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EFFECTS OF PLANTING DATE ON YIELD RELATED TRAITS OF SOME SOYBEAN GENOTYPES IN SENNAR STATE OF THE SUDAN

*Ngalamu, T.[1], Odra, J.[1], Ashraf, M.[1] and S. Meseka[2]
[1]University of Juba, Department of Agricultural Sciences P.O. Box 82, Juba South Sudan
[2]International Institute of Tropical Agriculture, PMB 5320, Oyo Road, Ibadan, Nigeria.
*lingarigwa@yahoo.co.uk, 7919soya@gmail.com; +211-918287361

ABSTRACT

Experiments were conducted at El Gantra farm in Sennar State, Sudan to verify the effects of sowing date on five soybean (*Glycine max* L. Merrill) genotypes planted at five different planting dates in 2009 and 2010. The objectives were to assess the performance of five soybean genotypes under different sowing dates and identify genotype(s) with high yield potential for release to local farmers in Sennar State. The trial was arranged as a split-plot design replicated three times, with planting date as main plot and genotype as subplot. The combined analysis of variance over two years showed significant effect ($P<0.01$) of sowing dates for all the measured traits, with the exception of number of seeds per pod and 100-seed weight in both years (2009 and 2010). The differential response of the genotypes to the different planting dates and the interaction effects were significant for all the traits evaluated except for plant height, first pod height, number of branches per plant, number of seeds per plant and 100-seed weight. Significantly higher grain or seed yield were obtained in 2010 with mean value of 0.79 t/ha compared with 0.69 t/ha in 2009. There was also no change in the trend of performance of genotypes across the five sowing dates in the two years. The highest seed yield of 1.2 t/ha was obtained from sowing carried out on 10th August in 2009, followed by that of 12th July (1.03 t/ha) and 26th July (0.93 t/ha) in 2010, which were the best of the five sowing dates in the two years. Thus, in order to achieve optimum productivity in soybean in Sennar State, it is recommended that planting of soybean should commence in early July. The best genotypes are TGx 1937-1F and TGx 1740-2F because they out yielded all other genotypes in the trials.

Keywords: genotype; interaction; planting date; soybean; yield potential

INTRODUCTION

Soybean (*Glycine max* L. Merrill) is one of the oldest crops grown in the world. The plant is classed more as an oil seed crop than a pulse. It is an annual plant that has been used for over 3,000 years by ancient Chinese, who considered soybean as an important and sacred crop. Soybean is an important legume with multifarious uses (Vaughan and Geissler, 2008).

Owing to its nutritional value, there is a growing demand for soy foods such as; soymilk, soybean sprouts, soy nuts, cottage cheese like soybean curd, rich in protein, and various vitamins and minerals (Rao *et al.*, 2002). Furthermore, they showed that the medicinal nature of soybean (genistein, photochemical and iso-flavon content) is extremely essential in building body immune system. In addition, Welty *et al.* (2007) reported that consumption of soybean by women leads to a healthy transition through menopause and reduction in various symptoms noted during post-menopause.

In the Sudan, the first soybean trials were carried out as early as 1925 at Gezira

Research Farm, where a poor yield of 500 kg/ha was obtained (Faisal, 1986). Further studies conducted from 1931 to 1935 and in the year 1939/40 also failed, due to poor performance of the introduced cultivars (Faisal, 1986). Since then, studies on soybean were irregular and not consistent, but dependent on the researchers' interest. However, of recent, work on 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.

Records of some introduced cultivars tested under both rain fed and irrigation conditions at Agadi experimental plots showed that seed yield produced ranged from 500 to 1000 kg/ha. Faisal (1986) concluded that delaying the planting date up to the beginning of August, severely reduced the yield and number of pods per plant. He recommended mid June and early July as suitable planting dates for soybean as this provides more days for flowering and maturity than when sowing is delayed exposing the crop to terminal drought.

