



# Influence of Reduced Seed Rate and Sowing Methods on Growth Parameters and Seed Yield of Soybean (*Glycine max* L. Merr.)

Sumalata Byadgi <sup>a\*</sup>, Jyothi B. L. <sup>a</sup>, Ashwini Kamat <sup>a</sup>  
and Siddaraju R. <sup>a</sup>

<sup>a</sup> Seed Technology Research Centre, AICRP on Seed (Crops), University of Agricultural Sciences, Bengaluru-65, India.

## Authors' contributions

This work was carried out in collaboration among all authors. Author SB carried out the research collected the data and wrote the paper. Author JBL assisted in data analysis. Author AK recorded the observations data. Author SR conceived and designed the analysis. All authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/IJPSS/2023/v35i203890

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/106532>

Original Research Article

Received: 23/07/2023  
Accepted: 27/09/2023  
Published: 05/10/2023

## ABSTRACT

The field experiment was carried out during *Kharif*, 2018 and 2019 with an objective to increase the productivity of soybean with reduced seed rate and varied sowing methods. The experiment comprising of two sowing methods *viz.*, flatbed and raised bed, two varieties (JS-335 and JS-9560) and three seed rates (70, 60, and 50 kg ha<sup>-1</sup>) was laid out in split plot design with four replications. The growth and yield parameters *viz.*, plant height (44.77 cm), canopy diameter (22.50 cm), pods per plant (37.72) and seed yield ha<sup>-1</sup> (18.32 q) were maximum in raised bed method of planting. Use of lower seed rate *i.e.*, 50 kg ha<sup>-1</sup> produced maximum canopy diameter (23.97 cm<sup>2</sup>), pods plant<sup>-1</sup> (39.86), seed yield plant<sup>-1</sup> (15.12 g) and seed yield ha<sup>-1</sup> (17.05q). Hence, there is a possibility of optimizing yield of soybean by adopting raised bed method of sowing at the seed rate of 50 kg ha<sup>-1</sup>.

\*Corresponding author: E-mail: [suma.b549@gmail.com](mailto:suma.b549@gmail.com);

**Keywords:** Raised bed method; seed rate; canopy diameter; flat bed method and optimization.

## 1. INTRODUCTION

Soybean designated as 'miracle bean' has established its potential as an industrially vital and viable oilseed crop in many areas of India. Soybean (*Glycine max* L.) Merrill is a legume that grows in tropical, sub-tropical and temperate climates. It is a multipurpose crop with many food and industrial values. It contains about 20-22% oil and 40-42 % high quality protein. It improves soil fertility by fixing atmospheric nitrogen at the rate of 65-115 kg ha<sup>-1</sup> per year with the process of symbiosis through *Rhizobium japonicum* micro-organisms. It also improves the structure and fertility of the soil by adding the leaves and straw having 9 per cent nitrogen, 12 per cent phosphorus and 8.9 per cent potash. Thus, it is soil fertility builder and eco-friendly. The area under soybean crop is increasing steadily and in India during 2018-19 the area covered was around 10.56 million ha with the production of 11.39 million tonnes. Soybean now has been established as one the most important oilseed crop in the world, accounting for more than 50 per cent of oilseed produced and 30 per cent of the total supply of all vegetable oils. There are many competitive factors that play an extremely important role in the production of soybean and its profitability to the producer. Seed quality, planting date, fertilizer, soil type, row spacing and seeding rate are just a few vital factors that producers must consider when planting soybean or any other production crop. It is important to plant the number of seeds that will achieve the desired number of plants per acre in a uniform stand of soybean. The seeding rate or plant population is one of the most important factors when it comes to profitability for the producer. Soybean seed costs have increased over the past few years, driven in part by soybean seed being priced similar to corn seed. Optimum plant population per unit area helps to maximum utilization of the available resource especially light, water and nutrient allowing the production of higher seed yield. Therefore, optimum seed rate is necessary for obtaining maximum seed yield. Uniform spacing generally gives better yield under favorable moisture condition. Farmers tend to plant 25 per cent more seed than needed. Some of it is just habit, but some producers feel that the high seeding rates are needed for better weed control. Most people can reduce seeding rate by 25 per cent without affecting either weed control or yield. Therefore, establishment of an optimum

seed rate requirement is a non-monetary input factor for enhancing the production of soybean. The advantage of lower or the minimum seed rate is distribution of plant equidistantly which leads to increased canopy leaf area development [1]. These changes in canopy formation increase crop growth rate, dry matter accumulation and seed yield [2,3].

