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Impact of Plant Population on Seed Yield of Water Stressed Soybean (*Glycine max* L) at Halfa Elgadidah

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Abstract: In order to evaluate the impact of plant population on stressed soybean clycine max (L.), a field experiment with 3 different plant populations (at three different irrigation regimes was carried out. Plants were grown under frequent irrigation (W1), moderate and severe drought stress (W2 and W3). The different plant population designated as D1, D2 and D3, corresponding to spacing between plants of 5, 10 and 15 cm. Seed yield components(number of fruiting branches, pods, seeds weight per plant , seed yield per unit area and measured related characters decreased from normal irrigation regime to water deficit stress in both seasons. Also, the same trend was observed due to increasing spacing between plants particularly under stress conditions. Based on results, soybean yield and yield components decreased when that drought stress occurred. Withholding irrigation reduced seed yield by more than 50% in stressed soybean plants compared with normal irrigated plants.
Keywords: Soybean, Water stress, plant population, Yield and Yield components.

INTRODUCTION

Soybean *Glycine max* L Merrill is a legume that grows in tropical, subtropical and temperate climate. Soybean is a crop which can provide complete protein, containing eight amino acids essential for human. That means it can play a major role in elevating nutritional standers of foods in developing countries, where human beings are facing protein deficiencies [1]. During the three production seasons (2011-2014), the average world soy bean areas were about 119.7 million hectares producing 489.1 million metric tons with average yields estimated at 4.08 tons per hectare [2]. Seed yield per plant increases as population declines [9].

Soybean yield affected by pod and seed number per plant and these traits are the most important yield components of soybean. Also, [3, 4] stated that occurrence of water deficit and high temperature at early of flowering to maturity shortening seed filling period and reduces grain weight. Drought is one of the most serious world-wide problems for agriculture. Water deficit results in various physiological and biochemical changes in plants [8]. In most of the crops, yield losses might be the result of decreasing in water supply during the vegetative phase, due to drought during reproductive development or due to terminal drought at the end of the crop cycle [5]. In this regard, [6] determined that early lodging was a major factor contributing to a yield decrease at higher seeding rates in highly productive environments.

Selecting the appropriate seeding rate for a soybean production system can affect optimal yield potential, economical net returns as well as some negative factors including potential for lodging.Moreover, of recent, work on the soybean has been revived which could be attributed to the increasing utilization and universal importance of the crop. As a result, its introduction is expected to contribute towards diversification of cash crops in the Sudan. However, research in the future should be directed to the proper water management and water use efficiency. To optimize yield of soybean crop for any given production system it is necessary first to understand the crop responses to water stress and management factors. Consequently adequate levels of irrigation and proper plant population are needed. Therefore this study aimed to evaluate the impact of three plant populations on yield of stressed soybean at Halfa Elgadida, Sudan.

MATERIALS AND METHODS

To evaluate the impact of plant population on yield of stressed soybean, G*lycine max* (L.) Merill, a field experiment was carried out during winter and summer seasons of (2014/2015) and (2015), at the faculty of Agriculture and natural Resources Farm, Kassala University, Halfa Elgadida, Sudan (latitude 15° 19' N.) Longitude 35° 36' E and Altitude 45 m asl).

A soybean cultivar; Willim was used in this study. The experiment was designed to study the effect of three watering intervals and three levels of plant population on the performance of soybean plants during two successive seasons. The watering intervals in this study are designed as W_1, W_2 and W_3 where plants were irrigated every 7, 14 and 21 days, respectively. The three plant population levels were designated as D_1, D_2 and D_3, corresponding to spacing between plants of 5, 10 and 15 cm, respectively. The experiment was arranged in 3×3 as split Plot trail for RCBD design with three replications in both seasons. Main plots were allotted for watering treatments and the sub plots for population treatments.

Yield parameters will be measured

The two inner rows in each subplot will be used for the determination of the following yield components.

Number of branches plant^{-1}

From the ten selected plants the average number of fruiting branches per plants will be determined.

Number of capsules plant^{-1}

From the ten selected plants the average number of capsules per plants will be determined.

- Number of seeds capsule $^{-1}$

The previous capsules will be threshed manually and the average number of seeds per capsule will be determined.

100-seed weight (g)

From each subplot, 100 seeds will randomly selected and weighed using sensitive balance to determine the average seeds weight.

- Seeds weight (g plant^{-1})

Seeds obtain from 10 randomly selected plants will be weighed using sensitive balance to determine the average seeds weight per plant.

- Seeds yield (Kg ha^{-1})

In each sub-plot, all plants grown in an area of 1.7 m^2 in the two central ridges will be harvested, air-dried, weighed to determine the average yield per unit area.

- Harvest index

Harvest index (HI) will be calculated as the ratio of gain yield to the total above ground shoot biomass as follows:

HI = (Grain yield)/(Biological yield) x 100

Data was statistically analyzed according to the analysis of variance (ANOVA) for randomized complete blocks design as split plot trail using computer software package. Mean comparisons was worked out by Duncan's Multiple Range Test (DMRT) at 5% level for probability.

RESULTS AND DISCUSSIONS

In the present investigation, frequent irrigation(W1) on soybean plants resulted in a pronounced increase in the mean of yield components (No. of branches, capsules , seeds per capsule, seed weight per plant, 100-seed weight and seed yields per unit area (tables 1. 2). Further, increases of seed yield per plant resulted in high value of harvest index (HI) with frequent irrigation regime as compared to prolonged watering regimes ($W_{2,}$ W_3) treatments. Withholding irrigation reduced grain yield more than 50% in stress soy bean plants compared with normal irrigated plants (tables 1, 2).

