Effect of land configuration,seed rates and variety on growth and yield of soybean in Central India

ABSTRACT

The present experiment was conducted under ongoing 'All India Coordinated Research Project' (AICRP) for Dry land Agriculture at College of Agriculture, Indore to study the effect of land configuration, seed rates and variety on growth and yield of soybean in Central India. The study was carried out with 03 main plot treatments (03 land configurations i.e. L1- Flat sowing-45 cm, L2- Raised bed of 90 cm with 3 Rows bed^{-1} and L3- Raised bed of 60 cm with 2 Rows bed^{-1}) and 04 sub plot treatments (02 varieties of soybean i.e. V1-RVS 2001- 4 and V2-JS335; 02 seed rates i.e. S_1-60kg ha^{-1} (75% of Normal seed rate) and S_2 40kg ha^{-1}(50 %of Normalseed rate)). The various observations related to plant growth parameters viz., plant height, number of branches per plant, leaf area, number of nodules per plant, plant dry weight, number of pods per plant, number of seeds per pod, grain weight per plant, grain yield, straw yield and harvest index were recorded. The obtained data was analyzed by method of variance and the null hypothesis was tested by the 'F' test. Further, the critical difference was worked out to judge the difference between the two treatment means. The results revealed that the land configuration, seed rates and variety showed significant effect on growth and yield of soybean.

Keywords: Soybean, land configuration, seed rate, yield, RVS2001-4, JS-335

INTRODUCTION

Soybean is an important cash crop in India. It is considered as one of the main oil crops all over the world. The present status of soybean in India indicates the cultivation of crop over an area of 108.34 lakh ha with an annual production of 104.37 lakh MT and productivity of 979 $kgha^{-1}$ (Anonymous, 2014). Madhya Pradesh is often called as 'Soybean state' or 'Fort of soybean' due to its contribution in national basket to the extent of 52 per cent of area and 57 per cent of production. It occupies 55.46 lakh ha area with an annual production 60.25 lakh MT and productivity of 1086 $kgha^{-1}$(Anonymous, 2014).Soybean contains 20% oil of dry seed weight and is an important source of protein, which reaches 40% of dry weight seed weight along with calcium, iron, carotene, thiamine and ascorbic acid (El- Abady*et al.,* 2008). Soybean plants like many others legumes are capable of fixing and utilizing atmospheric nitrogen through symbiotic relationship with *Rhizobium* bacteria at the root of the crops (Nassiuma and Wasike, 2002). The flat-land cultivation system is more popular in Malwa region at present for extensively cultivation of *Kharif*crop like soybean which faces the problem of waterlogging and poor aeration thereby affecting crop productivity adversely. The small change through land configuration in flat field conditions may help in improving the productivity of *Kharif* crops in Vertisols of Malwa region. Using light machinery like bund former and *desihal* with minor modifications may improve the physical conditions and drain ability. It is assumed that land treatments will help to improve the physical conditions, root development and overall productivity in Vertisols (Jadhav*et al.,*2012). Apart from soil related properties, the seed rate played a crucial role in optimizing crop productivity. Over seed rate or over plant population is causing non-poding in plant due to insects attack and resulting into excessive plant growth, shrinking seed size and reduced crop productivity.Thus, reduced seed rate may help in maintaining optimum plant population.Considering these facts, present field experiment was conducted to study the effect of land configuration, seed rates and variety on growth and yield of soybean in Central India.

MATERIALS AND METHODS

Experimental site and climate

Present experiment was conducted under ongoing "All India Coordinated Research Project" (AICRP) for Dryland Agriculture at College of Agriculture, Indore. Indore is situated in agro-climatic zone in the Western Madhya Pradesh at an altitude of 555.5 meters above mean sea level (MSL). It is located at latitude 22.43^{o}N and longitude of 75.66^{o}E.The meteorological data during crop growth period from month of June to October 2015 has been recorded and presented in Fig. 1. The total rainfall was 1174.1 mm received in 31 rainy days which was lower than normal rainfall. At 30 SMW the rainfall received was very high in three rainy days (152 mm). During growth period 27 days dry spell, the maximum and minimum temperatures varied from 25.43^{0}C and 34^{0}C and from21.14^{0}C to 28.14^{0}C, respectively. The relative humidity ranged in between 79 % to 92 %.

