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Varietal response of soybean (*Glycine max* L. Merrill) on growth, yield attributes and yield to different intra row spacing under ridge and furrow system

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Abstract
The present research work entitled "Varietal response of soybean (*Glycine max* L. Merrill) on growth, yield attributes and yield to different intra row spacing under ridge and furrow system" was conducted during 2019 on sandy loam texture soil at Tribal Research cum Training Centre, Anand Agricultural University, Devgadh Baria, Dahod, Gujarat. The experiment was laid out in randomized block design with factorial concept. Twelve treatment combinations include: three varieties V_1 (NRC 37), V_2 (JS 20-34) and V_3 (JS 335) and four intra row spacing S_1 (45 x 5 cm), S_2 (45 x 10 cm), S_3 (45 x 15 cm) and S_4 (45 x 20 cm) under ridge and furrow system. The soybean was considered as a test crop in this experiment. Results of the experiment showed that significant influenced on plant population at 20 DAS and at harvest, periodical plant height at 30, 60 DAS and at harvest, number of branches per plant at harvest, number of nodules per plant at 40 DAS, dry matter content at 30, 60 DAS and at harvest, crop growth rate at 0-30 DAS and 30-60 DAS, number of pods per plant, seed yield, stover yield and harvest index due to various varieties. However, results further manifested on pod length, number of seeds per pod and seed index were not altered statistically due to various varieties. Although, plant population at 20 DAS and at harvest, dry matter content at 30 DAS and at harvest, crop growth rate at 0-30 DAS and 30-60 DAS, number of pods per plant, seed yield and stover yield were significantly influenced due to different intra row spacing. Whereas, different intra row spacing failed to showed their significant results on periodical plant height at 30, 60 DAS and at harvest, number of branches per plant at harvest, dry matter content at 60 DAS, pod length, number of seeds per pod and seed index. Interaction effect between different varieties and various intra row spacing was found non-significant on all the growth and yield parameters during the experiment.

Keywords: Soybean, variety, NRC 37, JS 20-34, JS 335, intra row spacing, ridge and furrow system

Introduction
Soybean (*Glycine max* (L.) Merrill) is also known as soja bean, soya bean, chinese pea and manchurian bean which belongs to family fabaceae and has Eastern Asian origin. Soybean is considered as a 'wonder crop' due to its dual qualities *viz*., high protein (40-43 percent) and oil content (20 percent). It was introduced in India during 1960s, and is gaining rapid gratitude as a highly required pulse and oil seed crop. It's a rich source of fats, amino acids, vitamins and minerals. Its oil is also used as a raw material in manufacturing antibiotics, paints, lubricants varnishes and adhesives etc. It is also used for making soya milk, soya-paneer, soya-yogurt, soya-ice cream, soya-flour, soya fortified food stuffs and biscuits that have good acceptability among the people, because of its cost-effective and nutritional advantages. India stands next only to China in the Asia-Pacific region, with respect to area and production. Soybean existence the third in area and production of overall commercial oil seed crops, contributes 33 percent of our commercial oil seeds and 21 percent of total pulse production. In addition to this, soybean protein has 5 percent lysine, which is deficit in most of the cereals and enriching the cereal flour with soybean improves the nutritive quality (Narayana *et al.* 2009) [14].

In India, total area under soybean cultivation is 116.04 lakh ha with the production and productivity of 85.69 lakh tonnes and 738 kg/ha, respectively (Anon., 2016) [1]. In India major states growing soybean are Madhya Pradesh, Karnataka, Chhattisgarh, Gujarat, Maharashtra, Rajasthan and Andhra Pradesh. Varieties and intra row spacing both are the main factors of crop production. Varieties play an important role in the production of grain yield, selection of suitable varieties for a set of agro-climatic environments is very important to achieve maximum potential, because due to their different growth and development behavior. Row spacing is considered to be the foremost step to achieve suitable and uniform distribution of plants over cultivated area thereby better availability of above and below ground resources to increasing seed yield and decreasing competition among plants. It effects of crop yield through its influence on light interception, rooting pattern, nutrient extraction and moisture extraction pattern *etc*. In order to increase yield and net returns, many producers are switching to narrow-row spacing. However, some producers are limited by equipment availability and must plant wider rows. Therefore, it is necessary to have optimum plant spacing to achieve higher yield of soybean.