Sowing method also plays an essential role in the emergence and establishment of seedlings. Amidst the sowing methods, raised bed method is a novel method for cultivation of soybean in India whereas; flatbed sowing is conventional sowing method. This raised bed planting method have numerous benefits like better plant establishment, root development and ability to use inter bed cultivation for weed control, proper irrigation management etc., over conventional flatbed sowing [4].

Seeding rate and methods of sowing are agronomic decisions that producers can use to maximize soybean seed yield. Risks are associated with reduced seeding rates, but as seed costs increase and since yield responses are small the focus must be placed on economic return rather than yield maximization. Since the seed rate of soybean is high and it loses its viability and vigour at faster rate due to its delicate seed coat, seed rate compensation is an method for the farmers to use the saved seeds for sowing to compensate the germination and yield as well [5]. Hence, the present investigation was carried out to study the effect of soybean seeding rate and sowing methods on plant growth and seed yield

## 2. MATERIALS AND METHODS

To evaluate the effect of differed sowing methods and seed rates on growth yield and quality of soybean, field experiment was carried out during *Kharif*, 2018 and 2019 for two consecutive years at Seed Research Centre, UAS, GKVK, Bengaluru (12° 15' N Latitude and 77° 35' E longitude 930 m above Mean sea level). The annual rainfall ranges from 528 mm to 1374.4 mm with the mean of 915.8 mm. During *kharif* 2018 and 2019 the average rainfall received at Bangalore was 815 mm as against 78 rainy days. The experimental soil was sandy (46.3 %) with pH (7.5%), EC (0.32dsm<sup>-1</sup>), available nitrogen (143.5kg ha<sup>-1</sup>), available P<sub>2</sub>O<sub>5</sub> (27.16 kg ha<sup>-1</sup>) and K<sub>2</sub>O (374.2 kg ha<sup>-1</sup>). Seeds having initial

germination of 90 per cent were dried to safe level of moisture (9.0 %), graded to uniform size and then used for the study to avoid variations. The experiment comprised of two sowing methods viz., S<sub>1</sub>: Flat-bed sowing and S<sub>2</sub>: Raised bed sowing; two varieties with different maturity days, V<sub>1</sub>:JS-335 (medium duration) and V<sub>2</sub>: JS-9560 (short duration) and three seed rates T<sub>1</sub>:70 kg ha<sup>-1</sup>, T<sub>2</sub>:60 kg ha<sup>-1</sup> and T<sub>3</sub>:50 kg ha<sup>-1</sup>. Experiment was laid out under split plot design with four replications. Seeds were sown with spacing of 30 × 10 cm. The land ploughed 3 times and prepared to fine tilth and crop was raised as per the recommended package of practices. Sowing was done in the second fortnight of July at optimum soil conditions. The observation on growth and seed yield parameters were recorded. The data was pooled and data obtained from two years was statistically analyzed with MANOVA.

### 3. RESULTS AND DISCUSSION

Plant population per unit area is the key factor of production. Plant population significantly differed among the sowing methods, varieties and seed rates (Table 1). The highest plant population was noted in raised bed method of sowing (28.54 /m<sup>2</sup>) as compared to flat-bed method (17.41/m<sup>2</sup>). This might be due to appropriate drainage of water, more aeration of soil and root proliferation [6]. These results are in accordance with Singh (2009) in soybean. Among the varieties, JS-335 (V<sub>1</sub>) was having more plant population (24.37/m<sup>2</sup>) as compared to V<sub>2</sub>-JS-9560 (17.42/m<sup>2</sup>). The seed rate at 70 kg ha<sup>-1</sup> had significantly highest plant population (25.12/m<sup>2</sup>). Minimum number of plants/m<sup>2</sup> was noted in case of seed rate 50kg ha<sup>-1</sup> (19.68/m<sup>2</sup>). These results are also in line with the observations recorded by Achakzai and Taran [7] who reported that plant population ranged from 5-11 plants / m<sup>2</sup> by changing seed rates [8].

