Water Use and Water Use Efficiency of Field Pea and Chickpea Under the Semiarid Canadian Prairie Conditions

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INTRODUCTION

Diversification and intensification of cropping systems in the semiarid Canadian prairie are increasing adoption of grain legumes (Zentner et al. 2002). The main advantage of pulses in a cropping system is their ability to fix atmospheric N. Other benefits include breaking disease cycles, improving soil physical conditions, encouraging mycorrhizal growth and mobilization of soil phosphorous source (Subbarao et al. 1995). Chickpea is a relatively new crop on the Canadian prairie. Chickpea is a drought tolerant, cool season legume, which has been grown in semiarid regions around the world for centuries. Chickpea grown in Canada can be classified into large-seeded kabuli, small-seeded kabuli, and desi chickpea. Seed size of chickpea ranges from 170 mg in desi chickpea to 550 mg in large-seeded kabuli chickpea and varies with cultivars. Therefore, optimizing plant stand can significantly reduce cost of production, enhance seed yield and maximize net returns (Gan et al. 2003).

Water is the most important abiotic factor limiting crop productivity in the semiarid regions. Chickpea, like many other pulse crops, grows slowly in the early season. The bare soil early in the spring can increase evaporation fraction of seasonal water use. In addition, lack of crop competition early in the season can increase the weed problem (Siddique et al. 1998). Therefore, early ground cover through higher plant population may improve the efficiency of the crop water use. The optimum plant population for a crop in the semiarid environment depends on the growing environment. Therefore, proper understanding of water extraction patterns in response to population variations under fallow and stubble phase is needed for these crops.

The objectives of this study were to (i) examine water extraction patterns, water use efficiency and residual soil moisture in desi and kabuli chickpea in comparison to field pea under stubble and field phases; 2) determine effect of plant population on water extraction patterns, water use efficiency and residual soil moisture in desi and large-seeded kabuli chickpea compared to field pea.

MATERIALS AND METHODS

Field experiments were conducted from 1998 to 2000 at Swift Current (50.2 °N, 107.4 °W) and 1999 to 2000 at Stewart Valley (50.6 °N, 107.8 °W) in southwest Saskatchewan. The treatments consisted of three factors: 1) crops, 2) plant population densities, and 3) field phases. Two market classes of chickpea and a dry pea were used for this trial; a) large-seeded kabuli chickpea (Dwelley and Sanford in 1998; CDC Xena in 1999 and 2000) b) desi chickpea (Myles in all site years) c) field pea (Carrera, a semi-leaflets cultivar with yellow cotyledons). Four seeding rates were used to obtain target population of 20, 30, 40 and 50 plants m^{-2} for chickpea and 35, 50, 65 and 80 plants m^{-2} for dry pea. Actual seed rates were base on seed size, pre-seed germination and an estimated field emergence rate of 75%. At each site-year, factorial combinations of crop types and population were arranged in a randomized complete block design with four replications. All treatment combinations were tested on both wheat stubble and on conventional summer fallow. Plots were seeded between May 2nd (2000, Swift Current) and May 20th (1999, Stewart Valley). Soil temperatures at 10 cm depth at seeding ranged between 9 and 13 °C. Each plot was 7.5 m long and consisted of 10 rows at 0.20 m apart. All plots received 5.5 kg ha^{-1} of granular >Nitragin=, an appropriate soil implant *Rhizobium* inoculant for symbiotic N fixation (Lipha Tech Inc. Saskatoon, Canada). Pre-seeding and post-harvest soil moisture content was measured with gravimetric method. Water use efficiency was calculated as the ratio of the seed dry weight to the total water use.

RESULTS AND DISCUSSION

Both kabuli and desi chickpea extracted more soil water than field pea (Fig.1). Water extraction under stubble condition was significantly lower than under fallow. Even under stressful stubble conditions, chickpea extracted 9 to 11 mm more soil water than field pea. The greater water extraction of chickpea below 0.30 m layer was responsible for the difference. Plant population had no effect on soil moisture extraction in any of the soil layers examined regardless of field phases. Crop by population interaction was not significant, indicating similar responses by chickpea and field pea.

Desi and Kabuli chickpea used 5 to 16% more water than field pea under fallow conditions (Fig. 1). Similarly, chickpea used more water than pea under stubble conditions, but the differences were not statistically significant. Plant population had no effect on water use. As the water availability increased (stubble and fallow comparisons), all crops increased water use but the increase in field pea was the lowest. For example, at Swift Current, fallow phase increased water use by 50 mm in chickpea, while field pea increased 43 mm. At Stewart Valley chickpea increased water use by 20-30 mm under fallow compared to stubble, while field pea had no difference. In spite of less efficient root system, field pea recorded highest water use efficiency compared to both chickpeas. The differences in water use efficiencies between desi and kabuli were marginal, and were inconsistent across different site-years.