In Sudan, commercial production of soybean started in 1982 and 1983 season whereby an estimated area ranging from 1,260 to 2,100 ha was put under soybean production by Sudanese – Egypt Integration Agricultural Project in Damazin (Faisal, 1986). The knowledge of genetic variability is the most important aspect of plant improvement program. It is of equal importance for a soybean breeder to evaluate soybean genotypes from different genetic backgrounds, under different environments. Specht *et al.* (1999) put the yield potential of soybean productivity at 8 t/ha, based on the amount of light energy available in the field under optimum condition. Baker (1988) suggested that evaluation of soybean genotypes under different planting dates is vital in boosting production. Nevertheless, varietal screening and selection for adaptation under local conditions can be considered to be of prime importance. Although research on soybean in the Sudan started more than fifty years ago, with introduction of genotypes from USA, there are no released cultivars adapted to Sudanese local conditions. In addition, no research has been carried out in the Sudan to study the effect of planting date on the growth and yield of soybean to select genotypes suitable for growing by farmers. The aim of this study was, therefore, to assess the performance of five soybean genotypes sown on different dates so that genotypes with high yield potential could be selected to be grown by farmers in Sennar State.

MATERIALS AND METHODS

The trials were carried out during 2009 and 2010 main cropping seasons at the El Gantra Range and Pasture Farm, located at latitude 14° 24´N, and longitude 33° 29´E at an altitude of 411 feet. The soil of the experiment site could be described as heavy clay (60%) at times referred to as cotton soil with a pH of 8.2; low organic content (0.5%), nitrogen (0.05%) and available phosphorus (2.8 mg/k).

The land was disc ploughed, levelled and ridged before sowing. The prepared site was pre-irrigated two to three days ahead of the experiment to ensure sufficient moisture during planting. Seeds of the five genotypes were inoculated with *Rhizobium japonicum* before planting to ensure nodulation. A sugary solution was used for inoculation to ensure the sticking of the strain on the seed surface. Inoculation was done once, only in 2009 season, and the following season (2010) no inoculation was carried out because the trial was conducted in the same field assumed to have the remnant inoculums' effect in the soil. The seeds were inoculated with a strain of *R. japonicum* at the rate of 10 g per one kg of soybean seed. The design of the study was split-plot, with planting date as main plot factor and genotype as sub-plot factor, in three replications. The main plot size was 12 m × 5 m and the sub-plot size was 2.4 m × 5 m consisting of 4 rows, 5 m long each with 60 cm spacing between the rows and 10 cm spacing between the hills. All recommended cultural practices for growing soybean were applied equally to all the plots.

Two seeds were planted per hill on ridges and subsequently irrigated. However, in the first year (2009) of the study, the designated plots for the first sowing date trial were pre-irrigated, but upon planting, the trial could not be irrigated immediately due to unavailability of water. Consequently, all the sowing dates of the subsequent trials over two years had to be irrigated at an interval of seven days to ensure uniformity of irrigation period. In 2010, the first sowing date trial was immediately irrigated. The interval between each sowing date trials over the two years was two weeks. Re-sowing was carried out seven days after planting followed by the second irrigation. Four weeks later, the crop was thinned to one seedling per hill by cutting off the weak plants. Weeding was done manually, two times for every planting date (first after two weeks and the 2nd six weeks after planting), with continuous pulling out of emerging weeds.

Five planting dates (Table 1) were designated at random on main plots to test five genotypes of soybean obtained from International Institute of Tropical Agriculture (IITA) Nigeria; and ORNAS Company Khartoum on sub-plots, were studied at El Gantra (Um Dabiliba), Sennar State, Sudan. Seedling emergence was recorded two weeks after planting as the number of seedlings that emerged in a plot. Plant height was measured using a meter ruler from the ground surface to the base of meri-stem of the mother plant taken from 10 randomly selected plants. Numbers of branches per plant were recorded as the mean of count of branches of 10 randomly selected plants in a sub-plot. Leaf area was computed using Iamauti (1995) empirical relations where the maximum width (L) of the central leaflet of each ten leaf per sub-plot was measured with a ruler. The first pod height was measured at full bloom, whereas lodging, number of pods/plant, number of seeds/pod was recorded at physiological maturity of the crop. One hundred seed weight was determined by randomly counting 100 seeds from a bulked seed and weighed using a digital weighing-scale. Grain yield was quantified after harvest and converted into kg per hectare (kg ha^{-1}).