The plant height recorded was significantly highest in raised bed method of sowing S<sub>1</sub> (44.77 cm) as against flatbed sowing S<sub>2</sub> (30.56 cm). The better expression of plant height with raised bed method might be due to favourable conditions available for growth of plant with this method [9]. The results are in accordance with Kumar *et al.*, [10] Patel *et al.*, [11] in groundnut. However, no significant variation in plant height was noticed among varieties and seed rates.

Plant performance is strongly associated with plant development and growth. Several developmental features of plants, such as overall

plant architecture and leaf features are major traits that determine the overall performance of crop plants. Plant canopy structure is one such parameter which is directly related to the yield. The maximum diameter was noticed in raised bed method of sowing S<sub>1</sub> (22.50 cm<sup>2</sup>) as compared to flatbed method S<sub>2</sub> (20.04 cm<sup>2</sup>). This might be due to good water uptake and nutrient availability in raised bed method. Among the varieties, the variety JS-335 (27.33 cm<sup>2</sup>) recorded significant highest canopy diameter. This might be the varietal characters. In case of seed rate, the canopy diameter was noted significantly highest among the reduced seed rate 50 kg ha<sup>-1</sup> (23.97 cm<sup>2</sup>) as against the recommended seed rate of 70 kg ha<sup>-1</sup> (19.50 cm<sup>2</sup>). Hence, optimizing crop canopy structure can improve canopy photosynthetic productivity and thereby crop yield potential.

Like plant height and plant canopy, seed rate significantly influenced the number of branches/plant. Highest number of branches were noticed in raised bed method of sowing S<sub>1</sub> (4.80) as against the flat bed method S<sub>2</sub> (3.10). Among varieties, the highest number of branches per plant was recorded in JS-335 (4.50). Among the seed rates, 50kg ha<sup>-1</sup> recorded more number of branches per plant (4.6) while, less number of branches per plant was recorded in 70 kg ha<sup>-1</sup> (3.5). Higher interception of solar radiation under lower seed rates might be the results of higher plant branches. These findings are in agreement with [12,13].

The pod and seed number per plant are most important yield contributing traits which change in response of sowing methods and seed rate (Table 2). Highest number of pods per plant (37.72) and seeds per plant (86.4) was noted in raised bed method of sowing S<sub>1</sub> compared to flatbed method S<sub>2</sub> (34.67 and 72.7 respectively). The better growth of plant under raised bed method of sowing might have resulted in higher photosynthetic activity and better translocation of food reserves to the sink. With respect to seed rates, highest number of pods per plant (39.86) and seeds per plant (90.9) was recorded in seed rate 50 kg ha<sup>-1</sup>. While, lowest number of pods per plant (34.35) and seeds per plant (77.4) was noted in seed rate of 70 kg ha<sup>-1</sup>. Ohyama *et al.* [14] reported that soybean productivity mainly depends on pods and seeds per plant. The decreasing trend of pods and seeds number per plant with increasing seed rate could be attributed to the competition existing between the populated crops for water, nutrients and light.

The results are in resemblance with Bahr [15] in chickpea and Begum *et al.* [16] in mung bean.

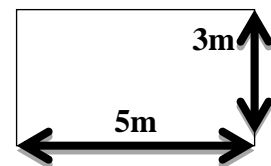
growth rate, dry matter accumulation and ultimately the seed yield [19].