Soybean, though is a rainy season crop but is highly sensitive to excess waterlogging conditions. Therefore, fast removal of excess water logging is necessary to protect the crop from damage. The excess moisture or water logging conditions during monsoon season create unfavorable conditions for growth, such as reduced porosity which in turn reduces soil aeration, reduced root growth, hampered nodulation, reduced nutrient uptake affecting the physiology and biochemistry of a plant adversely which ultimately reflects on its production and productivity. Land management system plays a major important role in reducing soil erosion and improving water use efficiency of field crops. Easy and uniform germination as well as growth and development of plant are provided by manipulation of sowing method. Land configuration increases water use efficiency and also increases availability of nutrients to crops (Chiroma *et al.*, 2008) [6].

Land configuration *viz*., ridge and furrow and bed systems have been known to dispose additional rain water (runoff) faster than flat beds as in former two methods, furrows act as drainage channel. Rain water falling on the ridges or on the beds goes down to furrows, which carries it out from the fields. Accordingly, the root zone of the crop receives less water in ridges and furrow and bed systems compared to flat beds (Deshmukh *et al*., 2016) [7]. Land configurations for sowing of soybean have been used to enhance *in situ* rain water conservation and minimize soil erosion and nutrient losses during water stressed period and sometime act as drainage channels during water logged conditions (Kamboj *et al*., 2008) [26]. Water logging can be managed or mitigated to some extent by adopting or altering some suitable package of practices. Among the technologies planting technique is the most important, as change in layout methods will be useful for emergence and establishment of soybean which contribute to overall crop performance. With these in mind, a field experiment was conducted during *kharif* to assess varietal response of soybean with different intra row spacing under ridge and furrow system on growth and yield of soybean.

Materials and Method

In order to achieve the pre-set objectives of the present exploration, a field experiment was conducted during the *kharif* season of the year 2019 on plot no. 4 at Tribal Research cum Training Centre, Anand Agricultural University, Devgadh Baria, Dahod, Gujarat. The field experiment was planned with 12 treatments in randomized block design with factorial concept under four replications. The experiment consisted of twelve treatment combinations with three varieties V_1 (NRC 37), V_2 (JS 20-34) and V_3 (JS 335) and four intra row spacing S_1 (45 x 5 cm), S_2 (45 x 10 cm), S_3 (45 x 15 cm) and S_4 (45 x 20 cm) under ridge and furrow system. The experimental field had an even topography with a gentle slope having good drainage and soil was sandy loam in texture. Data on initial soil analysis indicated that the experimental site was low in organic carbon (0.39%) and available nitrogen (228 kg/ha), while medium in available phosphorus (35 kg/ha) and medium to high in potassium (280 kg/ha). The soil responds well to fertilizers and suitable for all the crops of tropical and sub-tropical regions. RDF (45-60-00 NPK kg/ha) and sulphur (20 kg/ha) were applied common in all the treatments during the experiment as a basal. All the observation, growth and yield parameter was taken as per standard method and collected data for various parameters were statistically analyzed using Fishers analysis of variance (ANOVA) technique and the treatments were compared at 5% levels of significance (Cochran and Cox, 1967) [27].

