The influence of planting density on seed yield and seed yield components of *Cleistogenes songorica*

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Abstract

The present study explored the optimum plant density through testing seven plant density treatments with 5, 10, 15, 20, 25, 30 and 50 plants/m^2 under irrigated conditions in the northwest of China (Gansu province) during three consecutive growing seasons from April 2007 to August 2009. Results showed that planting density was significantly positive correlated with aboveground biomass and seed yield of *C. songorica* (P<0.05). For three successive seasons, a significant higher aboveground biomass (3023 kg/hm^2, 3127 kg/hm^2, 2860 kg/hm^2, respectively) was observed under 50 plants/m^2 treatments than the other treatments, except for 30 plants/m^2. However, the highest seed yield were obtained in three growing seasons (632kg/hm^2, 636kg/hm^2, 388kg/hm^2, respectively) under 30 plants/m^2 treatment. In addition, correlation analysis revealed that the seed yield were significantly positive correlated with the number of fertile shoots/m^2 for each treatment (r^2=0.924**, 0.741** and 0.780** in 2007, 2008 and 2009, respectively), which implied that the number of fertile shoots/m^2 was the most important component in determining seed yield and the optimal plant density for seed production was 30 plants/m^2.

Introduction

Cleistogenes songorica is one of the most important native perennial grasses in the northwest desert grassland of China because of its high economic and ecological value in arid region (Chen et al., 2002; Huang, 2008). Previous study had investigated the optimal soil condition for *C. songorica* seedling establishment in arid and semiarid areas (Tai, 2008). To better utilize this grass for economic and ecological purpose, understanding the effect of cultivation techniques on its forage and seed yield is very important, however, to our knowledge this has not yet been. The main objective of the present study was to evaluate the effects of plant density on seed yield and its components, aboveground biomass and harvest index of *C. songorica* under arid field conditions in the northwest of China, and further to determine the optimum plant density for seed production of test species.

Material and Methods

The field study was conducted from April 2007 to August 2009 at Hexi Corridor, Gansu province China (latitude 100°29′E, longitude 38°24′N, altitude 1450 m a.s.l.). The experiment was a completely randomized block design with seven plant density treatments (5, 10, 15, 20, 25, 30 and 50 plants/m^2) and four replications. Ten plants from each plot were selected randomly at ripening stage (September in each year) of *C. songorica* for seed yield components measurements. Plants were collected within 1m×1m from each plot to determine aboveground biomass, and plant materials was dried at 60℃ for 48 h, then weighed. Plants were harvested within another 1m×1m from each plot to obtain the seed, air-dried and weighed.

Results

Aboveground biomass

Aboveground biomass increased with increasing plant density, and it was significantly higher ($P<0.05$) under 50 plants/m^2 treatment than that under any other plant density except for 30 plants/m^2 in the three experimental years (Figure 1). In addition, the aboveground biomass of all treatments was higher in 2008 than that in 2007 and 2009.

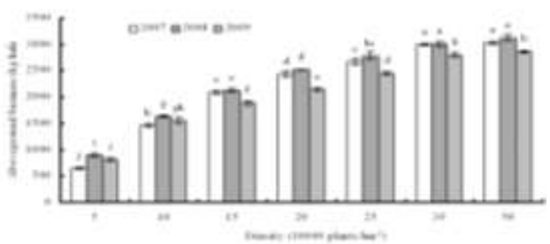

Figure 1. Effects of plant density on aboveground biomass of *C. songorica* in three years

Effects of density on seed yield and harvest index

Plant density significantly affected seed yield and harvest index of *C.songorica*. Seed yield and harvest index were increased when the plant density increased from 5 plants/m^2 to 30 plants/m^2, then decreased when the plant density rose to 50 plants/m^2 during three experimental years. In addition, seed yield of all treatments performed better in 2007 and 2008 than that in 2009 when the number of plants/m^2 was more than 10, but differences were not significant ($P>0.05$) differences between 2007 and 2008 (Table 1). Harvest index of *C. songorica* were the highest (21.1% in 2007, 21.3% in 2008 and 15.9% in 2009, respectively) under 30 plants/m^2 treatment while they were the lowest (6.1% in 2007, 12.2% in 2008 and 8.5% in 2009, respectly) under 5 plants/m^2 treatment.

Table 1 . Effect of plant density (plants/m^2) on seed yield (kg/hm^2) of *C. songorica* in three years

Density	2007	Significance		2008	Significance		2009	Significance	
	yield	*Y*	*T*	yield	*Y*	*T*	yield	*Y*	*T*
5	39.7	c	e	188.5	a	d	129.0	b	f
10	149.8	b	d	316.6	a	bc	166.5	b	ef
15	273.6	a	c	333.1	a	bc	189.2	b	de
20	340.9	a	c	410.4	a	b	214.7	b	cd
25	458.5	a	b	488.2	a	ab	293.2	b	b
30	631.5	a	a	636.2	a	ab	387.6	b	a
50	447.0	a	b	410.2	a	b	242.5	b	cd

Y and *T* indicate significant level at 5% among years and density treatments, respectively.

Simple correlation and regression analysis between seed yield and its components

The results showed that the most important yield component of *C. songorica* was the number of fertile shoots/m^2 that was significantly (P<0.05) positive correlated with seed yield over three years (r=0.924**, 0.741** and 0.780** in 2007, 2008 and 2009, respectively) (Table 2). In addition, seed yield also significantly positive correlated with thousand seed weights (r=0.475* in 2007, r=0.755** in 2008) and number of seeds/spikelet (r=0.454* in 2008).

Table 2. Correlations between seed yield and its components of *C. songorica* in three years

Year	Components	Fertile shoots/m^2	Spikelet /shoot	Seeds /spikelet	1000-seed weight	Seed yield
2007	Fertile shoots/m^2		0.032	0.371	0.288	0.924 **
	Spikelet/shoot			0.307	0.260	0.180
	Seeds/spikelet				0.242	0.381
	1000-seed weight					0.475 *
2008	Fertile shoots/m^2		0.532 *	0.577 **	0.712 **	0.741**
	Spikelet/shoot			0.069	0.366	0.270
	Seeds/spikelet				0.231	0.454*
	1000-seed weight					0.755 **
2009	Fertile shoots/m^2		0.218	0.444 *	-0.235	0.780 **
	Spikelet/shoot			0.010	0.068	0.288
	Seeds/spikelet				0.095	0.400
	1000-seed weight					0.017

Discussion

This field experiment showed that seed yield, forage yield and harvest index were markedly increased with the plant density increasing up to a certain level, then decreased as the density further increased. Similar results were also found in many previous studies (Moore et al., 1993, Brahim et al., 1998, Defoor et al., 2001, Cusicanqui and Lauer, 1999). Kebe et al. (1998) reported that low seed yield occurred at extremely low and high densities, as a result of the number of branches/unit area reduced. The fertile shoots number/m^2 was the most important component in determining seed yield of *C. songorica* observed in present study futher supporting the above mentioned study. Seed yield and forage yield in 2008 were higher than that in the other two years, this may be due to the annual accumulated temperature (≥10℃) in 2008 (3555.5℃) is higher than that in 2007 (3214.3℃) and 2009 (3489.7℃). This study suggests that the optimal plant density for seed production of *C. songorica* is 30 plants/m^2.

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