The collected data were subjected to Statistical Analysis System (SAS, 2000) package for computing analysis of variance (ANOVA) of mean performance of genotypes, planting dates and their interaction over the two years. In ANOVA, each sowing date and year was considered as an environment. Genotype was

Table 1: Planting dates in two seasons 2009 and 2010 at range and pasture farm, El Gantra, Sennar State

Number of Planting	Code	Date of Planting in the years	
		2009	2010
First planting	PD1	10th August	12th July
Second planting	PD2	24th August	26th July
Third planting	PD3	7th September	9th August
Fourth planting	PD4	28th September	23rd August
Fifth planting	PD5	12th October	6th September

considered as a fixed effect, while plots (main and sub-plots) and replications as random effects.

RESULTS AND DISCUSSION

The combined analysis of variance (Table 2) revealed that, genotype, planting date and their interaction were significant at 0.01 level of probability on the agronomic traits. This showed that the interaction of the genotypes with the planting dates was of relative importance in quantifying yield.

Plant height

The results of the mean squares from the combined analysis of variance (over two years) showed that planting date had significant effect on the height of the plants ($P \leq 0.01$). Mean comparison of the factor (Table 3) across the five planting dates over two years showed that genotypes sown on 10th October, 2009 and on 12th July, 2010 had the highest plant height (33.9 cm) and the shortest plants were those sown on 12th October, 2009 and on 6th September, 2010 (21.4 cm). Ahmed *et al.* (2010) reported that plant height differed between genotypes having taller plant G-2 (67.7 cm) compared with genotype TGx 1740-2F (40.3 cm) and they concluded that it was due gene makeup of the genotypes. However, there was no significant effect of interaction between sowing date and genotype on plant height across the sowing dates over two years.

This variability in plant height of the genotypes is in agreement with the findings of Malik *et al.* (2006), Ghatage and Kadu (1983), Rasaily *et al.* (1986) and Shegro *et al.* (2010). Moosavi *et al.* (2011) also reported that soybean planted in early May had significantly taller plants than those planted in August, in Iran temperate zones. Nizamuddin *et al.* (2007) reported a contradictory result, which showed that there is a significant effect of planting date on plant height.

First pod height

The result of combined analysis of variance across the five sowing dates over two years showed that the effect of planting date on the first pod height was significant at probability level of 1%. This result was confirmed by Muhammad *et al.* (2007). Furthermore, they found variability in the first pod height of different genotypes under different environments. In this experiment, the interaction of the factors had no significant impact on the first pod height (Table 2). This showed that genotypes were not affected by the planting date across the five sowing dates over the two years.

Days to 50% flowering

Statistical analysis on this trait showed that, sowing date had significant effect on the days to 50% flowering at probability level of 1%. In addition, the interaction between the genotype and planting date on the same trait revealed highly significant differences among the five sowing dates over two years (Table 2). The mean days to 50% flowering at various sowing dates (Table 3) showed that genotypes sown on 10th August, 2009 and on 12th July, 2010 had the longest number of days to 50% flowering (38.5 days), while genotypes sown on 12th October, 2009 and on 6th September, 2010 registered the shortest period (32.2 days). This finding is in accordance with Akande *et al.* (2009) who showed that, soybean varieties differed significantly in the number of days to 50% flowering. Inouye and Shanmugasundaram (1983) reported a similar high significant difference in response to days to 50% flowering, in some soybean genotypes they studied in Japan. Shegro *et al.* (2010) reported that delay in flowering was due to late planting; hence the interaction had significant difference on days to 50% flowering.