The sowing method and seed rate significantly influenced the per plant yield of soybean (Table 1). Raised bed method of sowing (14.07 g) recorded highest seed yield per plant as compared to flatbed method (11.42 g). Madhana Keerthana *et.al.*,[17] reported that ridges and furrow sowing method was found superior for biological yield dry matter accumulation, leaf area duration in soybean. Among the seed rates, highest seed yield per plant was obtained from the seed rate of 50 kg ha<sup>-1</sup> (15.12 g), while lowest was noted in 70 kg ha<sup>-1</sup> (13.15 g). Similar results were also reported by Singh and Singh [18]. Lower seed rate led to the increase in the canopy area and greater light interception. These changes in canopy formation increased crop

Seed yield per ha is the final expression of physiological and metabolic activities of plants. Seed yield per ha differed significantly between the methods of sowing, varieties and seed rates. Significant highest seed yield per ha was recorded in raised bed method (18.32 q). This may be owing to increase yield attributes like number of pods and seeds per plant. These results are in accordance with those of Bahr [12] in chickpea and Singh (2013) in soybean. Among varieties, highest seed yield per ha was recorded in JS-335 (18.41 q). With respect to seed rates, 50 kg ha<sup>-1</sup> recorded maximum seed yield per ha (17.05 q) as against the prevailing seed rate of 60 kg ha<sup>-1</sup> (15.03 q/ha). These findings confirm the results of [20,21].

Replication -I		Replication -II		Replication -III		Replication -IV	
S1	S2	S1	S2	S1	S2	S1	S2
V1T1	V1T2	V1T3	V1T1	V1T2	V1T3	V1T1	V1T2
V1T2	V1T3	V1T1	V1T2	V1T3	V1T1	V1T2	V1T3
V1T3	V1T1	V1T2	V1T3	V1T1	V1T2	V1T3	V1T1
V2T1	V2T2	V2T3	V2T1	V2T2	V2T3	V2T1	V1T2
V2T2	V2T3	V2T1	V2T2	V2T3	V2T1	V2T2	V2T3
V2T3	V2T1	V2T2	V2T3	V2T1	V2T2	V2T3	V2T1

Fig. 1. Plan and Layout of experimental plot



**Treatment details**

**Sowing method**

S<sub>1</sub>: Flat-bed sowing

S<sub>2</sub>: Raised bed sowing

**Varieties**

V<sub>1</sub>:JS-335 (medium duration)

V<sub>2</sub>: JS-9560 (short duration)

**Seed rates**

T<sub>1</sub>:70 kg ha<sup>-1</sup>

T<sub>2</sub>:60 kg ha<sup>-1</sup>

T<sub>3</sub>:50 kg ha<sup>-1</sup>

**Table 1. Influence of sowing methods and seed rates in medium maturing variety JS-335 and early maturing variety JS-9560 for seed yield and quality in soybean**

Treatments	Plant population /m <sup>2</sup>	Plant height (cm)	Plant canopy diameter (cm <sup>2</sup> )	No. of branches /plant	No. of pods / plant	No. of seeds / plant	Seed yield /plant (g)	Seed yield / ha (q)	100 seed weight (g)	Seed germination (%)	Vigour index-I	B :C Ratio
Main plot treatments (Sowing methods) : Two												
S <sub>1</sub>	28.54	44.77	22.50	4.80	37.72	86.4	14.07	18.32	15.04	83.41	1994	1: 1.57
S <sub>2</sub>	17.41	30.56	20.04	3.10	34.67	72.7	11.42	14.09	14.40	82.08	1903	1: 1.25
Mean	22.98	37.67	21.27	3.95	36.20	79.6	13.75	16.20	14.72	82.75	1948	
SEm±	0.58	1.65	0.34	0.20	0.68	4.81	0.61	0.18	0.23	0.17	52.3	
CD(P=0.05)	1.71	4.82	0.99	0.60	2.01	13.3	1.82	0.52	NS	0.50	NS	
b.Sub plot treatments (Varieties) : Two												
V <sub>1</sub>	24.37	39.43	27.33	4.50	36.39	93.0	14.900	18.41	15.90	84.71	2120	1: 1.60
V <sub>2</sub>	17.42	35.90	15.21	3.40	36.00	66.0	12.600	14.00	13.53	80.79	1777	1: 1.21
Mean	20.90	37.67	21.27	3.95	36.20	79.5	13.75	16.20	14.72	82.75	1948	
SEm±	0.60	2.34	0.53	0.18	1.09	1.84	0.76	0.87	0.29	0.39	51.0	
CD(P=0.05)	1.76	NS	1.54	0.52	NS	5.37	2.22	2.53	0.84	1.16	148.8	
c. Sub-sub plot treatments (Seed rate): Three												
T <sub>1</sub>	25.12	37.55	19.50	3.50	34.35	77.4	13.15	16.54	14.311	81.12	1811	1: 1.42
T <sub>2</sub>	24.12	39.30	20.34	3.70	34.37	80.2	13.97	15.03	14.423	83.94	2022	1:1.30
T <sub>3</sub>	19.68	36.15	23.97	4.60	39.86	90.9	15.12	17.05	15.428	83.18	2013	1:1.50
Mean	22.97	37.67	21.27	3.93	36.19	79.5	13.75	16.21	14.72	82.75	1948	
SEm±	1.13	2.25	0.65	0.21	2.08	3.01	0.75	0.59	0.19	0.80	61.2	
CD(P=0.05)	3.31	NS	1.91	0.61	NS	8.80	2.19	1.72	0.58	NS	178.5	