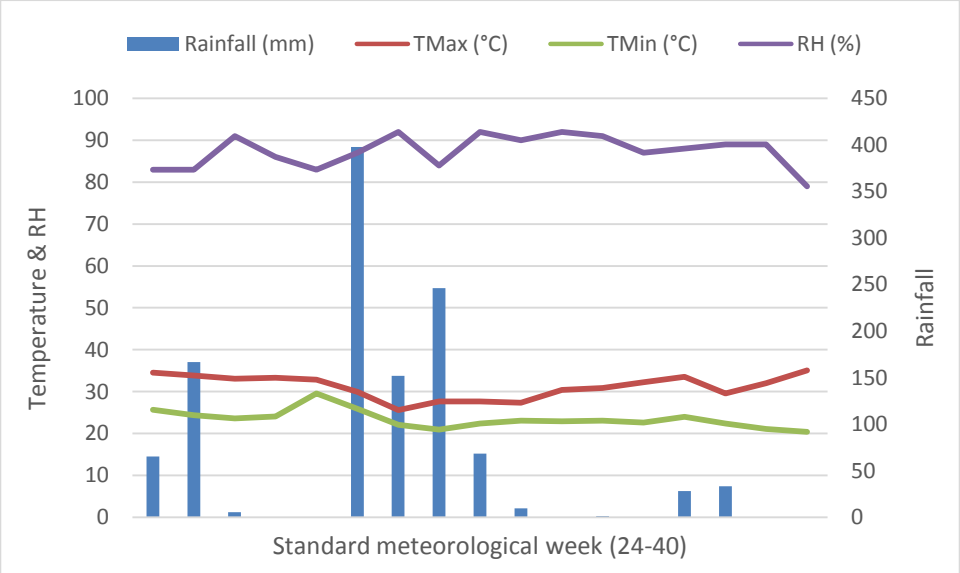

Figure 1. Meteorological observations recorded during crop period (June to October).

Initial characteristics of experimental soil

The soil of the experimental field has been grouped under medium black (*Vertisols*) belonging to fine montmorillonite hypothermic family of typical chromosterts predominantly clay in texture (clay- 54.9%, silt- 34.0% and sand- 11.1%). The organic carbon content (0.40%) and available nitrogen (180kgha^{-1}) were low. The available phosphorus (11.28kg ha^{-1}) was medium and potash (540kg ha^{-1}) was high.The soil pH was (7.70) slightly alkaline. Electrical conductivity (0.35ds m^{-1}) of soil is normal.

The experiment

The present experiment was carried out with 03 main plot treatments (03 land configurations i.e. L1- Flat sowing-45 cm, L2- Raised bed of 90 cm with 3 Rows bed^{-1} and L3- Raised bed of 60 cm with 2 Rows bed^{-1}) and 04 sub plot treatments (02 varieties of soybean i.e. V1-RVS 2001- 4 and V2-JS335; 02 seed rates i.e. S_1-60kg ha^{-1} (75% of Normal seed rate) and S_2 40kg ha^{-1}(50 %of Normalseed rate)).

Field operations and agronomic practices

In order to get a good tilth of soil for sowing, the field preparation was started with summer ploughing by tractor drawn plough followed by cross harrowing. Finally harrowing was followed by planking to level the field the raised beds were made with the help of tractor

drawn bed maker before sowing.The recommended dose of nutrient for soybean used was 20 kg N, 60 kg P_2O_5 and 20 kg K_2O ha^{-1} Nitrogen and phosphorus were applied through Di-ammonium phosphate (DAP) and remaining Nitrogen and phosphorus applied by Urea and SSP while potash was applied using Muriate of potash (MOP) fertilizer. All the fertilizers were applied as basal in the furrows made and mixed with soil before placing the seeds.For ensuring perfect germination, healthy and good quality seeds were used. Seeds were treated by carbendazim @ $2gkg^{-1}$ seeds and after that inoculated with Soybean *Rhizobium* culture @ $5gkg^{-1}$ seeds at the time of sowing.Sowing of the crop was done on 24th June, 2015 seed rate of soybean was used as 60 $kgha^{-1}$and 40 kg ha^{-1} as per treatments. Sowing was done manually.After germination, thinning was done at 15 days after sowing in order to maintain optimum plant population of the crop. Similarly, hand weedings were carried out twice to keep the crop weed free. To protect the crop from insects pests like girdle beetle, stem fly caterpillars, blue beetle etc. in soybean at early stage two time spray at 30 and 45 days growth stagesofTriazophos 40 EC 600 $mlha^{-1}$ were done. The crop was harvested on 27thseptember 2015 after attaining maturity. After harvesting the produce of each plot was tied in bundle properly labeled and it was allowed to dry in the field for 4-5 days. The produce of individual plot was threshed separately and winnowed. Yield of the crop in kilograms obtained from each net plot was recorded.

