irrigated on three occasions: at planting, flowering and podding. Soil moisture content was determined at 7-day interval using a neutron probe, and crop biomass and grain yield determined at harvest maturity. Grain yield was greater with early than medium and late planting probably due to longer duration of vegetative growth and seed filling period with early planting. Soil moisture content at 30-90 cm depth varied with planting date. Clearly, planting date affects chickpea productivity in the study site.

Key words: *chickpea, crop biomass, soil moisture content, planting date*

1. INTRODUCTION

Chickpea (*Cicer arietinum*) is one of the most important grain legumes in the world. The crop is being introduced in South Africa with the objective to increase the resilience of South African farmers to the impacts of drought and climate change. Climate change forecasts have shown that temperatures in North-Eastern part of South Africa, will increase by 3 - 4 ^{o}C, whilst rainfall will decrease by 15 - 20 % by the year 2100 (IPCC 2007; Waha et al. 2012; Webber et al. 2014). Farmers' perceptions on climate change in the region concur with scientific forecasts that the cropping season is getting shorter, and that crop productivity is decreasing (Koochki et al. 2006). Growing fears are that the predicted climate change may lead to worsening drought conditions and moisture stress, especially in dry environments, resulting into decreased productivity of crops. Also, the envisaged climate change is likely to lead not only to shifts in cropping seasons but also shortening of the seasons. Therefore management practices such as choice of crop genotypes and manipulation of planting dates may be important adaptation strategies for ameliorating effects of climate change on crop productivity especially in dry environments such as NE South Africa.

Although several adaptation strategies to minimise the impacts of climate change have been suggested (Webber et al. 2014), few studies (e.g. Waha et al. 2012) have looked at the importance of planting dates in improving the productivity of chickpea in water limiting conditions. Moreover, information on the interactive effect of planting dates and chickpea genotypes on yield components of chickpea such as number of pods per plant, pod weight and seed weight under varying water regimes is still limiting. The effect of planting date on chickpea yield has also been shown to vary with moisture availability (Piggin et al. 2015). However, some studies have suggested that planting date could be used as an adaptation strategy to ameliorate the effects of moisture stress on chickpea productivity (Regan et al. 2006) but the results have been largely inconclusive and not exhaustive enough for making farming decisions.

Use of inappropriate planting dates may expose farmers to the risk of crop failure and is likely to have a negative effect on chickpea crop water use and yield development. There are currently no

recommended planting dates for chickpea in South Africa. Thus appropriate planting dates for chickpea need to be developed not only for current climate scenario but also for climate change scenarios. Therefore this study aimed at assessing the effect of planting date on the growth and yield of four chickpea cultivars under two different moisture regimes in one location that is representative of the dry environments of the north eastern part of South Africa.

2. MATERIALS AND METHODS

2.1. Study site

The study was conducted at the University of Venda's experimental farm, which is situated at Thohoyandou (22° 58.081'S, 30° 26,411'E and 595 m asl), Limpopo Province, South Africa. The site is characterized by a highly variable annual rainfall of around 500 mm that falls mainly in summer, and average maximum and minimum temperature of 31 ^{o}C and 18 ^{o}C, respectively (Tadross et al. 2006). The soils at the site are predominantly deep, well drained clays with slightly acidic pH (Soil classification working group, 1991).