a. Main plot treatments (Sowing methods) : Two

S<sub>1</sub> : Raised bedS<sub>2</sub> : Flat bed

b. Sub plot treatments (Varieties) : Two

V<sub>1</sub> : JS-335 (Medium duration variety)V<sub>2</sub> : JS-9560 (Short duration variety)

c. Sub-sub plot treatments (Seed rate): Five

T<sub>1</sub> : Seed rate @ 70 kg per haT<sub>2</sub> : Seed rate @ 60 kg per haT<sub>3</sub> : Seed rate @ 50 kg per ha

**Table 2. Interaction effect of sowing method and seed rate on growth and yield of medium maturing soybean variety (V<sub>1</sub>) JS-335 and early maturing variety (V<sub>2</sub>) JS-9560**

Treatments	Plant population/m <sup>2</sup>	Plant height (cm)	Plant Canopy diameter (cm)	No. of branches	No. of pods / plant	No. of seeds / plant	Seed yield /plant (g)	Seed yield/ plot (kg)	Seed yield / ha (q)	100 seed weight (g)	Seed germination (%)	Vigour index
S <sub>1</sub> T <sub>1</sub>	31.62	44.77	20.27	4.0	35.97	74.8	12.47	1.709	18.99	14.686	81.12	1832
S <sub>1</sub> T <sub>2</sub>	28.87	46.17	20.85	4.6	34.57	85.2	14.32	1.498	16.64	15.780	84.12	1993
S <sub>1</sub> T <sub>3</sub>	25.12	43.37	26.37	5.7	42.62	99.0	15.42	1.730	19.32	16.469	85.00	2158
S <sub>2</sub> T <sub>1</sub>	18.62	30.32	18.72	2.9	32.72	60.0	11.82	1.269	14.10	13.154	81.12	1790
S <sub>2</sub> T <sub>2</sub>	19.37	32.42	19.82	2.8	34.17	75.3	13.62	1.207	13.41	13.066	83.75	2051
S <sub>2</sub> T <sub>3</sub>	14.25	28.92	21.57	3.4	37.10	82.9	14.82	1.330	14.77	14.387	81.37	1867
Mean	22.98	37.66	21.27	3.90	36.19	79.53	13.75	1.46	16.20	14.59	82.75	1948
SEm±	1.60	3.18	0.92	0.29	2.94	4.27	1.06	0.07	0.84	0.28	1.14	86.6
CD(P=0.05)	4.68	9.28	2.70	0.87	8.57	12.46	3.11	0.21	2.45	0.82	3.33	252.6
S <sub>1</sub> V <sub>1</sub> T <sub>1</sub>	33.50	52.80	25.80	4.7	38.45	90.8	13.10	1.902	21.12	15.910	83.25	1992
S <sub>1</sub> V <sub>1</sub> T <sub>2</sub>	32.50	53.15	26.65	5.2	37.25	96.7	16.25	1.740	19.33	16.225	87.25	2313
S <sub>1</sub> V <sub>1</sub> T <sub>3</sub>	26.50	44.65	33.40	6.7	46.80	119.1	16.95	1.936	21.73	16.310	87.75	2367
V <sub>2</sub> S <sub>1</sub> T <sub>1</sub>	29.50	36.75	14.75	3.2	33.50	58.8	11.85	1.517	16.86	13.463	79.00	1671
V <sub>2</sub> S <sub>1</sub> T <sub>2</sub>	25.50	39.20	15.05	3.9	31.90	73.7	12.40	1.256	13.96	13.463	81.00	1672
V <sub>2</sub> S <sub>1</sub> T <sub>3</sub>	23.75	42.10	19.35	4.8	38.45	79.0	13.90	1.524	16.93	14.850	82.25	1950
V <sub>1</sub> S <sub>2</sub> T <sub>1</sub>	17.50	29.45	25.60	3.1	29.40	60.4	12.75	1.446	16.07	15.025	81.25	1857
