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Effects of inter-row spacing and superabsorbent polymer application on yield and productivity of rainfed chickpea

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Abstract

Effects of row spacing and a superabsorbent polymer on some agronomic traits of chickpea were evaluated in this study using a factorial experiment with randomized complete block design in three replications. Three spacing of 20, 25 and 30 cm between sowing rows were compared as the levels of first factor and three doses of a super absorbent polymer (SAP) known Stockosorb® including 0, 9 and 18 kg/ha dry granules were assigned as the second factor levels. According to the results pods number/plant, seed weight and seed yield per unit area were increased with increasing row spacing and application of 18 kg/ha superabsorbent polymer led to seed yield improvement compared to control treatment, suggesting that more positive responses to the application of higher doses of SAP than which studied in this experiment is expected in rainfed conditions.

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Introduction

Water deficit stress is one of the main constraints to agricultural production around the world. Iran is a country located in arid and semi arid region of the Earth (Raziei *et al.,* 2005) with low precipitations about 250 mm per year which is less than 30 percent of the global average precipitation (Gheiby and Noorafshan, 2013). Chickpea (*Cicer arietinum* L.) as the most important grain legume in Iran is grown as a rainfed crop which is subjected to terminal drought stress (Soltani *et al.,* 2001). In such conditions, application of new technologies such as superabsorbent polymers (SAPs) in agriculture may be useful in crop growth and productivity. SAPs are products called often hydrogel. SAPs have high capacity to absorb and store water which, if necessary, is accessible for plant roots (Akhter *et al.,* 2004; Orzeszyna *et al.,* 2006). Hydrogel polymers or SAPs acts as a reservoir of water and nutrients which plants need to grow (Rehman *et al.,* 2011). Many studies declared the advantages of SAPs application in agricultural soils to crop growth and productivity under conditions of water deficiency (Henderson and Hansley, 1986; Johnson and Leah, 1990; Huttermann *et al.,* 1999; Arbona *et al.,* 2005; Yazdani *et al.,* 2007; Apostol *et al.,* 2009). Under rainfed conditions of Iran the problem of terminal drought stress often prevent the crop to attain its potential productivity. Hence it is very important to apply the optimum agricultural management techniques and methods to cope with plant water requirements. Water conservation is an important management factor in dryland farming systems. In addition selecting an appropriate spacing for plants plays a vital role in water conservation under rainfed conditions. Therefore, this experiment was aimed to study the effects of row spacing changes and application of a superabsorbent polymer known as Stockosorb® on some agronomic traits of a desi type chickpea cultivar under field conditions.

Materials and methods

Field conditions and experimental design

This study was carried out at the agricultural research station of Saral (35° 43′ N and 47° 8′ E with an altitude of 2100 m) in Kurdistan west of Iran, in 2004 under rainfed conditions. The long-term rates of mean temperature and annual rainfall of this station are 7.9°C and 393.6 mm respectively. The experiment was arranged in a factorial layout with randomized complete block design in three replications. Three spacing of 20, 25 and 30 cm between sowing rows were compared as the levels of first factor and three doses of Stockosorb® super absorbent polymer including 0, 9 and 18 kg/ha dry granules were assigned as the second factor levels. Each experimental plot contained 6 sowing rows 4 m in length with 10 cm between plants in each row.

Agronomic management

The operation of sowing the seeds of chickpea (*Cicer arietinum* L.) cultivar Pirooz (a desi type cultivar) was done by hand in the experimental plots. Dry granules of Stockosorb® super absorbent polymer were buried in soil at a depth of 10-15 cm between sowing rows at the rates of 9 and 18 kg/ha for related experimental plots.

Data collection

Different parameters including plant height, pods number per plant, seeds number per pod, 100-seed weight, seed yield, biological yield and seed protein content were determined.

Data analysis

Statistical operations of ANOVA and means comparison by Duncan’s multiple range test at the 0.05 level of significance were performed using the SAS software.

Results and discussion

Results of data analysis showed that the effect of row spacing on plant height was statistically significant (Table 1). The plant height was increased as the result of row spacing reduction (Table 2). With reducing row spacing the plant population per unit area was increased. Through increasing of plant density, the competition between plants for radiation interception is usually elevated which can be led to elongation of internodes. Application of superabsorbent polymer had no significant effect on plant height in this experiment (Table 1).

Table 1. Analysis of variance of chickpea traits affected by row spacing and SAP application.