Table 2: Mean squares from analysis of variance of five soybean genotypes across five sowing dates averaged over two years

Source	DF	pH	FstPdht (cm)	Branch pp (no.)	Pod pp (no.)	Seed ppd (no.)	Laef area (cm^2)	Dflower (day)	Tswgt (g)	Seedyld (t/ha)
Rep	2	0.1	3.9	0.07	169.6	0.02	368.5	5.6	2.0	0.03
Sowing date	4	734.8**	6.5**	14.56**	3334.3**	0.11	5929.0**	174.1**	7.9	3.59**
Year	1	1143.4**	72.8**	60.42**	9964.0**	1.13**	53069.0**	0.1	988.2**	0.39
Sowing date(Year)	2	66.1**	14.1**	3.45**	529.8**	0.04	4784.0**	34.8**	10.1	0.15
Rep (Year x Sowing date)	18	8.9	5.7**	0.52	44.9	0.04	260.4	5.6	4.8	0.16
Genotype	4	1591.0**	28.0**	38.64**	7435.4**	0.09	22246.5**	917.9**	23.7	0.93**
Genotype (Sowing date)	16	16.9	1.1	0.68	318.3**	0.07	545.0**	34.6**	9.6	0.11
Genotype(Year)	4	177.9**	1.3	2.71**	634.1**	0.05	830.2**	61.0**	6.9	1.42**
Genotype (Year x Sowing date)	16	45.7**	2.1	1.34**	194.1**	0.06	676.1**	29.8**	17.1	0.29**
Pooled Error	80	12.8	1.5	0.47	58.8	0.04	182.8	5.6	10.0	0.11

Key: * Significantly different at 0.05 and 0.01 level of probability
** Highly significant at 0.05 and 0.01 level of probability
ns Non-significant difference among treatments

Table 3: Average plant height and days to 50% flowering of various planting dates along with their significance ranking (DMR) in both 2009 and 2010

		Plant height (cm)			Days to 50% flowering		
Code	Planting date PD	1st Season	2nd Season	Mean	1st Season	2nd Season	Mean
PD1	10th Aug. & 12th July	32^{a}	35.8^{a}	33.90	37.8^{a}	39.2^{a}	38.50
PD2	24th Aug. & 26th July	28.9^{b}	35.3^{a}	32.10	33.2^{b}	35^{b}	34.15
PD3	7th Sept. & 9th Aug.	28.2^{b}	34.6^{ab}	31.40	38^{a}	35^{b}	36.50
PD4	28th Sept. & 23rd Aug.	26.5^{bc}	36.5^{a}	31.50	34.4^{b}	34.8^{b}	34.60
PD5	12th Oct. & 6th Sept.	20.9^{c}	21.8^{c}	21.35	31.5^{bc}	32.8^{bc}	32.15
C.V.		13.3	10.8		9.5	4.1	
S.E.		3.6	3.5		3.4	0.1	
Genotype and sowing date		NS	**		**	**	

Means within column having the same superscripts are not significantly different according to Duncan's Multiple Range test at 5% level

Number of branches/plant

Planting date effect on the number of branches per plant was significant at probability level of 1%. The interaction of the factors on this trait was highly significant in 2009 and non-significant across the five planting dates over two years (Table 2). This result was in agreement with that of Nizamuddin *et al.* (2007). The planting dates of 10th October, 2009 and 12th July, 2010 produced plants with the highest average number of branches per plant (3.9) and the lowest average number of branches per plant were produced by the genotypes sown on 12th October, 2009 and 6th September, 2010 (2.1). Such a variability associated with number of branches per plant was in agreement with Rasaily *et al.* (1986), Chand (1999) and Rajanna *et al.* (2000) who reported that taller plants are more likely to produce greater number of branches per plant and number of pods per plant. This was further confirmed by Malik *et al.* (2007) and Ahmed *et al.* (2010) who reported that the number of branches per plant was affected significantly by sowing date.