V <sub>1</sub> S <sub>2</sub> T <sub>2</sub>	22.00	29.05	14.75	3.0	31.45	90.0	14.90	1.395	15.50	15.335	87.00	2265
V <sub>1</sub> S <sub>2</sub> T <sub>3</sub>	14.50	27.50	26.00	3.9	35.00	101.4	15.45	1.507	16.74	16.628	81.75	1925
V <sub>2</sub> S <sub>2</sub> T <sub>1</sub>	19.75	31.20	11.85	2.8	36.05	59.7	10.90	1.097	12.13	12.845	81.00	1724
V <sub>2</sub> S <sub>2</sub> T <sub>2</sub>	16.75	35.80	13.65	2.5	36.90	60.6	12.35	1.018	11.31	12.670	80.50	1836
V <sub>2</sub> S <sub>2</sub> T <sub>3</sub>	14.00	30.35	16.60	2.9	39.20	64.3	14.20	1.153	12.81	13.925	81.00	1809
Mean	22.98	37.67	20.29	3.89	36.20	79.54	13.75	1.45	16.20	14.72	82.75	1948
SEm±	2.27	4.49	1.30	0.42	4.15	6.03	1.50	0.11	1.19	0.39	1.61	122.5
CD(P=0.05)	6.63	13.13	3.82	1.23	12.13	17.62	4.39	0.32	3.47	1.16	4.72	357.4
CV(%)	15.7	18.9	12.3	18.5	20.9	15.2	18.9	14.4	14.7	5.40	3.9	12.6

Significant differences were noticed in seed germination in soybean for methods of sowing, varieties and differed seed rates. Raised bed method has recorded highest seed germination (83.41 %) as compared to flatbed method (82.08 %). Among seed rates, 50 kg ha<sup>-1</sup> recorded highest seed germination (83.18%), while, lowest was noticed in 70 kg ha<sup>-1</sup> (81.12 %). This might be due to bolder seed size attained by better photosynthates accumulation in the seeds which might be due to nutrient uptake by the plants under raised bed method and sufficient availability of nutrients to plants under optimum plant population. Seed rates as they vary in the plant population are the major sources of variation in seed vigour. Vigour Index-I was noted highest at seed rate 50 kg ha<sup>-1</sup> (2013) and lowest in seed rate at 70 kg ha<sup>-1</sup> (1811). Under high plant population, stands compete for limited nutrient, water, light resources and subject to excessive vegetative growth resulting in smaller seeds with low vigour. These results are parallel to Reddy [22] in groundnut and Kaske *et al.* [23] in wheat.[24,25]

The B: C ratio was numerical more in raised bed method of sowing (1.57) and JS-335 (1.60) variety as compared to flatbed method (1.25) and variety JS-9560 (1.21). The seed rate @ 50 kg ha<sup>-1</sup> depicted highest B: C ratio (1.50) as compared to 70 kg ha<sup>-1</sup>. Hence, seed rate of 70 kg /ha could be optimized to 50 kg ha<sup>-1</sup> in soybean crop.