Increasing plant population tended to increase water use efficiency, although it was significant only under stubble conditions at Stewart Valley. The increased water use efficiency, without improvement in water extraction and water consumption, indicates that efficiency of water use in pulses can be improved by using higher plant population to cover ground quickly, thus reducing fraction of evaporation in evapotranspiration. Field pea and chickpeas possess plasticity. At lower population, plants try to compensate by producing more branches and fruits per branch. However, plasticity depends on growing environment. This explains the reason for getting population response under stressful stubble conditions.

Field pea had significantly more soil moisture left after harvest than chickpea crop in both stubble and fallow phases. There was no difference among crops in 0.0-0.15 and 0.15- 0.30 m layers. The major difference was in 0.30-0.60 and 0.60-0.90 m layers. Plant population had no effect on residual soil moisture. No significant difference between fallow and stubble phases for residual soil moisture indicates that all crops utilized most of the available moisture during the growing season.

SUMMARY

Desi and kabuli chickpea used more soil moisture than field pea in both fallow and stubble phases. The inability of field pea to root deeper when conditions warrant was the main reason for the difference. However, field pea used the limited soil moisture more efficiently than chickpeas. Plant population had no effect on water extraction or water use, but higher plant population increased water use efficiency by increasing the seed yield produced per unit of available water. More leaf area with higher population covered ground surface early to reduce evaporation. Field pea had more post-harvest residual soil moisture, mainly in 0.60 to 0.90 m layers. This may produce some rotational advantages.

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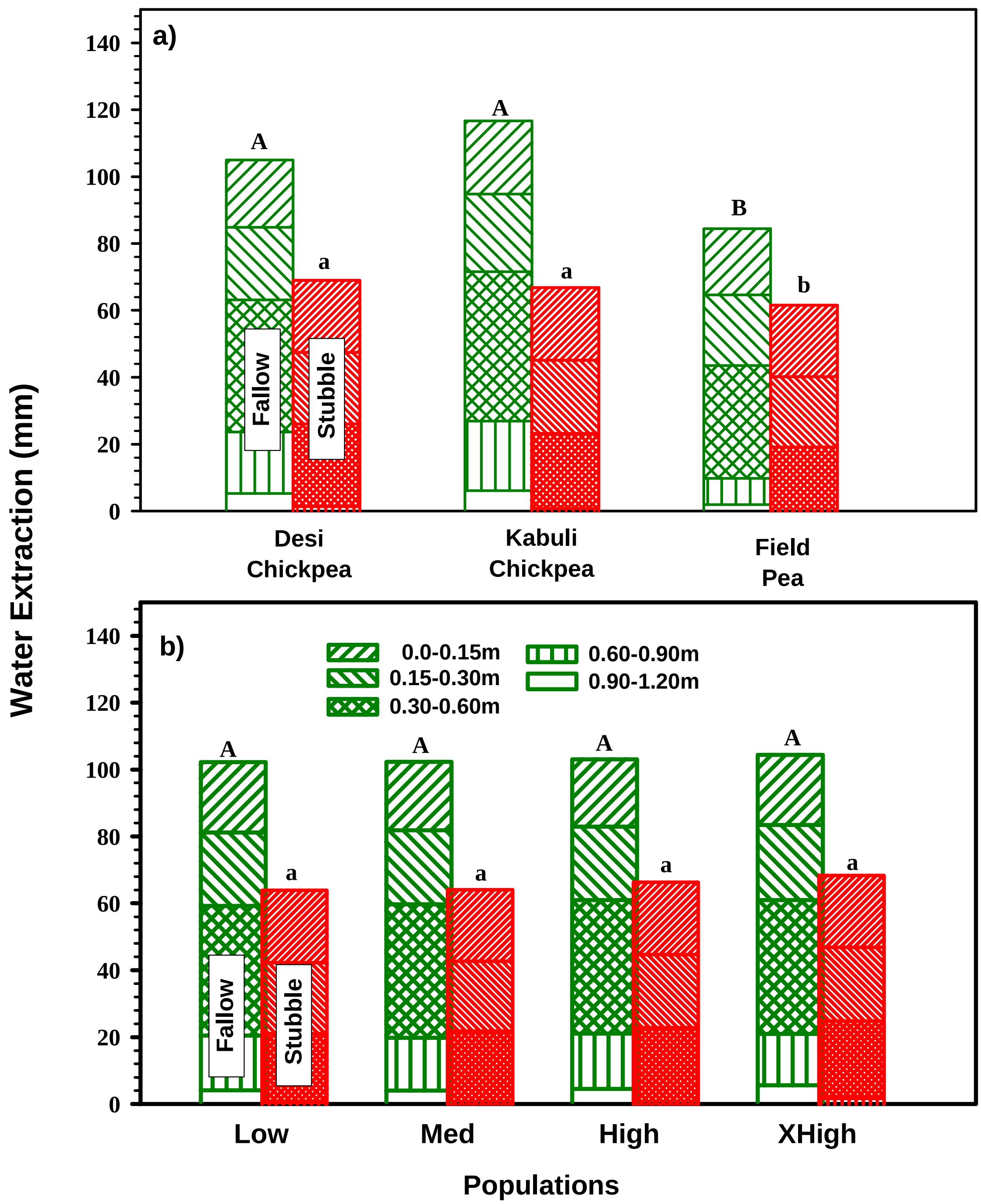