Results and Discussion

Effect on growth parameters of soybean

Plant population

An examination of data given in Table 1 revealed that plant population of soybean recorded at 20 DAS and at the time of harvest significantly influenced by various intra row spacing treatment but not by different varieties. Variety V_1 (NRC 37) recorded higher values of plant population (186680 and 182147 per ha) respectively, at 20 DAS and at harvest over the rest of variety of soybean. While, different treatments of intra row spacing revealed that significantly the highest value of plant population (342593 and 338027 per ha) were observed at 20 DAS and at harvest, respectively with the intra row spacing S_1 (45 x 5 cm). The result might be due to more seed rate in the spacing of 45 x 5 cm that leads to more germination of plants. However, closer spacing required high seed rate and there is slight competition for nutrients and moisture as well as solar radiation between crop and weed. These findings are in contrast with the result of Singh *et al.*, (2009) [23], Ibrahim (2012) [8] and Verma (2019) [24].

Periodical plant height

The data on periodical plant height (cm) was recorded at various crop growth stages *viz*. 30, 60 DAS and at harvest as influenced by varieties and intra row spacing in ridge and furrow are presented in Table 1. Tallest plants were observed at each stage to the tune of 34.61 cm, 59.12 cm and 61.28 cm at 30, 60 DAS and at harvest, respectively, with variety V_1 (NRC 37) as compared to rest of the varieties. While, numerically taller plant were observed with the 45 x 10 cm (33.07, 55.62 & 57.07 cm) intra row spacing and dwarf plant in 45 x 5 cm (31.95, 51.91 & 53.51 cm) intra row spacing under ridge and furrow system at 30, 60 DAS and at harvest, respectively. Significantly highest plant height observed in NRC 37 might be due to superiority in their genetic make-up and its performed superiority towards sunlight harvesting and nutrient uptake from soil, which ultimately influenced plant height. These results are in accordance with the findings of Rekha & Dhurua (2010) [18], Vyash & Khandwe (2014) [25], Singh *et al.*, (2014) [22] and Bhilore *et al.*, (2016) [4].

Number of branches per plant

The result of data presented in Table 1, number of branches per plant at harvest of soybean revealed that variety V_1 (NRC 37) produced significantly highest number of branches per plant (4.51). The lowest number of branches per plant (3.78) was recorded under the variety V_2 (JS 20-34). However, numerically higher numbers of branches per plant (4.29) were observed with intra row spacing S_2 (45 x 10 cm) among the different intra row spacing under ridge and furrow system. Results might be due to more interception of light and more compatibility of nutrient uptake by plant under 45 x 10 cm intra row spacing in under ridge and furrow system. Significantly highest number of branches per plant observed in NRC 37 might be due to favorable conditions during crop growth stage, which resulted in better physiological activities of cell division and stem elongation that leads to increase in the branches. This result are collaborate to Patel (2008) [15], Ramgiry *et al.* (2014) [17] and Bhilore *et al.* (2016) [4].

Number of nodules per plant

Data pertaining to the average number of nodules per plant as influenced by different varieties and intra row spacing are presented in Table 1. The variety V_1 (NRC 37) produced significantly the highest number of nodules per plant (37.77). The highest number of nodules per plant was found in the variety V_1 (NRC 37) might be due to increase with the advancement of the crop and the addition of the nutrients also creates the favourable conditions for nodulation. Similar results found by Patel (2008) [15], Mere *et al.* (2013) [12] and Vyash & Khandwe (2014) [25]. Whereas, significantly higher number of nodules per plant (35.87) was obtained under intra row spacing S_2 (45 x 10 cm), but it was at par (34.62 and 34.47) with intra row spacing S_3 (45 x 15 cm) and S_4 (45 x 20 cm) respectively. Results might be due to fact that more interception of radiation and more nutrients there by producing more nodules per plant under 45 x 10 cm intra row spacing under ridge and furrow system and also due to less competition between plants. The results collaborate the findings of Mehmet (2008) [11], Singh *et al.* (2009) [23], Bhalerao (2010) [3] and Chauhan *et al.* (2013) [5].