Source of variation	df	Mean squares						
		Plant height	Pods no./plant	Seeds no./pod	100-seed weight	Seed yield	Biological yield	Protein content
Replication	2	2.17194[ns]	1.2848[ns]	4.00[ns]	0.36507[ns]	6366.83[ns]	2593942[ns]	3.05255
Row spacing (A)	2	1.41867*	20.4448**	172.00**	12.7163**	93738.85**	14925500.16**	160.922
Superabsorbent (B)	2	1.18188[ns]	1.1003[ns]	21.44[ns]	3.61441[ns]	24930.85*	342340.29[ns]	5.776
A × B	4	0.67096[ns]	1.24[ns]	27.44[ns]	0.71992[ns]	2283.95[ns]	315368.50[ns]	9.8281
Error	16	0.33768	0.9339	26.75	1.03269	5655.83	944839.06	4.0311

ns, * and **: Non significant and significant at 5 and 1% levels of probability, respectively.

All studied yield components were significantly affected by inter-row spacing changes (Table 1). The highest rates of pods number/plant, seeds number per pod and 100-seed weight were recorded in 30 cm row spacing (Table 2). With increasing the space between planting rows the plant population per unit area was decreased because intra-rows spacing was constant at all three row spacing, which resulted in availability of more resources such as nutrients and assimilates for each plant, consequently the accumulation of more dry matter in plant organs including pods and seeds was occurred. Similar results have been obtained in other studies (Herbert and Baggerman, 1983; Boquet, 1990; Duthion and Pigeaire, 1991). SAP application had no significant effects on yield components (Table 1).

Table 2. Main effects of row spacing and SAP application on plant height and yield components of chickpea.

Treatments	Plant height (cm)	No. of pods/plant	No of seeds/10 pods	100-seed weight (g)
Inter-row spacing				
20 cm	22.1 a	6.2 c	9.8 b	18.6 c
25 cm	19.7 ab	8.0 b	10.4 a	20.0 b
30 cm	18.1 b	9.2 a	10.7 a	21.0 a
SAP levels				
0 kg/ha	21.3 a	7.6 a	10.4 a	20.1 a
9 kg/ha	20.4 a	8.2 a	10.2 a	19.5 a
18 kg/ha	20.7 a	7.6 a	10.4 a	20.4 a

Different letters in a group of each column indicate significant differences at $P \leq 0.05$ according to Duncan's test.

Row spacing alterations statistically influenced seed yield, biological yield and seed protein content of chickpea (Table 1). There was no difference between two treatments of 20 and 25 cm row spacing regarding seed yield, besides with increasing row spacing to 30 cm, the seed yield was increased at the rates of 32.3 % and 26.6% compared with 20 and 25 spacing respectively (Table 2). Plant population per unit area was increased due to row spacing reduction. In a high plant population, competition between vegetative and reproductive organs arises which reduces the allocation of photosynthetic assimilates and resources to reproductive organs resulting in yield loss (Fallah, 2008). In another study Jettner *et al.* (1999) reported that number of pods per plant and seed size of chickpea were reduced at high plant populations but seed yield tended to increase. They declared that seed yield was not significantly affected by inter-plant competition at high populations with considering the fact that rainfall was not a limiting factor in that experiment, whereas in our study water deficiency was a critical constraint to the crop.

On the other hand responses of biological yield and seed protein content to row spacing changes showed that, the highest amounts of biological yield and seed protein content were recorded in 20 cm row spacing (Table 2). Increasing the plant population through row spacing reduction led to increasing biological yield, indicating that in spite of increasing inter-plant competition at high populations, the total dry matter production per unit area has been increased. The significant increase of seed protein content at 20 cm row spacing may be attributed to the reduction of carbohydrates to protein ratio as the result of inter-plant competition for water.

Table 3. Main effects of row spacing and SAP application on seed yield, biological yield and seed protein content of chickpea.

Treatments	Seed yield (kg/ha)	Biological yield (kg/ha)	Seed protein (%)
Inter-row spacing			
20 cm	583.5 b	6017.1 a	24.1 a
25 cm	609.9 b	4573.6 b	16.5 b
30 cm	772.0 a	3448.1 c	17.0 b
SAP levels			
0 kg/ha	631.0 b	4899.1 a	19.8 a
9 kg/ha	618.4 b	4613.5 a	19.9 a
18 kg/ha	715.4 a	4526.2 a	18.8 a

Different letters in a group of each column indicate significant differences at $P \leq 0.05$ according to Duncan's test.

SAP application influenced seed yield of chickpea but biological yield and protein content of seeds were not affected by SAP (Table 1). Application of 18 kg/ha SAP resulted in a significant increase in seed yield compared with control (Table 2). Similarly Yazdani *et al.* (2007) reported that higher doses of SAP expressively increased the soybean yield compared with control.

Conclusion

According to the results of this study, with increasing row spacing and consequently reduction in plant density per unit area, resulted in improvement of yield components specially pods number/plant which finally terminated to seed yield elevation in wider row spacing of 30 cm. In addition the application of 18 kg/ha SAP led to seed yield improvement under rainfed conditions suggesting that using more amounts of SAP may be effective in yield enhancement, although more experiments about the effects of higher doses of SAPs in field conditions are needed.

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