Regarding plant density, the date in tables 1 and 2 clearly demonstrates that decreased plant density resulted in an increased in the all yield components and HI. The increases in these characters were substantial under frequent watering interval treatments, plant density and their interaction had significant effects on seed yield per unit area in both seasons (tables 1, 2). In this regard frequent watering, lowest plant population and their interaction significantly inversed seeds yield per hectare, compared to their respective treatments (tables 1, 2)

The reduction in yield obtained under prolonged watering interval was associated with significant decrease in all yield components measured in this study. This could be attributed to the reduction in number of branches per plant, number of capsules per plant, number of seeds per capsules and 100-seed wt under water stress condition, these results are in agreement with those reported by [4,5,7,8] they clouded that the reduction in these characters could be attributed to the fact that water deficit severely affected pollination process and caused floret abortion, while lack of assimilate needed for seed filling may reduce seed weigh capsule also, might due to reduction of leaf area under water stress condition. Grain yields enhancement resulted from sowing soybean in wider spaces could be manly attributed to low competition between individual plants for both moisture and nutrient in the soil, in this respect at low density, plant accumulate more dry matter, heaver seed which in turn increases seed yield per plant. These results are in accord with those reported by [9], they stated that plants in wider spacing faced little competition which increases in yield and its components, particularly, in low density was exacerbated under frequent watering intervals, these results are in accord with those results reported by [3] they attributed increased of seed yield per plant with low density under full irrigation to increasing number of grains per plant. In this study, shortening of grain–filling period due to water stress and decrease of transferring assimilates in to grains due to water stress as two major reasons for reduction of soybean grain weight and 100- seed weight as described by[4]. The grater harvest index (HI) may due to increase in 100-seed weight in al treatment as reported by [9].

Table-1: Responses of Yield Parameters and harvest index to Water Stress and Plant Population in Soybean (*Glycine max.L.*) during winter of 2014/2015 season

Treatments		Branches /plant	Capsules per plant	Seeds No/Capsule	Seeds weights /plant	100-seed weight	Seed yield kg/ha	HI
	W_1	6.63	74.76	2.95	10.95	9.97	1.38	35.16
	W_2	5.53	63.22	2.62	9.02	8.43	1.17	31.77
	W_3	5.12	51.78	2.44	7.31	7.41	0.82	27.01
	$LSD_{0.05}$	1.07	10.28	0.36	0.83	0.44	0.121	2.14
	D_1	5.30	50.89	2.43	6.80	8.03	1.27	29.79
	D_2	5.77	62.93	2.67	8.63	8.68	1.14	31.00
	D_3	6.21	75.93	2.91	11.84	9.10	0.96	33.14
	$LSD_{0.05}$	0.62	5.84	0.25	0.78	0.55	0.06	1.23
W_1	D_1	6.00	60.47	2.43	8.48	9.60	1.009	34.54
	D_2	6.53	72.33	2.85	9.87	9.53	1.27	35.00
	D_3	7.7.36	91.47	3.56	14.51	10.78	1.54	35.94
W_2	D_1	5.30	54.40	2.56	6.09	8.36	0.91	29.19
	D_2	5.60	61.87	2.63	10.04	8.45	1.19	34.54
	D_3	6.63	73.40	2.66	10.92	8.48	1.54	33.59
W_3	D_1	4.60	37.80	2.30	6.80	6.14	0.55	25.66
	D_2	5.20	54.60	2.53	8.63	8.07	1.05	25.45
	D_3	5.56	62.93	2.51	11.84	8.04	1.26	29.91
	$LSD_{0.05}$	1.38	13.09	0.50	1.38	0.89	0.15	2.74

Table-2: Responses of Yield Parameters and harvest index to Water Stress and Plant Population in Soybean (*Glycine max.L.*) during 2015 summer season

Treatments		Branches /plant	Capsules per plant	Seeds No/Capsule	Seeds weights /plant	100-seed weight	Seed yield kg/ha	HI
	W_1	6.34	55.37	2.60	3.99	8.37	1.16	36.00
	W_2	5.35	47.04	2.48	4.66	8.37	1.11	34.00
	W_3	4.48	40.43	2.42	4.37	8.37	0.87	.25.00
	$LSD_{0.05}$	0.72	-	0.24	-	-	0.10	1.09
	D_1	5.33	39.50	2.44	3.27	8.57	1.28	32.00
	D_2	5.33	39.86	2.56	4.75	8.15	1.10	34.00
	D_3	5.94	63.48	2.50	4.34	8.60	0.75	32.00
	$LSD_{0.05}$	078	-	0.13	-	-	0.07	2.87
W_1	D_1	5.00	44.46	2.50	3.58	8.87	1.51	35.89
	D_2	6.50	39.66	2.70	5.62	8.25	1.17	39.12
	D_3	7.53	82.66	2.60	2.79	8.003	0.80	34.85
W_2	D_1	5.300	43.93	2.50	5.35	8.5	0.96	35.11
	D_2	5.30	37.73	2.46	4.10	8.48	1.16	35.04
	D_3	5.46	59.46	2.50	4.55	8.14	1.20	33.27
W_3	D_1	4.43	30.100	2.33	2.88	8.36	0.51	31.18
	D_2	4.20	42.20	2.53	4.55	8.15	0.98	23.82
	D_3	4.83	49.00	2.40	5.69	8.60	1.13	22.32
	$LSD_{0.05}$	1.31	-	0.30	-	-	0.14	4.20

CONCLUSION

Based on results, soybean yield and yield components decreased when that drought stress occurred. Withholding irrigation reduced grain yield more than 50% in stress soy bean plants compared with normal irrigated plants.

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