Dry matter content (g/plant)

It was observed from data presented in Table 1 that dry matter content (g/plant) of soybean was found remarkably influenced due to varieties and various intra row spacing treatments. Significantly the highest dry matter content (g/plant) was observed at 30 DAS and at harvest (6.53 and 34.40 g/plant) respectively. While, at 60 DAS, significantly higher dry matter content (15.23 g/plant) was found under variety V_1 (NRC 37), but it was found at par with variety V_3 (JS 335). The result might be due to superior genetic makeup of variety which leads to the higher vegetative growth and development of crop, which ultimately affect dry matter content. The results are in conformity to those findings of Patel (2008) [15] and Malek *et al.* (2012) [10]. While, significantly higher dry matter content (6.09 g plant^{-1} and 31.94 g plant^{-1}) was recorded under intra row spacing S_4 (45 x 20 cm) at 30 DAS and at harvest, respectively. However, it was found at par with treatment S_2 (45 x 10 cm) and S_3 (45 x 15 cm). While, at 60 DAS dry matter content was found non-significant. The result might be due to more interception of solar radiation, moisture and nutrient under this intra row spacing which directly affect the plant growth that ultimately reflects the higher in dry matter content. The results reported are in accordance to those of Shamsi & Kobraee (2009) [21] and Singh *et al.* (2009) [23].

Crop growth rate (g m^{-2} day^{-1})

The data with respect to crop growth rate (g m^{-2} day^{-1}) as influenced by different varieties and various intra row spacing are presented in Table 1. Variety V_1 (NRC 37) recorded significantly the highest crop growth rate (4.76 g m^{-2} day^{-1}) at 0-30 DAS, while, at 30-60 DAS crop growth rate (10.46 g m^{-2} day^{-1}) were found significantly higher under variety V_1 (NRC 37), but it was found at par with variety V_3 (JS 335). The lowest crop growth rate (4.17 and 8.66 g m^{-2} day^{-1}) at 0-30 and 30-60 DAS respectively, was recorded under variety V_2 (JS 20-34). The result might be due to higher growth and dry matter content which ultimately affected crop growth rate. The results are in conformity to those findings of Malek *et al.* (2012) [10], Mere *et al.* (2013) [12] and Verma (2019) [24]. Intra row spacing S_1 (45 x 5 cm) was recorded significantly maximum crop growth rate (8.07 g m^{-2}day^{-1}) at 0-30 DAS, while, intra row spacing (S_4) 45 x 20 cm (12.04 g m^{-2} day^{-1}) at 30-60 DAS was found significantly higher crop growth rate, but it was found at par with intra row spacing S_3 (45 x 15 cm). The lowest crop growth rate (2.25 g m^{-2} day^{-1}) at 0-30 DAS under the treatment S_4 (45 x 20 cm) and at 30-60 DAS dry matter content 5.43 g m^{-2} day^{-1} was observed under intra row spacing S_1 (45 x 5 cm) respectively. The result might be due to higher dry matter content which ultimately affected crop growth rate. The results collaborate the findings of Shamsi & Petrosyan (2008) [20], Shamsi & Kobraee (2009) [21] and Verma (2019) [24].

Effect on yield attributes and yield of soybean

Total number of pods per plant

It was evident from data presented in Table 2 that varieties and various intra row spacing treatments exerted their valuable impact on total number of pods per plant. Variety V_1 (NRC 37) was recorded significantly maximum number of pods per plant (72.69). The lowest number of pods per plant (37.28) was recorded under variety V_2 (JS 20-34). The result might be due to higher plant growth and number of branches that provides better number of pods per plant. The results are in conformity to those findings of Rekha & Dhurua (2010) [18], Prajapat (2012) [16], Mere *et al.* (2013) [12], Singh *et al.* (2014) [22] and Angadi (2016) [2]. Significantly maximum number of pods per plant (60.63) was recorded with intra row spacing S_2 (45 x 10) however, it was closely related with intra row spacing S_3 (59.68) and S_4 (59.44) respectively. Number of pods per plant under S_2 (45 x 10) cm intra row spacing in under ridge and furrow system was recorded highest might be due to fact that better absorption of light, nutrients and water which may resulted in more translocation of metabolite towards reproductive organs of plant due lesser intra plant competition for space, nutrients and moisture. The results are in conformity to those of Reddy *et al.* (1990) [19] and Singh *et al.* (2009) [23].