Observations recorded

Various observations related to plant growth parameters viz., plant height, number of branches per plant, leaf area, number of nodules per plant, plant dry weight, number of pods per plant, number of seeds per pod, grain weight per plant, grain yield,straw yield and harvest index were recorded.

Statistical analysis

The obtained data was analyzed by method of variance as described by Fisher (1995). The null hypothesis was tested by the 'F' test, which revealed the significance of treatment effect. The critical difference (C.D.) of 5% was worked out to judge the difference between the two treatment means.

RESULTS

Growth of soybean

Plant height is an important index of plant growth, which differs due to different treatments and agronomic practices. The plant height recorded at the successive growth stages is presented in Table 1. The plant height, in general, was enhanced considerably in all the treatments with the advancement of plant growth up to 75 days stage and thereafter it decreased slowly till harvest stage. At 30 DAS, the height ranged from 18.19 to 20.69 cm, whereas at 75 DAS, it ranged from 44.01 to 47.31 cm. At harvest, the plant height ranged from 43.14 to 46.38 cm. A critical examination of the data clearly shows that the plant height marginally increased with the sowing of crop under raised bed at 60 cm spacing RB-60 cm, Raised bed at 90 cm spacing RB-90 cm over the crop sown under flat sowing at 45 cm row spacing FS-45 cm as well as with 60 kg ha^{-1} seed rate over 40 kg ha^{-1} and RVS 2001-4 variety over JS 335. Data revealed that the varieties differed in plant height significantly at 75 DAS and at harvest stage. At both the stages higher plant height was recorded with RVS 2001-4 as compared to JS-335. The difference in plant height at 60 kg ha^{-1} seed rate and 40 kg ha^{-1} seed rate was significant (Fig. 2). The number of branches $plant^{-1}$ recorded at 30, 45, 60, 75 DAS and at harvest and the data are presented in Table 1.

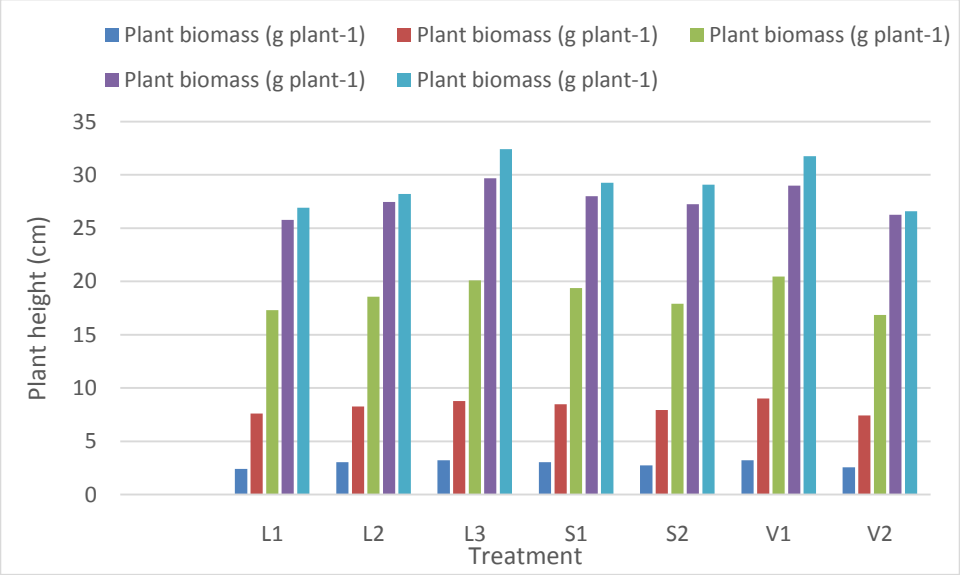

Fig. 2. Plant height of soybean as influenced by various treatments

It is evident from the data that the number of branches plant^{-1} was influenced significantly by different treatments. Among land configuration the lowest number of branches plant^{-1} was recorded in case of flat bed planting as compared to the treatments RB-60 cm and RB-90 cm at 75 DAS and harvest stage but remaining stages were unaffected. Among land configuration treatments RB-60 cm distance produced the highest number of branches plant^{-1} at 75 DAS and harvest stages at par with RB-60 cm. Number of branches plant^{-1} was non-significant due to seed rates at 30 DAS, 45 DAS and 60 DAS. Significantly more number of branches plant was counted in 60 kg ha^{-1} seed rate over 40 kg ha^{-1} at 75 DAS and at harvest stage. In case of varieties, the difference in number of branches plant^{-1} was significant. Maximum number of branches plant^{-1} was recorded in RVS 2001-4 which gave significantly more number of branches plant^{-1} as compared to JS 335. This trend was maintained at all the growth stages (Table 1).