Leaf area

Planting date had a significant effect on leaf area at 0.01 level of probability (Table 2). In addition, genotype and planting date interaction on this trait had significant effect across the five sowing dates over the two years, as the planting dates were delayed. This result conformed with Shegro *et al.* (2010) who reported that the leaf area was reduced as result of delay in planting and this reduction seriously affected the yield of the crop.

Genotypes sown on 10th, 24th August, 2009 and on 12th, 26th July, 2010 had the greatest leaf area per plant (123 cm^2) and those sown on 12th October, 2009 and on 6th September, 2010 had the lowest leaf area per plant (77 cm^2). A similar finding was reported by

Table 4: Average number of branches/plant and leaf area of various planting dates along with their significance ranking (DMR) in both 2009 and 2010

		Number of branches/plant			Leaf area (cm^2)		
Code	Planting date PD	1st Season	2nd Season	Mean	1st Season	2nd Season	Mean
PD1	10th August & 12th July	3.0^{a}	4.8^{a}	3.90	111.90^{a}	133.4^{b}	122.65
PD2	24th August & 26th July	2.3^{b}	4.4^{a}	3.35	107.50^{b}	138.6^{a}	123.05
PD3	7th September & 9th August	2.4^{b}	3.7^{ab}	3.05	105.45^{b}	134.7^{b}	120.08
PD4	28th September & 23rd August	2.4^{b}	3.8^{ab}	3.10	95.45^{c}	109.4^{c}	102.43
PD5	12th October & 6th September	2.0^{bc}	2.1^{c}	2.05	77.15^{d}	76.6^{d}	76.88
C.V.		26.7	18.9		17.9	10.6	
S.E.		0.7	0.7		14.5	12.5	
Genotype × Sowing date		**	NS		**	**	

Means within column having the same superscripts are not significantly different according to Duncan's Multiple Range test at 5% level

Morrison *et al.* (1999) and confirmed by Kumudini *et al.* (2001) who reported that the greater the leaf area, the higher the yield of soybean due to increased interception of solar radiation and carbon exchange rate, resulting in greater photosynthesis and increased assimilation.

Number of pods/plant

The analysis of variance (ANOVA) showed that, the effect of planting date on the number of pods per plant is important at 0.01 levels. The interaction of the factors on this trait had significant effect across the five sowing dates mean over two years (Table 2). The highest numbers of pods per plant (54.1) were produced by genotypes sown on 10th August, 2009 and on 12th July, 2010 whereas; planting on 12th October, 2009 and on 6th September, 2010 produced the lowest number of pods per plant (27.1). This variability in the number of pods per plant is genetically determined and it was in accordance with Magyarosi and Sjodin (1976) reported that the number of pods per plant greatly dependent upon the magnitude of the number of pods per node. Further, they reported that number of seeds per pod and number of pods per plant were the most important factors in determining seed yield. And it was confirmed by several plant scientists in many crops (Malik *et al*., 2006 and Oz *et al*., 2002).

Yield

Planting date had significant influence on the yield of genotypes at 1% level of probability. The interaction of the factors on this trait had no effect across the five sowing dates averaged over two years (Table 2), but had a significant effect in 2009 trial. Mean performance comparison showed that planting on 10th August, 2009 and on 12th July, 2010 had the highest yield of 1.1 t/ha whereas, genotypes planted on 12th October 2009 and on 6th September, 2010 produced the lowest yield of 0.3 t/ha (Table 5). Pedersen and Lauer (2004) reported that yield decreases as a result of drought stress, which depend on both the chronological timing of the stress and the degree of yield component compensation. Furthermore, they showed that yield is more influenced by changes from flowering to physiological maturity compared with emergence to flowering period.