Pod length (cm)

Perusal of data showed in Table 2 reflected that different varieties and intra row spacing failed to show their significant influenced on pod length. However, numerically higher values of pod length (4.00 cm) was recorded under the variety NRC 37 and lowest value of pod length was obtained under the variety JS 20-34 (3.89 cm). Although, numerically higher values of pod length (4.04 cm) was recorded with intra row spacing S_2 (45 x 10) cm and intra row spacing S_1 (45 x 5 cm) recorded the lowest value of pod length (3.81 cm).

Number of seeds per pod

Data pertaining to the number of seeds per pod as influenced by different varieties and various intra row spacing presented in Table 2 did not exert their significant influenced on number of seed per pod. However, numerically higher value of number of seeds per pod (2.93) was recorded under variety V_3 (JS 335) and numerically lower value of seeds per pod (2.89) was recorded under V_1 (NRC 37). Whereas, numerically higher number of seeds per pod (2.93) was recorded with intra row spacing S_2 (45 x 10 cm) and S_3 (45 x 15 cm) and numerically lower values (2.87) of number of seeds per pod was recorded under intra row spacing S_1 (45 x 5 cm).

Seed index (g)

Mean data regarding to seed index of soybean as influenced by different varieties and intra row spacing failed to show their significant results and are given in Table 2. Variety V_3 (JS 335) recorded numerically higher value of seed index (12.61 g). The numerically lower value of seed index (12.45 g) was found in variety V_2 (JS 20-34). However, numerically higher seed index (12.69 g) was recorded under intra row spacing S_2 (45 x 10 cm). The numerically lower value of seed index (12.29 g) was recorded with intra row spacing S_1 (45 x 5 cm).

Seed and stover yield (kg/ha)

Data on yield (kg/ha) as influenced by different varieties and various intra row spacing are presented in Table 2. Result of experimental data show that seed and stover yield of soybean significantly influenced by varieties and intra row spacing treatments. Variety V_1 (NRC 37) recorded significantly the highest seed and stover yield (1615 and 1812 kg/ha) of soybean respectively. Whereas, the lowest seed and stover yield (1149 and 1378 kg/ha, respectively) of soybean was recorded under variety JS 20-34. The higher seed and stover yield of soybean might be due to higher growth components that leads to higher photosynthetic activities which increase cell division, cell elongation and higher metabolic activities that ultimately increase the seed and stover yield. However, higher number of nodules also helps in availability of nutrients throughout the growing periods. These results are in conformity with findings of Rekha & Dhurua (2010) [18], Mere *et al.* (2013) [12], Jaybhay *et al.* (2014) [9], Ramgiry *et al.* (2014) [17], Singh *et al.* (2014) [22], Angadi (2016) [2], Bhilore *et al.* (2016) [4] and Verma (2019) [24]. The result of intra row spacing treatment showed that intra row spacing S_2 (45 x 10 cm) recorded significantly the highest seed and stover yield (2060 and 2273 kg/ha, respectively) of soybean. While, the lowest value of seed and stover yield (799 and 1038 kg/ha, respectively) was recorded with intra row spacing S_4 (45 x 20 cm). The higher seed yield under intra row spacing 45 x 10 cm might be due to advantage of better utilization of moisture and nutrient as well as solar radiation due better orientation of the leaves which in turn resulted in greater amount of photosynthesis leading to increase in yield attributes there by resulted in higher seed yield. Similar results were confirmed by Reddy *et al.* (1990) [19], Singh *et al.* (2009) [23], Bhalerao (2010) [3], Ibrahim (2012) [8], Mondal *et al.* (2014) [13] and Angadi (2016) [2].

