Effect of Planting Date and Intra-row Spacing on Some Agronomic Traits and Yield of Soybean (*Glycine max* L.)

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المستخلص

اجريت تجارب حقلية لدراسة تاثير تاريخ الزراعة والمسافات البينية على بعض الصفات الحقلية والانتاجية فى فول الصويا الصنف سودان-1. اجريت التجربة للموسمين 2013-2014 و2014-2015م فى موقعين فى النيل الابيض. الموقع الاول , كلية الزراعة والموارد الطبيعية, الدويم ,(الموسم الشتوى) , الموقع الثانى المزرعة التجريبية لشركة سكر النيل الابيض (الموسم الخريفى). استخدم تصميم القطع المنشقة باربعة مكررات. تواريخ الزراعة بداية, منتصف ونهاية نوفمبر فى الموسم الشتوى. بداية , منتصف ونهاية يوليو للموسم الخريفى للقطع الرئيسية. المسافات 5, 10 و15 سم عينت للقطع الثانوية.. كانت انتاجية الحبوب افضل فى الموسم الشتوى. عموما ادى تاخير مواعيد الزراعة الى انخفاض انتاجية الحبوب. اعلى انتاجية للحبوب (3240 كجم/ه) كانت فى تاريخ الزراعة الاول. بالنسبة للمسافات البينية اعطت المسافة الاولى اعلى متوسط (3245.5 كجم/ه) فى الموسم الشتوى, بينما اعطى التداخل بين تاريخ الزراعة الاول والمسافة البينية الاولى ايضا فى الموسم الشتوى اعلى متوسط (3613.5 كجم/ه). اقل انتاجية حبوب 330.5 كجم/ه حصلت عند تاريخ الزراعة الثالث مع المسافة الثانية فى الموسم الثانى (الخريفى). اوضحت نتائج هذه الدراسة ان الانتاجية العالية للحبوب حدثت فى الزراعة المبكرة وان الموسم الشتوى افضل من الموسم الخريفى لزراعة فول الصويا، الدويم ، النيل الابيض، السودان.

Abstract

Field experiments were conducted to study the effects of planting date and itra-row spacing on some agronomic traits and yield of soybean variety(Sudan-1), experiments were conducted for two seasons 2013- 2014 and 2014 2015, at two sites in White Nile State, Sudan. The first site was experimental farm of the Faculty of Agriculture and Natural Resources, University of Bakht Alruda, EDduim (winter season). The second site was experimental field of the White Nile Sugar Company (autumn season). The study was designed in split –plot design replicated four times. Planting dates first (T1), mid (T2) and last of November (T3) in winter growing season and first, mid and last July in autumn growing season were the main plots. Spacing of 5 (S1), 10 (S2) and 15(S3) cm were considered as the sub plot. Grain yield was better in the first season (winter). Generally delayed planting date caused reduction in grain yield. The highest grain yield (3242.0 kg/ha) was obtained at T1. The spacing S1 scored the highest mean (3245.4 kg/ha) in winter season, while interaction T1S1 although in winter season gave the highest mean (3613.5 kg/ha). Minimum grain yield (330.6 kg) was obtained by T3S2 in the second season (autumn). The results of this study illustrated, that higher grain yield was obtained in early planting date and winter season is better than autumn season for sowing soybean in EDduin, White Nile, Sudan.

1. Introduction

Soybean (*Glycine max* L.) is the most important oil seed and grain legume crop of the world. It has occupied the top position in terms of oil source in the world. It contains 20-22% essential amino acids, 40% protein and 18–22% oil of which 85% is cholesterol free (Malik *et al* 2006). Its cost effectiveness is ensured through biological nitrogen fixation and rotation with exhaustive crops. It replenishes and maintains soil fertility. In the Sudan, soybean trials started as early as 1925 at Gezira Research Farm where a low yield of 500 kg/ha was obtained. This low yield was attributed to lack of cultivars adaptable to the Sudan agro-ecological conditions. Thus, researchers at the stations were reluctant to work on soybean. Nevertheless, in early 1980's several attempts were made, one at Agadi Experimental Farm where a yield of 500–1000 kg/ha was obtained (Faisal 1986). Furthermore, he reported that in Damazin an area of 1260 hectares was used for commercial production, but the crop failed to meet the desired objective of the project. The time of planting varies depending on the climatic condition of the region and the variety to be grown. Different varieties of soybean are sensitive to change in environmental conditions where the crop is being grown. Therefore, it is necessary to study the genotype × environment interaction to identify the varieties which are stable in different environments (Calvino *et al*., 2003). Sowing date is the variable with the largest effect on crop yield (Calvino *et al*., 2003). Fine-tune management of soybean by sowing date is a good approach to enhance both crop yield and economic benefit. Effects of planting date on soybean yield and other traits varied at locations (Hoeft *et al*., 2000; Naeve *et al*., 2004). Among cultural agronomic practices, spacing is one of the most important agronomic factors that have great impact on growth and yield. It plays an important role in modulating the environmental factors related to growth and development of the crop.