Weather was noted to be a key factor controlling yield and soybean development in all agro-climates in Sennar State. The study revealed that the five sowing dates in the two years produced quite different patterns of plant growth and development. The climatic data from Sennar Research Station showed that July was the best month for raising soybean. The climatic data was confirmed by Smith (2000) who reported that the minimum and maximum temperature for growth was 10^{o} and 40^{o}C and the optimum was 25^{o}C. As such, an early July, (mid June) could be experimented and recommended to farmers because soybean germinates at 13°C but its optimum is 30°C. Onwueme and Shina's (1991) study revealed that temperature of 38°C or above is lethal to the crop. On the other hand, Christmas (2008) showed that soil and air temperature of 13 - 16°C were necessary for germination and seedling emergence, but further increase to about 32°C were better. Furthermore, the study revealed that the optimum sowing date was determined on basis of various factors of weather parameters, during cropping season, maturing, soil type, moisture availability at sowing.

It was deduced from the findings of this study that timely sown crops generally result in higher yields, but delay in planting led to weakness, resulting to short height, with fewer branches producing fewer pods. Nevertheless, the effect of agro-climatic factors on the crop establishment, flowering, pod initiation, pod filling and seed

Table 5: Average number of pods/plant and seed yield of various planting dates along with their significance ranking (DMR) in both 2009 and 2010

Code	Planting date PD	Number of pods/plant			Seed yield t/ha		
		1st Season	2nd Season	Mean	1st Season	2nd Season	Mean
PD1	10th Aug. & 12th July	42.8a	65.3a	54.1	1.19a	1.03a	1.1
PD2	24th Aug. & 26th July	41.8b	59.9b	50.9	0.77b	0.93b	0.9
PD3	7th Sept. & 9th Aug.	32.2c	55.4bc	43.8	0.70b	0.56c	0.6
PD4	28th Sept. & 23rd Aug.	31.3cd	46.5c	38.9	0.50c	0.46d	0.5
PD5	12th Oct. & 6th Sept.	26.2d	28.7d	27.5	0.30d	0.32de	0.3
C.V.		28.9	7.9		53.62	35.8	
S.E.		10.1	4.1		0.37	0.28	
Genotype and sowing date		NS	**		**	NS	

Means within column having the same superscripts are not significantly different according to Duncan's Multiple Range test at 5% level

Table 6: Monthly temperature and rainfall data for 2009 and 2010

Month	Maximum Temperature °C		Minimum Temperature °C		Mean Temperature °C		Rainfall mm	
	2009	2010	2009	2010	2009	2010	2009	2010
June	40.6	37.7	26.3	36.0	33.45	36.9	26.1	31.2
July	35.0	32.5	22.8	23.5	28.9	28.0	198.5	59.9
August	35.4	32.1	23.3	23.2	29.35	27.6	33.9	116.5
September	37.5	33.6	23.8	23.0	30.65	28.3	23.6	125.5
October	38.8	37.6	21.5	27.5	30.15	32.6	128.0	45.7
November	34.7	37.7	18.3	18.1	26.5	27.9	Nil	Nil

Source: Agricultural Research Station Sennar maturation reduces seed yield (Hundal *et al*., 2003). Hence, timely planting particularly, in mid-May and early June, could also be tried to escape late planting that affects the performance of the genotypes across the sowing dates. The findings of this study were in agreement with the results of Salem (2000) who reported that sowing date played important role in crop productivity, in that, the productivity of the genotypes decreased with delayed sowing. Furthermore, Faisal (1986), Mohamed (1988) and Ali (1993) added that higher yields were associated with weight per plant. The genetic variability associated with plant size and seed yield in the study was confirmed by Malik *et al.* (2006).

CONCLUSION

Crop performance is in fact strongly influenced by weather conditions. Thus, genotypes differential responses to environmental variations can be considered both as a barrier and as an advantage to improving yield potentials of genotypes or varieties of crops. This was confirmed by several researchers (Burton, 1987; Bos and Caligari, 1995) who found that seed yield was a complex trait and consists of components of quantitative nature, whose expression was determined by genetic and environmental factors as well as their interactions.