Table 1. Effect of land configuration, seed rates and varieties on plant height of soybean at different stages.

Treatment	Plant height (cm)					No of branches plant^{-1}				
	30 DAS	45 DAS	60 DAS	75 DAS	Harvest	30	45	60	75	Harvest
L1	18.57	29.97	39.77	44.02	43.14	2.25	2.92	3.81	4.48	4.48
L2	19.83	32.27	40.38	45.98	45.35	2.55	3.80	4.18	5.73	5.73
L3	19.92	33.29	42.37	46.97	46.35	2.66	3.75	4.74	5.91	5.91
S.Em (±)	0.23	0.38	0.31	0.50	0.57	0.2	0.2	0.3	0.3	0.3
CD at 5%	0.70	1.50	0.90	1.60	1.70	NS	NS	NS	0.9	0.9
S1	19.86	32.18	41.45	46.30	45.71	2.56	3.62	4.45	5.76	5.76
S2	19.02	31.50	40.23	45.02	44.02	2.41	3.36	4.03	4.99	4.99
S.Em (±)	0.23	0.22	0.36	0.33	0.35	0.1	0.2	0.2	0.2	0.2
CD at 5%	0.70	0.70	1.10	1.10	1.00	NS	NS	NS	0.7	0.7
V1	20.69	32.88	42.08	47.31	46.38	2.81	3.92	4.64	5.81	5.81
V2	18.19	30.80	39.60	44.01	43.35	2.16	3.05	3.84	4.94	4.94
S.Em (±)	0.23	0.22	0.36	0.33	0.35	0.1	0.2	0.2	0.2	0.2
CD at 5%	0.70	0.70	1.10	1.10	1.00	0.4	0.6	0.6	0.7	0.7

L1:Flat sowing-45 cm; L2:Raised bed of 90 cm with3 Rows bed^{-1}; L3:Raised bed of 60 cm with2 Rows bed^{-1}; S1:75 % of normal Seed rate (60 kg ha-1); S2: 50% of normal Seed rate

(40 kg ha-1); V1: RVS 2001-4; V2: JS 335.

Physiological parameters of soybean

The effect of various land configurations, seed rates and varieties with respect to leaf area was found significant at both the stages of crop growth (Table 2). The data revealed that the land configuration treatments significantly influenced the leaf area at both stages of crop growth. At before flowering stage, raised bed of 60 cm width with 2 rows bed^{-1} (797.49 cm^2) and raised bed of 90 cm width with 3 rows bed^{-1} (759.24 cm^2) were at par to each other recorded significantly higher leaf area over flat sowing method (633.47 cm^2) both the stages of crop growth. Leaf area (cm^2) was non-significant due to seed rates at 30 DAS and 60 DAS. Further, the data showed improvement in leaf area with the variety RVS 2001-4 over JS 335.

The number of root nodules plant^{-1} was counted at flowering stage of the crop under different treatments (Table 2). It is clear from the data that the number of root nodules plant^{-1} was influenced significantly by different treatments. In case of land configuration the least number of root nodules plant^{-1} was recorded in flat bed sowing 22.04 plant^{-1} as compared to the treatment RB-90 cm (24.83 plant^{-1}) and RB-60 cm (26.60 plant^{-1}).In case of seed rate the differences in number of root nodules plant^{-1} were non-significant. A marked variation in the number of root nodules plant^{-1} was noted due to varieties. RVS 2001-4 being significantly proved superior over JS-335 and gave the maximum (26.41 plant^{-1}) root nodules plant^{-1} at the flowering stage. The plant biomasswas studied at various growth stages (Table 2).