2.2. Experimental design

Two field experiments, laid out as a split plot design with planting date (1, 14 and 28 May 2014; being early, medium and late, respectively) as main plots (12 m^2) replicated three times and chickpea cultivar (Range 1, Range 3, Range 4 and Range 5) as subplots were conducted during the 2014 winter season. Experiment I was well watered (weekly irrigation) while Experiment II was subjected to periods of water stress (only irrigated on three occasions: at planting, flowering and initiation of podding). Range 1, Range 2, Range 3 and Range 5 are desi chickpea types. Sowing was done manually in rows that were 30 cm apart at seed rates which provided crop stands denser than the target density. Both experiments were thinned to the target plant density (33 plants per m^{-2}) at 14 days after emergence (DAE). There are no planting density recommendations currently available for chickpea in this region. Therefore the planting density used in the current study was based on earlier studies at the same site showing that grain yield was greater at 33 plants m^{-2} compared to 20 and 25 plants m-2 in summer sowing while in winter sowing greater (though non-significant) grain yield was obtained at 25 plants m^{-2} (Thangwana and Ogola 2012). Nitrogen (N) was applied in the form of Limestone Ammonium nitrate (LAN 28 % N) at a rate of 50 kg N ha^{-1} and phosphorus (P) was applied in the form of Single Superphosphate (SSP 20.3% P) at a rate of 90 kg P ha^{-1}. The P fertilizer rate was based on findings of Madzivhandila et al. (2012). The plots were kept weed-free throughout the season.

2.3. Data collection

Soil water content was measured at 7 days interval using a neutron probe. Measurements were taken between 4 and 22 weeks after emergence (WAE) in both experimens. On each occasion the probe was lowered in access tubes inserted 1.3 m deep in each experimental plot soon after crop emergence. The 16-second counts readings were taken at 30, 60 90 and 120 cm depths. Prior to each day's measurements, a standard count was taken and used to calculate count ratios (count readings/standard count). Volumetric water content (Qv) at each depth was calculated using the calibration equations (equations 1-3) for the site (Thangwana MN personal communication).

0.30 m depth: $Qv = 0.0818x + 0.0268$ 1

0.60 m depth: $Qv = 0.3227x - 0.2733$ 2

0.90 m depth: $Qv = 0.3736x - 0.3297$ 3

Where x is the count ratio.

Crop biomass and grain yield were determined at harvest maturity in both experiments. All the plants from 0.6 m^2 of two guarded innermost rows of each experimental plot were cut at ground level. The

pods were removed from all harvested plants and the shoots were dried at 65°C for 48 hours to obtain total shoot dry weights. Pods were dried, threshed and seeds from threshed pods were weighed to obtain grain yield (g m^{-1}). Sub-samples of the seeds were used to determine 100 seed weight (100-SW).

All data were subjected to analysis of variance (ANOVA) using Genstat 16th Edition. Significant difference between treatments was determined at 5% level, using the least significant difference of the means (LSD).

3. RESULTS AND DISCUSSION

3.1. Crop biomass, grain yield and yield components

The effect of planting date and genotype on seed weight, pod weight, number of pods per plant, harvest index and grain yield was significant ($P<0.05$) in experiment 1 (Table 1). In contrast, crop biomass varied with planting date but not genotype in experiment 1 (Table 1). Similarly, planting date affected seed weight, pod weight, number of pods per plant, and grain yield in experiment 2 (Table 2). Grain yield was greater with early planting compared with medium and late planting in both experiments. The greater grain yields with early planting could be due to longer growing season and grain filling period (Regan et al. 2006). The lowest grain yield recorded in the late planting plots was probably due to the observed shorter duration of vegetative growth. Variation in grain yield with planting date has been reported in chickpea (Singh and Saxena 1996; Gan et al. 2003; Regan et al. 2006; Mathews et al. 2011; Piggin et al. 2015) and other crops (Kerr et al. 1992; Jin et al. 2014; Ozturk, et al. 2014; Richards et al. 2014).

The crop biomass, grain yield, number of pods per plant and pod weight was lower under water-stress conditions compared with full irrigation as expected suggesting that a reduction in rainfall with climate change may lead to significant decrease in chickpea productivity in dry environments of South Africa. Similar findings have been reported elsewhere (Ghassemi-Golezani, Ghassemi & Bandehhg 2013). Although grain yields were substantially lower under water-stress experiment than in the well-watered one, it has been argued that attainable yields by chickpea under dry conditions are economically significant when compared to other crops (Regan 2006). Therefore it is plausible to identify chickpea as adapted to moisture stress and could be important as part of adaptation strategy against the expected huge decrease in rainfall in Southern Africa due to climate change (IPCC 2007). We thus propose further field experiments and simulation of the effects of planting date and genotype under varying climatic scenarios.