There were no research work has been done to explore the potentiality of soybean production in White Nile State. Therefore, the aim of this study was to determine the optimum sowing date and intra-row spacing of soybean variety Sudan-1 under White Nile State conditions.

2. Material and Methods:

Field experiments were conducted for two successive seasons 2013- 2014 and 2014 2015, at two sites in White Nile State, Sudan. The first site was the experimental farm of the Faculty of Agriculture and Natural Resources, University of Bakht Alruda, EDduim (winter season).The second site was the experimental field of the White Nile Sugar Company(autumn season). The design of study was split –plot design replicated four times. Planting dates first (T1), mid (T2) and last of November (T3) in winter growing season and first, mid and last July in autumn growing season were the main plots. Spacing of 5 (S1), 10 (S2) and 15(S3) cm were considered as the sub plot. In both site the experimental area was ploughed, leveled and ridged in 0.8 m apart. The sizes of the main and subplots were 12 m × 5 m and 4 m × 5 m, respectively. These subplots consisted of 5 rows 5 m long. Two seeds were planted per hole on the ridged then thinned to one after three weeks. Number of days to 50% flowering was recorded on plot basis when almost half of the sub-plot had flowered. Five plants were randomly selected on sub-plot basis to measure the plant height, number of branches per plant, number of leaves per plant , number of pods per plant and number of seeds per pod. 1000-seed weight was determined randomly from a seed bulk using digital balance. Grain yield was quantified after harvesting and converted into kg/hectare. All data collected were subjected to Statistical Analysis System package (SAS) for computing analysis of variance (ANOVA) and mean performance of sowing date, spacing and their interaction were compared using Duncan's Multiple Range Test (DMRT) 5%.

3. Results and Discussion:

The Analysis of Variance (ANOVA) shows highly significant (P = 0.01) effects of planting date for most of the traits studied., while spacing and interaction between planting date and spacing showed no significant differences for most of the studied traits.

4. Growth Parameters

The effects of sowing date, plant spacing and their interaction on soybean vegetative growth traits in the two successive seasons were shown in Table 1 and 2.

5. Plant height

The vegetative growths of soybean were determined by evaluating the plant height and the number of leaves. This is in agreement with Pfeiffer and Harris (1990) who observed that, plant height measurements are used as an indicator of vegetative growth. The

planting dates showed significant effect for plant height in both season. Maximum plant height (50.0 cm) was observed in T3 treatment while the minimum plant height (28.9 cm) was obtained in T1 treatment. However, in case of spacing within rows, plants in season 2013-2 014 were shorter in compare with the second season 2014-2015. Maximum plant height (55.cm) was observed in S1. There were no significant difference in plant height in interactions effects of sowing date and spacing (T x S) but the maximum plant height (58.3 cm) was recorded at (T1 x S1).

6. Number of branches/plant

There were no significant differences in the average number of branches per plant in both season for planting date, plant spacing and their interaction. The highest number of branches (6.0) was recorded in T3 S3in season one , while lowest means (4.1) was revealed by T3S1 and T3S2 in the second season.

Table 1. The effects of sowing date, plant spacing and their interaction on soybean vegetative growth traits in winter season 2013-2014.

Traits / Treatments	Plant height (**cm**)	Number of branches/plant	Number of leaves/plant	Days to 50% flowering
Sowing date				
T1	28.9 b	4.9 a	14.6 a	48.3 b
T2	33.6 ab	5.2 a	18.2 a	48.4 b
T3	34.3 a	5.4 a	16.7 a	56.6 a
Spacing				
S1	32.2 a	5.0 a	14.4 b	49.3 a
S2	32.4 a	5.1 a	16.5 ab	50.2 a
S3	32.3 a	5.4 a	18.5 a	49.8 a
Interaction				
T1S1	29.3 bc	5.0 ab	14.0 ab	47.3 c
T1S2	27.8 c	4.5 b	13.8 ab	48.8 c
T1S3	29.8 abc	5.3 ab	16.0 ab	49.0 bc
T2S1	34.3 ab	5.0 ab	17.0 ab	48.3 c
T2S2	35.3 a	5.5 ab	17.8 ab	48.5 c
T2S3	31.3 abc	5.0 ab	19.8 a	48.5 c
T3S1	33.0 abc	5.0 ab	12.3 b	52.5 ab
T3S2	34.3 ab	5.3 ab	18.0 ba	53.3 a
T3S3	35.8 a	6.0 ab	19.8 a	52.0 ab
Mean	32.2	5.1	16.4	43.8
CV%	10.3	17.4	24.7	3.6

Means within columns followed by the same letter(s) are not significantly different

Table 2. The effects of sowing date, plant spacing and their interaction on soybean vegetative growth traits in autumn season 2014-2015.