The dry matter plant^{-1} was gradually increased with advancement in the age of the crop. The accumulation was maximum between 30 and 75 days in almost all the treatments. Later on rate of increase in dry weight accumulation reduced. Among land configuration treatments the maximum dry matter accumulation at 30 DAS was recorded in the treatment RB-60 cm (3.21 g) and it was found statistically superior to the treatments FS-45 cm (2.40 g).Similar trend of plant biomass was observed at 45 DAS and 60 DAS. At 75 DAS the values of plant biomass was recorded in the treatment RB-60 cm was 29.67 g, which was found statistically superior to that recorded in RB-90 cm and FS-45 cm treatments. At harvest the maximum plant biomass (32.42 g) was recorded in RB-60 cm which was found significantly higher than rest of the treatments. Dry weight plant^{-1} was significant due to seed rates at 30 DAS, 45 DAS and 60 DAS. Significantly more dry weight plant^{-1} was recorded in 60 kg ha^{-1} seed rate over 40 kg ha^{-1} and in variety RVS 2001-4 over JS-335 at all the growth stages (Table 2).

Table 2. Effect of land configurations, seed rates and varieties on Leaf area, nodulation and plant biomassof soybean at different stages

Treatments	Leaf area (cm^2)		Nodules plant^{-1}	Plant biomass (g plant^{-1})				
	30 DAS	60 DAS	at flowering stage	30 DAS	45 DAS	60 DAS	75 DAS	Harvest
L1	633.47	2117.88	22.04	2.40	7.59	17.30	25.79	26.92
L2	759.24	2305.73	24.83	3.03	8.26	18.57	27.45	28.20
L3	797.49	2341.44	26.60	3.21	8.78	20.10	29.67	32.42
S.Em (±)	25.6	38.0	0.64	0.13	0.19	0.52	0.59	0.86
CD at 5 %	75.0	112,9	1.20	0.40	0.60	1.60	1.80	2.50
S1	751.38	2260.61	24.93	3.04	8.48	19.39	28.00	29.27
S2	708.76	2249.42	24.05	2.72	7.94	17.92	27.26	29.08
S.Em (±)	16.6	49.0	1.12	0.10	0.16	0.49	0.66	0.58
CD at 5 %	NS	NS	NS	0.30	0.50	1.50	NS	NS
V1	832.28	2353.77	26.41	3.21	9.00	20.46	28.99	31.76

V2	627.85	2156.27	22.58	2.55	7.42	16.85	26.27	26.60
S.Em (±)	16.6	49.0	1.12	0.10	0.16	0.49	0.66	0.58
CD at 5 %	49.4	145.4	3.33	0.30	0.50	1.50	1.96	1.74

L1:Flat sowing-45 cm; L2:Raised bed of 90 cm with 3 Rows bed^{-1}; L3:Raised bed of 60 cm with 2 Rows bed^{-1}; S1:75 % of normal Seed rate (60 kg ha-1); S2: 50% of normal Seed rate (40 kg ha-1); V1: RVS 2001-4; V2: JS 335.

Yield attributes and yield of soybean

The maximum number of pods (20.54 plant^{-1}) was recorded with the raised bed of 60 cm width with 2 rows bed^{-1}, which was significantly higher over planting methods of FS-45cm and RB-90 cm (Table 3). Crop sown with 60 kg ha^{-1} and.40 kg ha^{-1} seed rate produced non-significantly. The maximum number of pods (20.70 Plant^{-1}) was recorded with variety RVS 2001-4, which was significantly higher than JS 335. The response of the crop to the varieties under different land configuration was found to be significant.Among land configuration treatments the maximum number of seeds pod^{-1} were recorded in the treatment RB-60 cm (2.75), which was followed by the treatments RB-90 cm (2.29) and minimum in case of FS-45 cm (2.24). The perusal of the data further revealed that the influences of seed rates on no. of seeds pod^{-1} were found non-significant. The treatment RVS 2001-4 (2.71) gave higher number of seeds pod^{-1} and lower in JS 335.Further, among land configuration treatments the highest grain weight plant^{-1} was recorded in the treatment RB-60cm (4.93 g), which was found significantly superior to the rest of the treatments. The treatments RB-60 cm recorded (4.93 g) grain weight plant^{-1} which was closely followed by the treatment RB-90 cm (3.42 g) these treatments mere found statistically at par with each other but were found statistically superior to the treatments FS-45 cm (2.86 g), which recorded lowest grain weight plant^{-1}. The perusal of the data further revealed that the influence of seed rates on grain weight plant^{-1} was found non-significant. Data further revealed that the treatment RVS 2001-4 gave significantly higher grain weight plant^{-1} (4.05 g) as compared to JS-335 (3.42 g).