Table 1. Response of crop biomass, grain yield and yield components to genotype and planting date in experiment 1 (well-watered)

Treatment	**Seed weight per plant (g)**	**Log Biomass (g/m)**	**Number of pods per plant**	**Pod weight (g)**	**Harvesting index %**	**Yield (g/m)**
Planting Date						
Early	25.36 a	2.767 a	70.6 a	19.4 a	55 a	384 a
Normal	23.14 ab	2.161 b	40.8 b	24.6 a	47 b	247 b
Late	22.02 b	1.676 c	52.2 b	12.3 b	36 c	149 c
p-value	*0.007**	*<0.001**	*0.028**	*<0.001**	*<0.001**	*<0.001**
Lsd	*1.864*	*0.4013*	*15.18*	*6.67*	*5.78*	*75.9*
Plant						

Genotype						
Range 1	21.08 a	2.055	57.0 ab	20.0	52 a	317
Range 3	25.72 b	2.180	68.8 b	20.1	50 a	303
Range 4	21.75 a	2.257	50.3 a	18.0	46 b	296
Range 5	25.47 b	2.312	42.1 a	16.9	42 c	270
Mean	*23.51*	*2.201*	*54.5*	*18.8*	*48*	*297*
p-value	*<0.001**	*0.692*	*<0.001**	*0.717*	*<0.001**	*0.653*
Lsd	*2.152*	*0.4633*	*17.52*	*5.78*	*5.84*	*65.8*
CV%	*9.5*	*21.6*	*28.3*	*26.9*	*13.6*	*28.4*

*Significant at 5% level

Means in the same column followed by the same letter are not significantly different.

Table 2. Analysis of variance for parameters measured on chickpea under dry land conditions

Treatment	**Seed weight per plant (g/m)**	**Log Biomass per plant (g/m)**	**Number of pods per plant**	**Pod weight (g)**	**Yield (g/m)**
Planting Date					
Early	20.9 a	2.218	56.9 c	18.4 b	189.1 b
Normal	23.5 b	2.105	42.3 b	17.9 b	180.9 b
Late	21.9 ab	1.959	26.8 a	11.7 a	71.1 a
p-value	*0.016**	0.290	*<0.001**	*0.037**	*<0.001**
Lsd	*1.726*	0.3297	*13.17*	*5.58*	*59.8*
Plant Genotype					
Range 1	23.4	2.147	45.0	16.4	169.9
Range 3	22.2	2.116	47.8	18.2	141.0
Range 4	20.9	1.794	35.4	13.3	138.0
Range 5	22.0	2.219	39.9	16.0	139.3
Mean	*22.1*	*2.094*	*42.0*	*16.0*	*147.0*
p-value	*0.097*	*0.091*	*0.365*	*0.487*	*0.741*
Lsd	*1.993*	*0.3807*	*15.21*	*6.62*	*69.0*
CV%	*9.3*	*18.9*	*27.1*	*21.4*	*28.2*

*Significant at 5% level.

Means in the same column followed by the same letter are not significantly different.

3.2. Soil moisture content

There was no significant effect of genotype and planting date on soil moisture content at the 30 and 120 cm depths in both experiments. In contrast, soil moisture content at the 60 and 90 cm depths varied with planting date and genotype in both experiments, probably due to similar variation in water extraction by plants. Total moisture extraction from the entire profile was greater with the early planting compared with the medium and late planting date (Fig 1). This variation in soil moisture extraction was similar to the variation in grain yield and could partly be due to longer growing season with early planting as well as variation in root system development among genotypes. Ogola and Thangwana (2013) similarly reported an association of greater grain yield in chickpea with greater soil moisture extraction especially in the 60 cm soil depth.