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REFERENCES

Ahmed, M. S., Alam, M. M. and Hasanuzzaman, M. 2010. Growth of different (Glycine max.L. Merril) varieties as affected by sowing dates. *Middle-East Journal of Scientific Research* 5 (5): 388 - 391.

Ali, K. A. M. 1993. Response of some new early maturing, soybean genotypes to planting dates and plant population densities. PhD. Thesis submitted to Faculty of Agriculture, Assuit University Egypt.

Akande, S. R., Taiwo, E. L., Adegbite, A. A. and Owolade, F. O. 2009. Genotypes ´ environment interaction for soybean grain yield and other reproductive characters in the forest and Savannah agro-ecologies of South-West Nigeria. *African Journal of Plant Science* 3(6): 127 - 132.

Baker, R. J. 1988. Tests for crossover genotype environment interactions. *Canadian Journal of Plant Science* 68: 405 – 410.

Bos, I. and Caligari, P. 1995**.** Selection methods in plant breeding. Chapman & Hall, London, UK, p. 100 – 132.

Burton, J. W. 1987. Quantitative genetics: Results Relevant to Soybean Breeding. In: WILCOX, J. R. (ed.): Soybeans: Improvement, Production and Uses. Agronomy 16, ASA, CSSA and SSSA, Madison, USA, p. 211 – 247.

Chand, P. 1999. Association analysis of yield and its components in soybean (Glycine max L. Merrill). *Madras Agricultural Journal* 86 (7-9): 378-381

Christmas, E. P. 2008. Plant populations and seeding rates for soybeans. Agronomy Guide, Purdue University, Cooperative Extension Service, West Lafayette, Indiana.

Faisal El, G. A. 1986. Influence of sowing and harvesting, timing, seed position, and storage on the quality of soybean. Thesis submitted to University of Khartoum in partial fulfilment of requirement for the degree of M.Sc. (Agriculture). University of Khartoum, Sudan.

Ghatge, R. D. and Kudu, R. N. 1983. Genetic variability and heritability studies in soybean. *Advances Plant Science.* 6: 224 – 228.

Hundal, S. S., Singh, H., Kaur, P. and Dhaliwal, L. K. 2003. Agro-climatic models for growth and yield of soybean (*Glycine max*). *Indian Journal of Agricultural Sciences* 73: 668–670.

Iamauti, M. T. 1995. Avaliac¸a˜o dos danos causados por *Uromyces* Welles, J. M. and J. M. Norman. 1991. Instrument for indirect measure *appendiculatus* no feijoeiro. PhD. diss. Escola Superior de Agricultural measurement of canopy architecture. Agronomy Journal. 83:818–825.cultura "Luiz de Queiroz", Piracicaba, SP, Brasil.

Inouye, J. and Shanmugasundaram, S. 1983. Photoperiod and temperature effects on the growth and reproductive behaviour of less photoperiod sensitive soybean 354. Proceedings of a Symposium, Tsukuba, Japan 26th September - 1st October, 1983.

Kumudini, S., Hume, D. J. and Chu, G. 2001. Genetic improvements in short season soybeans I. Dry matter accumulation, partitioning and leaf area duration. *Crop Science;* 41: 391 – 398.

Magyariosa, T. and Sjodin, J. 1976. Investigation of yield and yield components in the field bean (Vicia faba L.) varieties with different ripening time. *Z. Pflanzenzutctchutg* 77: 133 - 144.

Malik, M. F. A., Qureshi, A. S., Ashraf, M. and Ghafoor, A. 2006. Genetic variability of the main yield related characters in soybean. *International Journal of Agriculture & Biology.* 8 (6): 815 - 819.

Malik, M. F. A., Qureshi, A. S., Ashraf, M. and Ghafoor, A. 2007. Assessment of genetic variability, correlation & path analysis for yield and yield components in soybean. *Pakistan Journal of Botany*: 405 - 413.