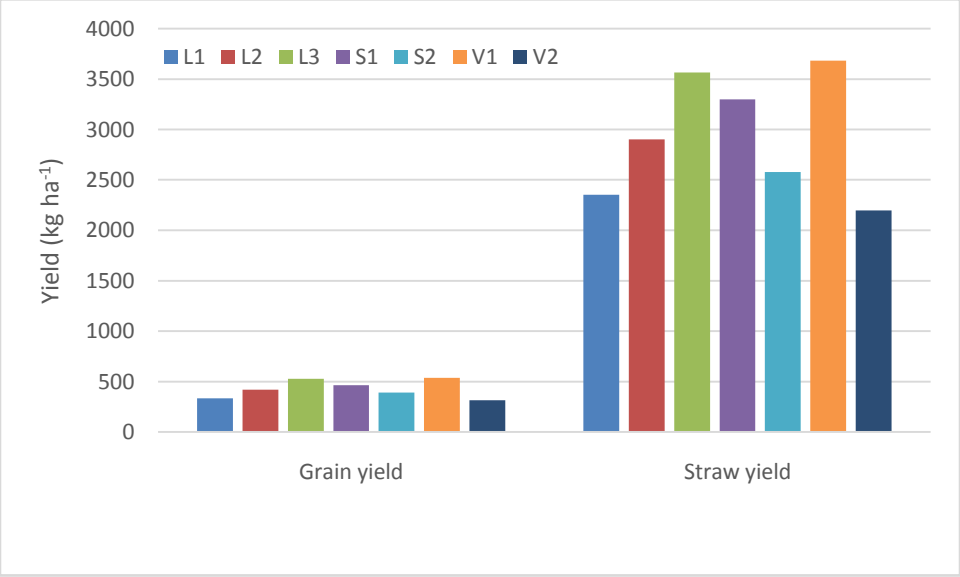

Fig. 3. Grain and straw yield of soybean as influenced by different treatments

Among the land configuration treatments, RB-60 cm 2 rows bed^{-1} resulted in significantly higher grain yield (526 kg ha^{-1}) over other land configuration treatments (Table 3 and Fig. 3). The seed rate of 60 kg ha^{-1} (462 kg ha^{-1}) recorded significantly higher grain yield than 40 kg ha^{-1} (389 kg ha^{-1}). Further, the variety RVS 2001-4 (537 kg ha^{-1}) recorded significantly higher grain yield than JS 335 (313 kg ha^{-1}). The straw yield under land configuration RB-60 cm

(3565 kg ha^{-1}) was produced highest as followed by RB-90 cm (2901 kg ha^{-1}) and the lowest in FS-45 (2351 kg ha^{-1}). Straw yield of soybean with seed rate 60 kg ha^{-1} (3299 kg ha^{-1}) was recorded significantly higher than 40kg ha^{-1} (2579 kg ha^{-1}). In case of varieties, RVS 2001-4 gave the straw yield of 3681 kg ha^{-1} the higher than JS 335 (2196 kg ha^{-1}).The straw yield recorded under different treatments was a significant effect of different treatments and on the straw yield of soybean. However, the land configuration and varieties were not influenced the harvest index significantly whereas the seed rated influenced the harvest index significantly.

Table 3. Yield attributes and yield of soybean as influenced by land configuration, seed and varieties

Treatments	Pods plant^{-1}	Seed pod^{-1}	Grain weight (g plant^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
L1	14.49	2.24	2.86	332	2351	14.5
L2	20.30	2.29	3.42	418	2901	14.4
L3	20.54	2.75	4.93	526	3565	14.6
S.Em (±)	1.23	0.10	0.30	9.8	57.1	0.28
CD at 5 %	3.60	0.30	0.88	29.0	169.5	NS
S1	18.86	2.61	3.78	462	3299	15.1
S2	18.03	2.24	3.69	389	2579	13.9
S.Em (±)	0.91	0.16	0.19	8.6	62.1	0.33
CD at 5 %	NS	NS	NS	25.4	184.3	1.0
V1	20.70	2.71	4.05	537	3681	14.50
V2	16.19	2.13	3.42	313	2196	14.03
S.Em (±)	0.91	0.16	0.19	8.6	62.1	0.33
CD at 5 %	14.49	2.24	2.86	25.4	184.3	NS

L1:Flat sowing-45 cm; L2:Raised bed of 90 cm with 3 Rows bed^{-1}; L3:Raised bed of 60 cm with 2 Rows bed^{-1}; S1:75 % of normal Seed rate (60 kg ha-1); S2: 50% of normal Seed rate (40 kg ha-1); V1: RVS 2001-4; V2: JS 335.