Table 1: Growth parameters of *kharif* soybean influenced by various treatments of varieties and intra row spacing

Treatments	Plant population ha^{-1}		Periodical plant height (cm)			No. of branches plant^{-1}	No. of nodules plant^{-1}	Dry matter (g plant^{-1})			CGR (g m^{-2} day^{-1})	
	20 DAS	At Harvest	30 DAS	60 DAS	At harvest	At harvest	40 DAS	30 DAS	60 DAS	At harvest	0-30 DAS	30-60 DAS
Varieties												
V_1 : NRC 37	186680	182147	34.61	59.12	61.28	4.51	37.77	6.53	15.23	34.40	4.76	10.46
V_2 : JS 20-34	178723	173708	30.40	45.46	46.78	3.78	28.94	5.42	12.83	25.78	4.17	8.66
V_3 : JS 335	181182	176215	32.19	56.93	58.44	3.93	35.11	5.66	14.34	31.43	4.32	10.01
S.Em. ±	4269	4224	0.74	1.24	1.211	0.14	0.83	0.15	0.39	0.57	0.14	0.42
C.D. at 5%	NS	NS	2.13	3.56	3.48	0.39	2.38	0.43	1.11	1.64	0.39	1.20
Spacing												
S_1 : 45 x 5 cm	342593	338027	31.95	51.91	53.51	3.78	30.81	5.45	13.50	28.04	8.07	5.43
S_2 : 45 x 10 cm	171618	165766	33.07	55.62	57.07	4.29	35.87	5.89	14.30	30.49	4.36	9.94
S_3 : 45 x 15 cm	119792	115934	32.43	53.51	55.36	4.25	34.62	6.04	14.43	31.68	2.98	11.44
S_4 : 45 x 20 cm	94779	89699	32.14	54.31	56.06	3.97	34.47	6.09	14.29	31.94	2.25	12.04
S.Em. ±	4930	4877	0.85	1.43	1.40	0.16	0.96	0.17	0.45	0.66	0.16	0.48
C.D. at 5%	14184	14033	NS	NS	NS	NS	2.75	0.50	NS	1.90	0.45	1.39
V x S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	9.37	9.53	9.12	9.18	8.73	13.37	9.77	10.26	10.93	7.49	12.24	17.22

Table 2: Yield attributes and yield of *kharif* soybean influenced by various treatments of varieties and intra row spacing

Treatments	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	Seed index (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Varieties						
V_1 : NRC 37	72.69	4.00	2.89	12.50	1615	1812
V_2 : JS 20-34	37.28	3.89	2.91	12.45	1149	1378
V_3 : JS 335	55.77	3.98	2.93	12.61	1421	1636
S.Em. ±	1.70	0.08	0.04	0.19	36.33	46.35
C.D. at 5%	4.89	NS	NS	NS	104.54	133.47
Spacing						
S_1 : 45 x 5 cm	41.23	3.81	2.87	12.29	1553.	1743
S_2 : 45 x 10 cm	60.63	4.04	2.93	12.69	2060	2273
S_3 : 45 x 15 cm	59.68	3.94	2.93	12.48	1169	1380
S_4 : 45 x 20 cm	59.44	4.03	2.90	12.63	799	1038
S.Em. ±	1.96	0.09	0.05	0.22	41.95	53.53
C.D. at 5%	5.64	NS	NS	NS	120.71	154.12
V x S	NS	NS	NS	NS	NS	NS
C.V. %	12.29	7.97	5.75	6.01	10.41	11.53

Interaction effect on growth, yield attributes and yield of soybean

An examination of data presented in Table 1 and Table 2 interaction effect of varieties and various intra row spacing treatments revealed that growth, yield attributes and yield parameters of soybean was not significantly influenced by varieties and various intra row spacing treatments.

Conclusion

In view of the results obtained from the one year investigation, it is concluded that for getting higher seed and stover yield of soybean, soybean variety NRC 37 should be sown at 45 x 10 cm spacing under ridge and furrow system.

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