Traits / Treatments	Plant height (**cm**)	Number of branches/plant	Number of leaves/plant	Days to 50% flowering
Sowing date				
T1	53.9 a	5.3 a	16.5 a	62.8 a
T2	52.8 a	4.5 a	15.3 a	59.0 a
T3	55.0 a	4.3 a	11.1 a	58.9 a
Spacing				
S1	55.6 a	4.6 a	14.5 a	60.4 a
S2	53.5 a	4.7 a	12.8 a	60.1 a
S3	52.7 a	4.8 a	14.6 a	60.1 a
Interaction				
T1S1	58.3 a	5.3 ab	19.5 a	67.3 a
T1S2	51.6 a	4.9 ab	14.0 a	54.5b
T1S3	52.0 a	5.8 a	16.0 a	66.5 ab
T2S1	54.1 a	4.6 ab	15.0 a	55.0 ab
T2S2	54.3 a	5.2 ab	14.0 a	63.0 ab
T2S3	50.2 a	3.8 b	16.8 a	59.0 ab
T3S1	54.4 a	4.1 ab	11.8 a	59.0 ab
T3S2	54.7 a	4.1 ab	10.0 a	63.0 ab
T3S3	55.9 a	4.8 ab	11.0 a	54.8 b
Mean	53.9	4.6	14.2	58.8
CV%	6.8	10.3	15.5	4.1

Means within columns followed by the same letter(s) are not significantly different.

7. Number of leaves/plant

Number of leaves per plant was not affected by treatments in both seasons. Highest value (18.2) for planting date was obtained by T2 in the first season. For spacing maximum mean (18.5) was recorded by S3 in the first season. For interaction with small differences T3S3 season one and T1S1 scored highest mean 19.8 and 19.5, respectively. It could be concluded that the number of leaves per plant increased with increasing the spacing.

8. Days to 50% flowering

The analysis of variance revealed that period to 50% flowering was highly significant affected by planting dates in both season. The spacing and

Interaction had no effect on days to flowering. Maximum days to flowering (62.8day) were recorded in T1 in the second season. In spacing, maximum number of flowering period duration (60.4day) was recorded in S1 in the second season. In case of interaction (T x S) maximum flowering period duration (67.3day) was recorded at (T1 S1). However,

the magnitude of delay in flowering due to delayed planting was much greater in season 2013-2014(winter).

9. Yield and yield components

The effects of sowing date, plant spacing and their interaction on soybean yield and yield components in the two successive seasons were shown in Table 3 and 4.

10. Days to maturity

The analysis of variance showed highly significant differences for planting date in both season for days to maturity, while spacing and interaction (T x S) were not significant in first season but their effect was significant in the second season. Generally it was observed that longer period durations to maturity in the second season were 160.6day in T1, 158.9 day in S2 and 164.3 for T1 S1. Shorter period durations in the first season were observed in T2 (68.3), S1 (68.5) and 68.3 in T2 S1, T2 S2 and T2 S3.

Table 3. The effects of sowing date, plant spacing and their interaction on soybean yield and yield components in winter season 2013-2014.

Traits / Treatments	Days to maturity	Number of pods/plant	Number of seeds/ pod	1000-seed weight (g)	Grain yield kg/ha
Sowing date					
T1	73.4 b	127.7 a	2.7 a	164.8 a	3242.0 a
T2	68.3 c	101.7 a	2.5 b	145.8 a	2639.4 b
T3	125.5 a	107.3 a	2.8 a	121.1 c	2419.3 b
Spacing					
S1	88.5 a	101.7 a	2.6 a	141.9 a	3245.4 a
S2	89.9 a	115.8 a	2.6 a	141.2 a	2522.7 b
S3	88.8 a	119.3 a	2.8 a	148.6 a	2532.6 b
Interaction					
T1S1	72.3 d	111.3 ab	2.8 a	166.0 ab	3613.5 a
T1S2	75.3 c	129.5 ab	2.7 a	155.8 bc	2870.5 abc
T1S3	72.8 d	142.3 a	2.8 a	172.8 a	3242.0 ab

T2S1	68.3 e	90.3 b	2.3 b	141.5 c	2702.8 abc
T2S2	68.3 e	100.8 b	2.4 b	145.8 c	2608.5 abc
T2S3	68.3 e	114.0 ab	2.7 a	150.0 bc	2607.0 abc
T3S1	125.0 ab	103.5 ab	2.8 a	118.3 d	3420.0 a
T3S2	126.3 a	117.0 ab	2.8 a	122.0 d	2089.0 bc
T3S3	125.3 ab	101.5 ab	2.9 a	123.0 d	1748.8 c
Mean	89.0	112.2	2.6	143.8	2766.8
CV%	2.7	21.9	7.8	6.6	25.5

Means within columns followed by the same letter(s) are not significantly differen**t.**

11. Number of pods per plant

The analysis of variance exhibited that number of pods per plant was significantly affected by planting date in the first season, while spacing and interaction between planting date and spacing was not significant in both seasons. The highest mean 127.7 was recorded in T1 in the first season. For spacing, the highest number of pods per plant (119.3) was obtained by S3 in the

first season. In the interaction, maximum number of pods per plant 142.3 were recorded in T1S3 in the first season.