The interactions also varied significantly among the treatments (Table-2). The interaction S<sub>1</sub>T<sub>3</sub> (raised bed method of sowing x seed rate at 50 kg ha<sup>-1</sup>) recorded maximum number of pods (42.62), seed yield plant<sup>-1</sup> (15.42 g) seed yield ha<sup>-1</sup> (19.32 q), seed germination (85.00 %) and Vigour Index-I (2158) which was on par with S<sub>1</sub>T<sub>1</sub> (raised bed method of sowing x seed rate at 70 kg ha<sup>-1</sup>) with seed yield (18.99 q ha<sup>-1</sup>). While, lowest seed yield was recorded in interaction of flatbed method of sowing with seed rate at 60 kg ha<sup>-1</sup> S<sub>2</sub>T<sub>2</sub> (13.41 q ha<sup>-1</sup>). Overall, the interaction of S<sub>1</sub>V<sub>1</sub>T<sub>3</sub> recorded significantly maximum seed yield (21.73 q ha<sup>-1</sup>) which was statistically on par with S<sub>1</sub>V<sub>1</sub>T<sub>1</sub> (21.12 q ha<sup>-1</sup>). Hence the seed yield on soybean could be positively enhanced by adopting raised bed method of planting and the seed rate at 50 kg ha<sup>-1</sup>.

#### 4. CONCLUSION

From the present study it can be concluded that the higher seed yield could be obtained from the moderate seed rate and raised bed method of

sowing. The raised bed method of sowing and lower seed rate of 50 kg ha<sup>-1</sup> showed superiority with respect to yield and attributing characters when compared to flatbed method of sowing and seed rate of 70 kg ha<sup>-1</sup>. Hence there is a possibility of optimizing the yield of soybean by adopting raised bed method of sowing and 50 kg ha<sup>-1</sup> seed rate.

#### ACKNOWLEDGEMENT

Sincere thanks to Seed Technology Research Centre, AICRP on Seed (Crops) for providing all the facilities for the conduct of research.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Weber CR, Shibles RM, Byth DE. Effect of Plant Population and row spacing on soybean development and production. *Agro. J.* 1966;58:99-102.
2. Andrade FH, Calvino P, Cirilo A, Barbieri, P. Yield responses to narrow rows depend on increased radiation interception. *Agron. J.*, 2002;94:975–980.
3. Bullock D, Khan S, Rayburn A. Soybean yield response to narrow rows is largely due to enhanced early growth. *Crop Sci.* 1998;38:1011–1016.
4. Lakpale R, Tripathi VK. Broad-bed furrow and ridge and furrow method of sowing under different seed rates of soybean (*Glycine max* L.) for high rainfall areas of Chhattisgarh plains. *Soybean Res.* 2012; 52.
5. Priyanka M, Parashivamurthy, Devaraju PJ, Ramanappa TM, Siddaraju R, Manjanaik C and Usha Ravindra. Impact of seed rate compensation on seed yield and quality of soybean (*Glycine max* (L.) Merrill). *The Pharma Innovation Journal* 2020; 9(12): 158-161.
6. Chaurasiya AK. Effect of different sowing methods and seed rate on growth and yield of soybean under rainfed condition of Rewa region of Madhya Pradesh. Ph.D. (Agri.) Thesis, JNKVV, Jabalpur; 2013.
7. Achakzai AKK, Taran SA. Effect of seed rate on growth, yield components and yield of mash bean growth under irrigated conditions of arid uplands of Balochistan, Pakistan. *Pak. J.Bot.* 2011; 43(2):961-969.
8. Ganesh Shankar. Optimization of seed rate and nutrient level for enhancing yield