Mohamed, M. S. A. 1988. Implication of genotype ´ planting date and row spacing interaction in soybean cultivar development, M.Sc. Thesis submitted to faculty of Agriculture, Cairo University, Egypt

Moosavi, S. S., Seyed, M. J. M., Ali, I. A., Ali, K. M. and Babak, M. S. 2011. Study of effect date on vegetative traits, reproductive traits and grain yield of soybean cultivars in cold region of Ardabil (Iran). *African Journal of Agricultural Research* 6(21): 4879 - 4883.

Morrison, M. J., Voldeng, H. D. and Cober, E. R. 1999. Physiological change from 58 years of genetic improvement of short-season soybean cultivars in Canada. *Agronomy Journal* 91: 685 – 689.

Muhammad F. A. M., Muhamad, A., Afsari, Q. S. and Abdul, G. 2007. Assessment of genetic variability, correlation and path analysis for yield and its components in soybean. *Pakistan Journal of Botany* 39 (2): 405 - 413.

Nizamuddin, M. B. and Maqsood, Q. 2007. Finding of suitable planting date of TPS parents for hybrid seed production in Northern areas of Pakistan. *Sarhad Journal of Agriculture* 23 (4): 991 - 1002.

Onwueme, I. C. and Shina, T. D. 1991. Field Crop Production in Tropical Africa, Principles and practice. Published by CTA, Wageningen, and Netherlands.159-175.

Oz, M., Karasu, A., Goksoy, A. T. and Turan, Z. M. 2002. Interrelationships of agronomical characteristics in soybean (Glycine max) grown in different environments. *International Journal of Agriculture and Biology* 11: 85 – 88.

Pedersen P. and Lauer, J. G. 2004. Response of soybean yield components to management system and planting date. *Agronomy Journal* 96: 1372 - 1381.

Rajanna, M. P., Viswanatha, S. R., Kulkarni, R. S. and Ramesh, S. 2000. Correlation and path analysis in soybean (*Glycine max* (L.) Merrill). *Crop Research Hisar* 20: 244 – 247.

Rao, M. S. S., Mullinix, B. G., Rangappa, M., Cebert, E., Bhagsari, A. S., Sapra, V. T., Joshi, J. M. and R. B. Dadson. 2002. Genotype x Environmental Interactions and Yield Stability of Food Grade Soybean Genotypes. *Agronomy Journal*; 94: 72-80

Rasaily, S. K., Desai, N. D. and Kukadia, M. U. 1986. Genetic variability in soybean (*Glycine max* L. Merrill). *Gujarat Agricultural University Resources Journal;* 11: 57–60

Salem, S. A. 2004. Yield Stability of Some Soybean Genotypes Across Divers Environment. *Pakistan Journal of Biological Science* 7 (12) 2109-2144.

SAS INSTITUTE Inc. 2000. The Stastical Analysis Software (SAS®) version 8.01. Statistical Package. Cary, North Carolina: SAS Institute

Shegro, A., Atilaw, A., Pal, U. R. and Geleta, N. 2010. Influence of varieties and planting dates on growth and development of soybean in Metekel zone, north western Ethiopia. *Journal of Agronomy* 9(3): 146-156

Smit, M. A. 2000. Your guide to successful soybean production, Agricultural Research Corporation, Grain Crops Institute

Specht, J. E., D. J. Hume and S. V. Kumudini. 1999. Soybean yield potential a genetic and physiological perspective. *Crop Science;* 39:1560–1570

Vaughan. J. G. and Geissler, C. A. 2008. The New Oxford Book of Food Plant. Published by Oxford University Press. 30

Welty, F. K., Lee, S. K., Lew, S. N., Nasca, M. and Zhou, R. J. 2007. The association between soy nut consumption and decreased menopausal symptoms. Journal of Women's Health 16:361-369.