The differences observed in the number of pods per plant on different planting dates could be explained in terms of fewer flowering nodes, rainfall pattern and suppression of both primary and secondary branches .This agrees with the findings of Board and Tan (1995) who reported similar results in the number of pods per plant of soybean.

12. Number of seeds per pod

There were no significant differences between all treatments in number of seeds per pod. Maximum number seeds per pod were recorded in the first season 2.8, 2.8 and 2.9 for T3, S3 and T3 S3, respectively.

13. 1000-seed weight

In both seasons planting date exhibited highly significant differences for 1000- seed weight, while other treatments were not statistically different. The highest value (164.8 g) was obtained by T1 , the spacing S3 gave the highest value (148.6 g), whereas the interaction between them (T1S3) scored the highest value (172.8 g) in the first season. In

the second season- means for 1000- seed weight were less than that in the first season, since maximum values 137.1 and 136.o g were obtained from T1 and S3, respectively. In the interaction effects the treatments T1S2 and T2S1 recorded highest means (140.0 g) . In both seasons it was observed that, 1000-grain weight decreased as planting was delayed .This result was agree with finding of (Ibrahim 2012).

Table 4. The effects of sowing date, plant spacing and their interaction on soybean yield and yield components in autumn season 2014-2015.

Traits / Treatments	Days to maturity	Number of pods/plant	Number of seeds/ pod	1000-seed weight (g)	Grain yield kg/ha
Sowing date					
T1	160.6 a	114.9 a	2.6 a	137.1 a	1208.1 a
T2	159.2 a	94.9 a	2.6 a	135.4 a	1345.4 a
T3	156.6 a	92.5 a	2.6 a	132.1 a	1021.9 a
Space					
S1	158.8 a	92.3 a	2.6 a	134.8 a	1135.1 ab
S2	158.9 a	107.3 a	2.5 a	133.8 a	1003.5 b
S3	158.6 a	102.7 a	2.6 a	136.0 a	1436.9 a
Interaction					
T1S1	164.3 a	115.5 a	2.7 a	133.0 bcd	769.4 cd
T1S2	156.3 de	114.5 a	2.5 ab	140.0 a	1711.2 ab
T1S3	161.3 abc	114.6 a	2.6 ab	138.1ab	1143.9 bc
T2S1	158.3 bcd	87.6 a	2.6 ab	140.0 a	1795.2 ab
T2S2	157.5 cde	123.1 a	2.6 ab	131.9 bcd	968.6 cd
T2S3	161.8 abc	74.2 a	2.5 ab	134.3 bcd	1272.5 abc
T3S1	154.0 de	73.8 a	2.6 ab	131.4 cd	840.8 cd

T3S2	163.0 ab	84.3 a	2.4 b	129.1 d	330.6 d
T3S3	152.8 e	119.4 a	2.6 ab	135.7 abc	1894.3a
Mean	95.1	62.3	2.4	134.8	1191.8
CV%	0.82	18.2	8.7	7.4	27.2

Means within columns followed by the same letter(s) are not significantly different

13. Grain yield

The effects of sowing date showed significant differences in grain yield in both seasons, while spacing was significant only in the first season. Interaction effects were not significant in the two seasons. There was wide range of variance in means of grain yield for main effects and their interactions in both seasons. Grain yield was better in the first season (winter). Generally delayed. Planting date caused reduction in grain yield. Salem (2004) confirmed our finding by reporting that date plays an important role in the crop productivity as the seed yield of genotypes decreased with delayed sowing date. Although, many researchers have reported quite a reasonable degree of relationship between pod-filling period and seed yield of soybean (Futuless, 2010).The highest grain yield (3242.0 kg/ha) was obtained by T1. The spacing S1 scored (3245.4 kg), while the interaction T1S1 gave the highest grain yield (3613.5 kg). Minimum grain yield (330.6 kg) was obtained by T3S2 in the second season.

Conclusion

The results of this study illustrate, that higher grain yield was obtained in early planting date. Narrow spacing gave highest grain yield in winter season, whereas wide spacing gave highest yield in autumn season. Generally winter season is better than autumn season for sowing soybean in EDduin, White Nile State, Sudan.

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