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Effect of time of sowing and row spacing on growth, yield and quality of soybean (*Glycine max* L.) under rainfed condition

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Abstract
A field experiment was conducted during the *kharif* season of 2020 at the College Farm, College of Agriculture, N.A.U, Bharuch, to study the "Effect of time of sowing and row spacing on growth, yield and quality of soybean (*Glycine max* L.) under rainfed condition". The soil of the experimental field was clayey in texture having medium to poor drainage capacity, good water holding capacity, medium in available nitrogen, medium in available phosphorus, high in available potassium and low in available sulphur and slightly alkaline in reaction. Total nine treatment combinations consisting of three levels of time of sowing (T1: Onset of monsoon, T2: One week after T1 and T3: One week after T2), and three levels of row spacing (S1: 30 cm, S2: 45 cm and S3: 60 cm) were evaluated in factorial randomized block design with three replications. The results revealed that sowing of soybean at onset of monsoon with 60 cm row spacing were found to be optimum agronomic practices for obtaining the higher growth, yield and quality under rainfed condition.

Keywords: Soybean time of sowing, row spacing, growth, yield and quality

Introduction
Soybean [*Glycine max* (L.)] is a well-known oilseed and pulse crop. It is the richest and cheapest source of high quality proteins, minerals, vitamins and fats. Soybean is called as miracle "Golden bean" of 21st century. It is a boon for malnourished world because it is high nutritive and energy rich monocarp legume with protein (40%), oil (20%) and high level of essential amino acid like lysine (5%), minerals (4%), phospholipids (2%) and the vitamins (thiamine and riboflavin). It has a greater potential to substitute different oilseeds and pulses to overcome the shortage of edible oils and protein rich food. Soybean being leguminous crop can fix up atmospheric nitrogen in soil to an extent of 65 to 100 kg/ha depending on the soil type and climatic conditions through Rhizobial symbiosis. Soybean accounts for 54% of global oilseed production. In India the area under soybean crop was 10.76 million ha with 9.3 million MT of total production in 2019 and an average productivity was 865 kg/ha (SOPA, 2019) [18]. In Gujarat, it is cultivated in about 1 lakh hectares with an annual production of 0.86 lakh tonnes and average productivity of 858 kg/ha (SOPA, 2019) [18].
Sowing date plays a significant role in determining growth, development and yield of soybean. Sowing after optimum time usually leads to final yield loss. Sowing crop at optimum time increases the yield due to suitable environment at all the growth stages of the crop. Achieving the correct planting date is one of the most important factors in producing optimal soybean yield. Optimal planting dates vary by variety, cropping system and environmental conditions. Planting prior to or later than the optimal planting date can greatly reduce soybean yield and quality since photoperiodism controls not only the number of days to flowering, but also the amount of time available for vegetative plant growth and development (Berger *et al*. 2014) [6]. Soybean is a rainfed crop so its planting depends on the onset of monsoon. Spacing is one of the important parameter, which ultimately affected nutrients uptake, growth and yield of plant. Increase in spacing, the total population decrease, but with more nutrition the individual plant grow better and get more yield and vice-versa. The increase or decrease of row spacing and plant population has definite pattern in relation to the yield. In these simultaneous opposing effects of the two components there should be a point where maximum yield is expected and that should be at the optimum spacing. Therefore, it becomes imperative to test the role of time of sowing and row spacing of soybean.

With this background information, the present experiment was planned at the College Farm, college of agriculture, Navsari Agricultural University, Bharuch, Gujarat.

Materials and Methods

The field experiment was conducted during the *kharif* season of the year 2020 at College Farm, College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat. The experimental soil was clay in texture, medium in available nitrogen (256 kg/ha), low in available phosphorus (25 kg/ha), high in available potassium (340 kg/ha), low in available sulphur (7 mg/kg) and slightly alkaline in reaction (pH 7.50). Total nine treatment combinations consisting of three levels of time of sowing (T1: Onset of monsoon, T2: One week after T1 and T3: One week after T2), and three levels of row spacing (S1: 30 cm, S2: 45 cm and S3: 60 cm) were evaluated in factorial randomized block design with three replications. Required quantity of seed as per treatment was calculated for experimental area. Five plant were selected randomly from each net plot and tagged for recording growth and yield attributing parameters. The data on seed and straw yield was recorded from the net plot and converted on a hectare basis. The nitrogen content in soybean seed was estimated by micro Kjeldahl's method as described by Jackson (1973) [9]. The protein content of the seed was computed by multiplying the nitrogen percentage with 6.25 for each treatment. Oil content of seed was determined by soxhlet apparatus as per the method suggested by Tiwari *et al*., 2011 [19].

Results and Discussion

Effect of time of sowing

Effect on growth parameters

The significantly taller plant (81.78 cm) and number of branches/plant (6.36) were observed under the treatment T1 (Onset of monsoon). This is probably due to timely sowing which might have enjoyed favourable climatic conditions in term of temperature and other parameters during crop growth. These results lend support to those reported by Ibrahim (2012) [8] and Asewar *et al*. (2015) [1].

Effect on yield attributes and yield

Significantly highest number of pods/plant (84.36), number of seeds/pod (2.76), seed yield (1764 kg/ha) and straw yield (3434 kg/ha) were recorded under treatment T1 (Onset of monsoon). This was might be because of adequate and increased availability of nutrients for development of more number of pods per plant and better seed filling with maintenance of better source-sink relationship. With delayed planting the growth period becomes short, while high temperature during flowering decreases the seed yield and yield components of soybean planted early. The results are in conformation with Ibrahim (2012) [8], Barati *et al*. (2013) [5], Sadeghi and Niyeki (2013) [14], and Yari *et al*. (2013) [22]. However, sowing dates had non significant effect on test weight indicating uniform effects of various time of sowing on test weight. Continuity with the results of Ram and Dixit (2000) [13].