a) Irrigation b) Dryland

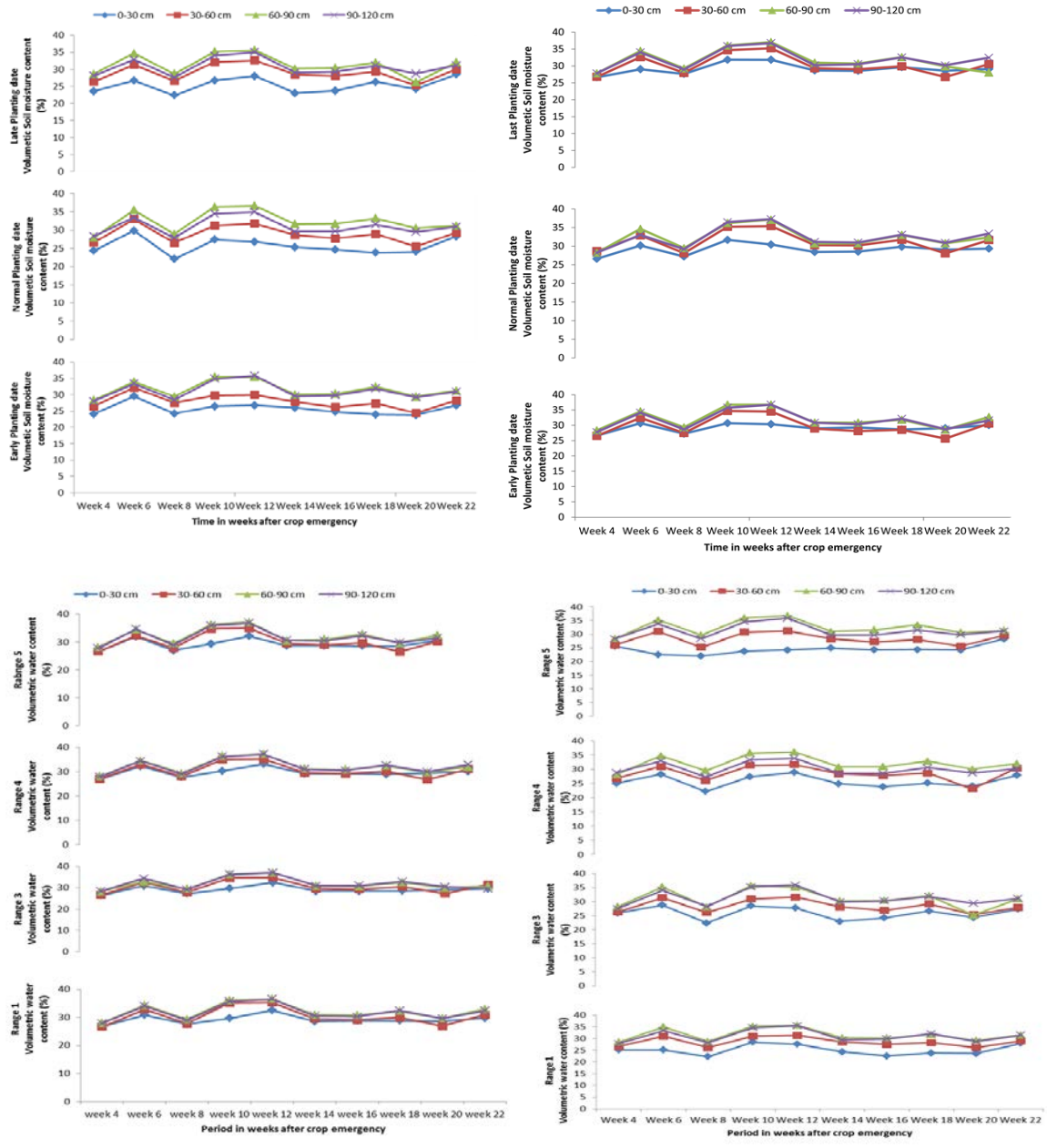

Fig 1. Response soil moisture content (mm) to genotype and planting date under well-watered (a) and water-stressed (b) conditions.

4. CONCLUSION

Clearly, these preliminary findings show the importance of planting date in affecting chickpea productivity in the study site. We propose to conduct further field experiments and to simulate the effects of different planting dates under various climate change scenarios before making definite conclusions.

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