DISCUSSION

Crop growth and physiology

Growth parameters *viz*., plant height, number of branches plant^{-1}number of root nodules plant^{-1}, dry weight plant^{-1} were significantly influenced by land configuration at all the growth stages which might be attributed to the better soil plant water relationship and soil physical condition.The raised bed land configuration performed better over flat sowing method due to better aeration, deep root system and better utilization of nutrients.Further, the increase in root nodules may be due to better root development under raised bed condition which provided better physical condition of soil and lower penetration resistance to roots. Further, increase in branches per plant may be attributed to the better root formation and increase in root nodules thus better nutrient availability and better moisture management due to better physical condition of soil. Lupway*iet al.* (1997) reported that 33% reduced the nodules dry matter due to water logging condition. Ralli and Dhingra (2003) also reported that number of branches plan^{-1}, dry matter accumulation, nodules count and nodule dry weight were higher in ridge sowing as compare to flat bed sowing of soybean in loamy sand soils of Ludhiana.The present findings are in close vicinity of Lupway*iet al.* (1997), Raut*et al.* (2000), Hague *et al.* (2002), Khatri*et al.* (2002), Nikam and Firake (2002), Jat and Singh (2003), Thakur *et al.* (2004b), Kumari and Rao (2005) and Jha*et.al*. (2014).The growth parameter were significantly influenced by seed rates at most of the crop growth stages. Verma*et al.* (2004) andNikam and Firake (2002) have also reported higher plant population due to higher seed rate resulted from more vegetative growth. Bilal *et al.,* (2009) showed

significant and consistent increase with the increase in seed rates at all growth stages of the crop. Jain *et al.* (1996) reported that due to increased row spacing and a reduced seed rate the crop growth rate and Net assimilation rate decreased significantly.Maximum dry weight plant^{-1} was recorded in 60 kg ha^{-1} seed rate which gave significantly higher than 40 kg ha^{-1} seed rate. It signifies that over and reduced plant population adversely affected the root nodules per plant. The better plant growth in terms of plant height and number of branches, Leaf area index due to optimum plant population might have resulted into higher N fixation etc which might be responsible for better nodulation. Similar results were also reported by Jain *et al.* (1996), Halvankar*et al* (1999), Ball *et al.* (2001), Graterol and Montilla (2003), Rambo *et al.* (2003), Kumar and badiyala (2004), Verma*et al.* (2004), and Lone *et al.* (2009) and Taher-soula and Mohammadi (2013). The growth parameter like plant height, number of branches plant^{-1}, number of root nodules plant^{-1}, dry weight plant^{-1} were significantly influenced by varieties at various growth stages. Plant height was affected by two varieties depend on their genetic characters and climatic condition. RVS 2001-04 performed better as compared to JS 335 variety.

The soybean variety RVS 2001-04 gave more number of branches plant^{-1}, number of nodules plant^{-1}, dry weight plant' and was significantly superior to JS 335. It was due to physiological processes, yield characteristics and the atmospheric nitrogen through symbiosis with microorganism in the soil. It improves crop performance and crop yields by providing better soil environment, which enhanced root growth and nutrient use. Similar results were also reported by Hassan *et al.* (2001), Rezaie and Tajbakhsh (2002), Rahman*et al.* (2011) and Taher-soula and Mohammadi (2013). Significant interaction between land configuration and varieties revealed that crop sown with RVS 2001-4 produced significantly more -plant height at 75 DAS and at harvest, dry weight plant^{-1} at 45 DAS and at harvest stage under raised bed of 60 cm width with 2 rows bed^{-1} MVO over crop sown with JS 335 on flat sowing at 45 cm inter row spacing method FS-45 cm and JS 335 This was probably due to better aeration, deep root system and better utilization of nutrients in raised bed of 60 cm width with 2-rows bed^{-1} by variety RVS 2001-04. The leaf area was found significantly superior over flat sowing of 45 cm inter row spacing but the leaf area in raised bed of 60 cm width (2 rows bed^{-1}) and raised bed of 90 cm width (3 rows bed^{-1}) were found at par to each other at before flowering stage which might be due to light interception properly on leaf area and favorable environment condition. Khatri*et al.* (2002) also reported improved physiology of wheat crop under raised bed of 60 cm width over flat sowing method of 45 cm inter row spacing. Many researchers *viz.*Tomar*et al.* (1996), Raut*et al.* (2000), Hague *et al.* (2002), Khatri*et al.* (2002), Nikam and Firake (2002), Jat and Singh (2003), Thakur *et al.* (2004), Kumari and Rao (2005) and Hari*et al.* (2011) also reported similar findings.