Effect on quality

Varying sowing time failed to produce significant effect on quality of soybean in terms of protein content and oil content. However, numerically higher protein content (39.15%) and oil content (19.55%) in soybean was observed under the treatment T_1 (Onset of monsoon). Significantly higher protein yield (692.10 kg/ha) and oil (346.53 kg/ha) yield were recorded under the treatment T_1 (Onset of monsoon). The higher protein yield and oil yield obtained under the above treatment was the resultant of perceptibly higher seed along with the higher protein content and oil content which were directly responsible for higher protein yield and oil yield. The timely sown crop experienced favorable weather conditions for longer duration recorded better growth and seed yield resulted in more protein and oil productivity. Similar results were reported by Aastha and Singh (2017) [3] and Shivani and Kumar (2002) [15].

Effect of row spacing

Effect on growth parameters: The significantly tallest plant (82.18 cm) and higher number of branches/plant were observed under the treatment S_3 (60 cm) than S_1 (30 cm) and S_2 (45 cm). This increase in plant height at wider row spacing might be due to fact that plant gets enough space for growth i.e. 60 cm row spacing showed a better row to row spacing for better plant height. Similar finding reported by Lone (2006) [10] and Aastha and Singh (2016) [2]. While, higher number of branches/plant due to sufficient availability of sunlight and nutrient which increased plant growth and development. The present results are in cognizance with those of Lone (2006) [10] and Mondal *et al*. (2014) [11].

Effect on yield attributes and yield

Significantly higher number of pods/plant (85.16) and number of seeds/pod (2.84) were recorded under treatment S_3 (60 cm). This was possibly due to less competition between plants for nutrient, soil moisture, space and solar radiation etc. in wider spacing than closer spacing. This also confirms the results of Siva Kumar *et al*. (2018) [17], Tomar and Tiwari (1991) [20] and Rahman *et al*. (2013) [12]. The treatment S_3 (60 cm) recorded significantly higher seed yield (1742 kg/ha) and straw yield (3359 kg/ha) over S_1 and S_2. This was due to the fact that at 60 cm row spacing the number of rows/m^2 get decreased and as the row to row spacing is decreased the number of rows/m^2 get increase hence increasing the plant population per m^2. Plants in close proximity have more competition as compared to wider spacing. Improved yield attributing characters such as test weight, seeds per pod and number of pods per plant was recorded at higher spacing ultimately increasing the seed yield and straw yield. Similar findings were observed by Babalal *et al*. (2005) [4], Lone (2006) [10] and Vyas and Khandwe (2014) [21]. An appraisal of results in respect of weight of 100 seeds was found to be non significant due to various spacing, however, the numerically higher test weight (6.46 g) was observed in treatment S_3 (60 cm). These results lend support to those reported by Shivani and Kumar (2002) [15] and Singh (2011) [16].

Effect on quality: Protein content and oil content were not influenced significantly due to spacing. The wider spacing of S_3 (60 cm) recorded significantly higher protein (692.10 kg/ha) and oil yield (346.53 kg/ha). The higher protein and oil yield achieved under this treatment was due to the higher seed yield, which is directly responsible for higher protein and oil yield. Almost similar findings were also reported by Vyas and Khandwe (2014) [21] and Halvankar *et al*. (1999) [7].

Interaction Effect: All the interaction effect on growth parameters, yield and yield attributes and quality of soybean were found non- significant.

Table 1: Effect of time of sowing and row spacing on growth parameters, yield attributes, yield and quality of soybean

Treatment	Plant height (cm)	Number of branches/plant	Number of pods/plant	Number of seeds/ pod	Test weight (g)	Seed Yield (kg/ha)	Straw Yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)
Time of sowing (T)											
T1	81.78	6.36	84.36	2.76	10.37	1764	3431	39.15	692.10	19.55	346.53
T2	75.84	5.97	81.53	2.36	10.02	1531	3053	38.74	595.00	18.78	288.48
T3	57.28	5.27	74.38	2.05	9.87	1279	2501	37.92	488.10	18.87	241.37
S.Em. ±	1.84	0.17	1.79	0.07	0.25	38.23	70.10	0.79	24.00	0.43	11.26
C.D.at 5%	5.51	0.51	5.39	0.21	NS	114.62	210.14	NS	71.90	NS	33.76
Spacing (S)											
S1	55.61	6.18	72.86	1.95	9.77	1312	2520	37.55	495.80	18.65	244.63
S2	77.12	5.20	82.25	2.38	10.18	1521	3112	38.80	592.2	19.26	294.31
S3	82.18	6.23	85.16	2.84	10.31	1741	3353	39.46	687.20	19.30	337.44
S.Em. ±	1.84	0.17	1.79	0.07	0.25	38.23	70.10	0.79	24.00	0.43	11.26
C.D.at 5%	5.51	0.51	5.39	0.21	NS	114.62	210.14	NS	71.90	NS	33.76
Interaction (T x S)											
S.Em. ±	3.18	0.29	3.11	0.12	0.44	66.23	121.42	1.37	41.50	0.74	19.51
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

(T_1: Onset of monsoon, T_2: One week after T_1, T_3: One week after T_2, S_1: 30 cm, S_2: 45 cm, S_3: 60 cm)

Conclusion

Finally it is concluded that for getting potential yield and quality from soybean Cv.KDS-344 grown under rainfed condition could be obtained by sowing of soybean during onset of monsoon along with spacing 60 cm. Yield reduction in late sowing has been attributed to lack of sufficient vegetative growth and reduce seed weight.

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