Fig 1. Soil water extraction by chickpea and field pea grown on conventional summer fallow and on wheat stubble at Swift current and Stewart Valley over five site-years between 1998 and 2000. a). Differences among crops across plant populations. b). Effect of plant population. Bars within stubble or fallow were not different when alphabets on top of them were same.

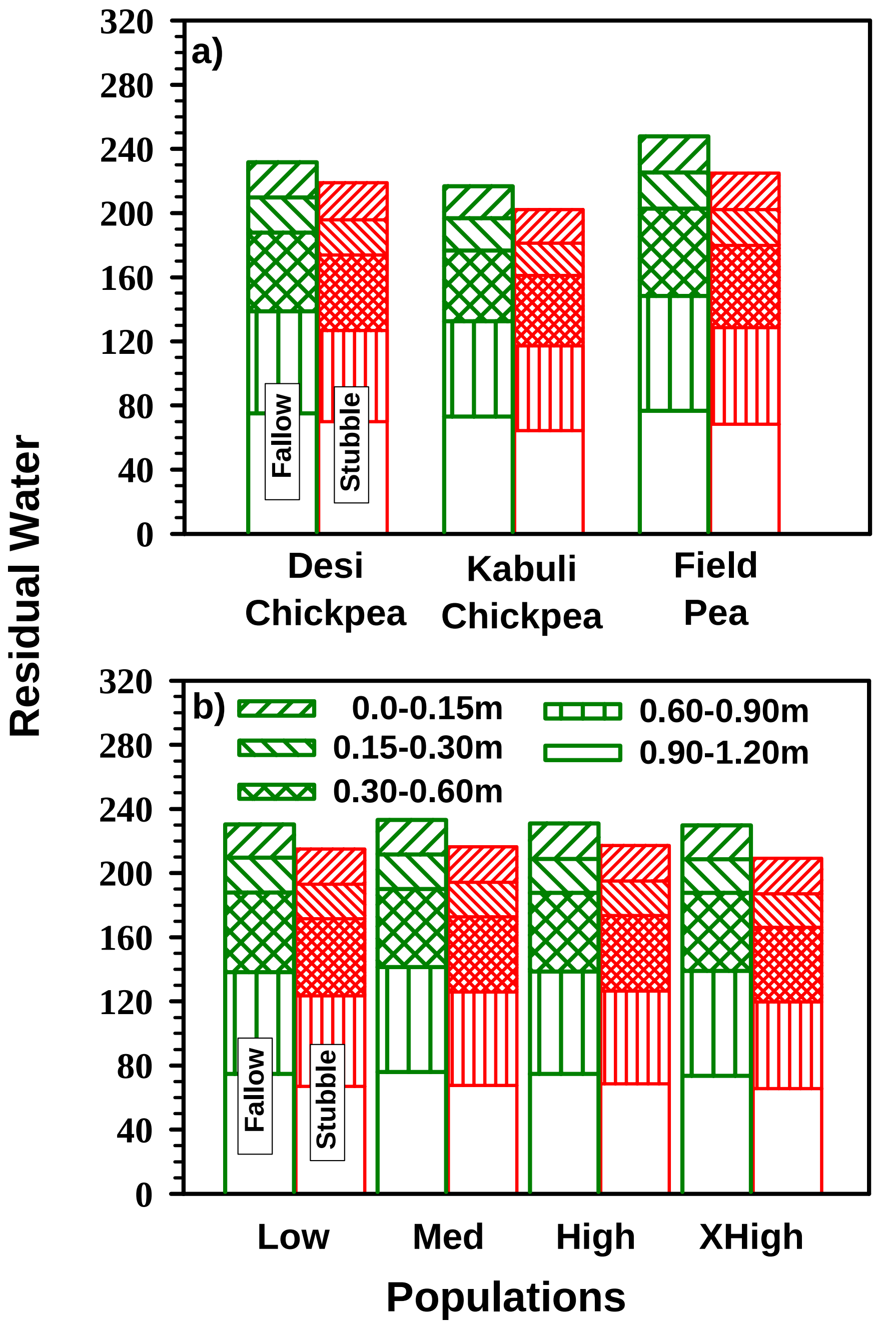

Fig 2.Residual soil moisture after chickpea and field pea grown on conventional summer fallow and on wheat stubble at Swift current and Stewart Valley in five site-years between 1998 and 2000. Bars within stubble or fallow phases were not different when alphabets on top of them were same.