- and profitability of bold seeded urdbean (*Vigna mungo* L.), MSc. Agri. Thesis submitted to Dept. of Agriculture (Agronomy), Indira Gandhi Krishi Vishwa vidyalaya, Raipur; 2017.
9. Hari ram, Guriqbal Singh, Navneet Aggarwal and Sekhon HS. Effect of sowing method, nutrients and seed rate on mungbean (*Vigna radiate* L.) growth, productivity and water use efficiency. J. Appl. & Nat. Sci., 2018;10(1):190–195.
  10. Kumar N, Singh MK, Praharaj CS, Singh, U, Singh, SS. Performance of chickpea under different planting method, seed rate and irrigation level in Indo-Gangetic plains of India. Food Leg., 2015;28(1):40-44.
  11. Patel H, Thanki J, Patel T, Patel D, Patel H. Planting techniques and irrigation levels influenced on chickpea (*Cicer arietinum* L.). Adv. Life Sci., 2016;5(4):1191-1195.
  12. Saitoh K. Effect of row-spacing and planting density on podding and yield performance of early soybean cultivar “Enrei” with reference to raceme order. In: El-Shemy H (Ed.). Agricultural and Biological Sciences. Soybean Physiology and Biochemistry. 2011;275-288. DOI: 10.5772/19025.
  13. Worku M, Astatkie T. Row and plant spacing Effects on yield and yield components of soybean varieties under hot humid tropical environment of Ethiopia. J. Agron and Crop Sci., 2011;197: 67-74.
  14. Ohyama T, Minagawa R, Ishikawa S, Yamamoto M, Van phi hung N, Ohtake N, Sueyoshi K, Sato T, Nagumo Y, Takahasi, Y. Soybean seed production and nitrogen nutrition. In: Board J (Ed.), A Comprehensive Survey of International Soybean Research-Genetics, Physiology, Agronomy and Nitrogen Relationships, In Tech; 2013. DOI: 10.5772/52287.
  15. Bahr AA. Effect of plant density and urea foliar application on yield and yield components of chickpea (*Cicer arietinum*). Res. J. Agric. Biol. Sci., 2007; 3(4): 220-223.
  16. Begum MSTN, Begum M, Anwar MP, Juraimi AS. Optimizing seed rate for summer mung bean varieties. J. Agric. Soc. Sci., 2009;5:114-118.
  17. Madhana S, Keerthana R. Shiv Ramakrishnan, Nidhi Pathak, Dibakar Ghosh GK. Koutu, Sachin Nagre, A. S. Gontia, Radhesham Sharma, Ashish Kumar, Stuti Sharma, R. Vinoth, and Vikash Jain. Soybean Physiology and Yield Response to Seed Rate and Sowing Method. International Journal of Plant & Soil Science. 2021;33(15):18-27.
  18. SINGH R. Response of soybean [*Glycine max* (L.) Merrill] varieties to different seed rates under agro-climatic conditions of Vindhyan plateau. Ph.D. (Agri) Thesis, JNKVV, Jabalpur; 2009.
  19. De Bruin JL, Pedersen P. Soybean seed yield response to planting date and seeding rate in the Upper Midwest. Agron. J., 2008;100.
  20. Kumar J, Badiyala D. Effect of seed rate, row spacing and sowing time on yield and yield attributes of soybean. Leg. Res.- Intl. J., 2005;28(4):288-290.
  21. Prajapati BL, Dixit JP, Kulmi GS, Sharma, J. Effect of land configurations and weed management practices on growth and yield of soybean. J. Multidisciplinary Adv. Res., 2018;7(1):43-47.
  22. Reddy HM. Effect of methods of cultivation on seed yield, quality and storability of summer groundnut (*Arachis hypogea* L.). Ph.D (Agri) Thesis, Uni. Agric. Sci., Bangalore, Karnataka (India); 2006.
  23. Kaske K, Atilaw A, Esatu A. Lower seed rates favour seed multiplication ratio with minimal impact on seed yield and quality. Ethiop. J. Agric. Sci., 2015; 26(1):49-58.
  24. Patidar A. Effect of seed rate and variety on growth and yield of soybean under dryland condition of Kymore plateau and Satpura hills zone of Madhya Pradesh. Ph.D. (Agri.) Thesis, JNKVV, Jabalpur; 2015.
  25. Ram H, Singh G, Aggarwal N, Kaur J. Soybean (*Glycine max*) growth, productivity and water use under different sowing methods and seeding rates in Punjab. Indian J. Agron. 2011;56(4): 377.

Peer-review history:

The peer review history for this paper can be accessed here:  
<https://www.sdiarticle5.com/review-history/106532>