Yield attributes and crop yield

Raised bed system of 60 cm width with 2 rows bed^{-1} significantly enhanced the number of pods per plant, number of seeds per pod and grain weight per plant over flat sowing of 45 cm inter row spacing and raised bed of 90 cm width with 3 rows bed^{-1} However, raised bed of 90 cm width with 3 rows bed^{-1} also recorded higher number of pods, number of seeds per pod and grain weight per plant over flat sowing at 45 cm inter row spacing. This might be due to the fact that increase in number of leaves lead to increased photosynthesis so there by more food was prepared by plants, leading to more number of pods per plant and heavier seeds. The results obtained by Gupta *at al.* (1993), Raut*et al.* (2000), Basavarajappa*at al.* (2002), Hague *et al.* (2002), Khatri*et al.* (2002), Nikam and Firake (2002), Ralli and Dhingra (2003), Thakur *et al.* (2004), Autkar*at al.* (2006), Jadhav*et al.* (2012), Aher*et al.* (2019) and Aher*et al.* (2022) were in conformity of these findings. The yield attributing characters were remained unaffected due to seed rate. The present findings

are in close vicinity of Halvankar*et al.* (1999) and Ball *et al.* (2001). Different varieties showed significant differences in yield attributes of different varieties. Adeniyan and Ayoola (2006), Rani *et al.* (2008), Reddy*et al.* (2010), All *et al.* (2013) and Muhammad and Khalil (2013) also concluded similar results in their experiments. Raised bed system of 60 cm width (2 rows bed^{-1}) significantly increased the seed yield and straw yield. The 37.47 % increase in seed yield was recorded in raised bed system of 60 cm width (2 rows bed^{-1}) against flat sowing of 45 cm inter row spacing. Raised bed system of 90 cm width (3 rows bed^{-1}) also significantly increased the seed yield over flat sowing of 45 cm inter row spacing. Superior yield with raised bed system of 60 cm width (2 rows bed^{-1}) and raised bed system of 90 cm width (3 rows bed^{-1}) as compared to sowing on flat sowing method of 45 cm inter row spacing was mainly due to increased number of pods, number of seeds per pod and grain weight per plant. Similar results of higher yields in altered land configuration over flatbed method were also reported by Tomar*et al.* (1996), Chavan*et al.* (1999), Selvaraju*et al.* (1999), Raut*et al.* (2000), Khatri*et al.* (2002), Singh *et al.* (2004), Autkar*et al.* (2006) and Tomar*et al.* (2007), Patel *et al.* (2009), Rajput *et al.* (2009) and Lakpale and Tripathi (2012).

The grain yield of soybean was significantly influenced by seed rates. Seed rate of 60 kg ha^{-1} resulted in significantly higher grain yield (462 kg ha^{-1}) over 40 kg ha^{-1} seed rate (389 kg ha^{-1}). Jasani*et al.* (1993) reported that the increasing seed rate from 40 kg ha^{-1} to 70 kg ha^{-1} increased the seed yield of soybean significantly. The increases in grain yield due to optimum seed rate have also been reported by Kumar and Badiyala (2005b), Patel and Varshney (2007), Annual Report (2008) and Lone *et al.* (2010) and Singh *et al.* (2012). Among the soybean varieties, RVS 2001-4 gave the grain yield higher than JS 335. Grain yield was positively related with plant height, primary and secondary branches, total dry matter and number of pods per plant. Varieties play an important role in determining the yield of a crop. The potential yield of variety within its genetic limit is set by environment. Islam *et al.* (2008) also reported a significant genotypic difference with respect to morphological, physiological, phonological characters and yield and yield components.

CONCLUSION

The study revealed that the land configuration, seed rate and variety significantly influenced the performance of soybean crop in central India. Among the treatments tested raised bed of 60 cm with 2 Rows bed^{-1} with 75 % of normal Seed rate (60 kg ha^{-1}forvariety RVS 2001-4 emerged a viable technique for obtaining better yield of soybean. The raised bed cultivation of soybean (60 cm with 2 Rows bed^{-1}) variety RVS 2001-4 at 60 kg ha^{-1} seed rate is recommended for better yield is recommended.

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