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Research Paper

Influence of seed rate and planting geometry on growth and yield of soybean (*Glycine max*) varieties

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ABSTRACT

A study was conducted during 2015 and 2016 Rudrur, Nizamabad, Telangana, to study the response of 2 varieties, viz. 'JS 335', 'Asb 22', and 7 planting geometries vis-a-vis seed rate (30 cm × 10 cm, 30 cm × 15 cm, 30 cm × 30 cm, 45 cm × 10 cm, 45 cm × 15 cm, 45 cm × 30 cm, 45 cm × 45 cm) in split-plot design, replicated thrice. Seed yield was significantly influenced by varieties and plant geometries. Between the 2 varieties studied, 'Asb 22' was found superior to 'JS 335' with mean seed yield of 2808 kg/ha, being 12% higher over existing variety 'JS 335' with mean seed yield of 2209 kg/ha. Among plant geometries, 30 cm × 15 cm resulted in significantly higher yield (2,874 kg/ha) closely followed by 45 cm × 10 cm (2,675 kg/ha) and 45 cm × 15 cm (2,614 kg//ha) over the existing spacing 30 cm × 10 cm (2,500 kg/ha). Yield reduction with 30 cm × 10 cm was to the extent of 6–12% compared to plant geometry of 30 cm × 15 cm or 45 cm × 10 cm. Variety 'Asb 22' was found economically superior with net returns of ₹58,519/ha and benefit: cost ratio 2.56, being 40% higher over existing variety 'JS 335' with net returns of 41,774/ha and benefit: cost ratio of 1.86. Plant geometry with 30 cm × 15 cm proved superior with net returns 59,361/ha. However, cultivation of soybean with plant geometry of 45 cm × 10 cm or 45 cm × 15 cm was on par with 30 cm × 15 cm, with net returns of 53,569/ha and 53,444/ha, respectively. The study revealed that, present variety 'JS 335' of soybean can be replaced with variety 'Asb 22' with plant geometry of 30 cm × 15 cm or 45 cm × 10 cm or 45 cm × 15 cm over existing geometry of 30 cm × 10 cm.

Key words: Seed rate, Plant geometry, Plant growth, Yield attributes, Economics

Soybean is one of the most important oilseed crops in the world, accounting for more than 50% of oilseed produced and 30% of the total supply of all vegetable oils. It is unique two-in-one crop having both high-quality protein (43%) and oil content (20%) and major source of high-quality protein for human daily diet and livestock feed in the world (Lie *et al*., 2006). The protein form of soybean is equivalent to that of meat, milk products and eggs in quality. Among various agronomic factors limiting yield, planting pattern is considered of great importance. Ahmad *et al*. (2009) stated that, the optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions. Ismail and Hall (2002) stated decrease in grain yield of cowpea with increased spacing. Liu *et al*. (2008) reported that adjusting planting density is an important tool to optimize crop growth and the time required for canopy closure, and to achieve maximum biomass and grain yield.

Soybean cultivation started in Telangana from the early 1990s along with Maharashtra. Telangana contributes 2% to area and 3% to total production in India. In Telangana, the area under soybean cultivation picked up to 1.9 lakh ha in 2008–09 and further increased to 2.43 lakh ha in 2015–16. Its share in cropped area is 6.3%; however its share in area under oilseed crops is 78%. Soybean production increased from 1.93 lakh tonnes in 2008–09 to 2.5 lakh tonnes in 2015–16 but productivity has decreased from 1,380 to 1,047 kg/ha of crop (Revathi *et al*., 2016). In Telangana there is a trend of increasing its area in response to water scarcity and need for crop diversification of rice, maize and cotton which are major crops and high-resource demanding. Dual problems of moisture-stress (drought and excess moisture in Vertisols), besides biotic stresses (stem fly, rust, yellow mosaic virus, and spodoptera), high seed rate, low seed replacement rate (SRR), improper plant population maintenance are the major factors that limit pro-

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ductivity realization as per potential.

'JS 335', a recommended variety, is popularly used by farmers in Telangana. The potential yield of this variety is 10 to 12 quintals per acre (0.4 ha). But yield potential of this variety declined for past 5 years in the state and is a matter of concern and replacement of variety with other suitable variety is required. Farmers in the state use high seed rate and higher plant population densities (lack of proper spacing) to compensate for low seed germination which is identified as major technical gap due to which crop is subjected biotic and abiotic stress at critical growth stages which is drastically affecting seed yield and simultaneously rising cost of production ultimately making uneconomical benefit. Due to the rising costs of soybean seed, seeding rates are being scrutinized by farmers, agronomists, and agribusinesses that work with them.

The arrangement of the plants in different rows and columns in an area to efficiently utilize the natural resources is called crop geometry. This is very essential to utilize the resources like light, water, nutrient and space. Keeping these facts in view, present study was conducted to find out suitable plant geometry and appropriate seed rate with existing variety 'JS 335' and new variety 'Asb 22' to enhance productivity and profitability of soybean in state.

MATERIALS AND METHODS

A study was carried with 2 varieties 'JS 335' and 'Asb 22' and 7 planting geometry 30 cm × 10 cm, 30 cm ×15cm, 30 cm× 30 cm, 45 cm × 10 cm, 45 cm × 15 cm, 45 cm × 30 cm, 45 cm × 45 cm during 2015 and 2016 at Regional Sugarcane and Rice Research Station, Rudrur, Professor Jayashankar Telangana State Agricultural University (286.3. m above mean sea-level) at 180 49'41' and 78056'45" E, Nizamabad (District), Telangana. The experiment was laid out in a split plot design with 2 soybean varieties as mainplot treatments and plant geometry as subplot treatments, replicated thrice. Sowing was done manually by dibbling seeds. Pendimethalin 38.7% CS @ 700 ml/acre (0.4 ha) as pre-emergence and Imazethapyr 10% SL @ 400 ml/ac (0.4 ha) as post-emergence spray at 18 days after sowing (DAS) was applied for control of weeds common to all treatments. Recommended dose of chemical fertilizers (30 kg N, 60 kg P_2O_5, 40 kg K_2O kg/ha) was applied basal in all treatments. Remaining 30 kg N was topdressed at 27 DAS coinciding with rain. The sources of N, P, K were urea, single superphosphate and muraite of potash respectively. One irrigation was given during R5 (seed filling) (October). Timely plant-protection measures were taken and crop was managed such that pests and diseases were at below threshold level all through crop-growing period.

Immediately after crop emergence, 10 consecutive plants from central rows were tagged to record growth and yield parameters. Plant height was measured from base of the plant to the top-most node and expressed in centimeters. Other attributes were recorded by counting and computed as number per plant. The gross returns, cost of cultivation, net returns and benefit: cost ratio (B: C ratio) were calculated by using prevailing prices of inputs and outputs. All the data were subjected to analysis of variance (ANOVA) as per the standard procedure

Required seed rate for different plant geometry was calculated using the formula :

$$\frac{\text{Desired plant population}}{\text{Per cent germination} \times \text{per cent pure seed} \times \text{per cent live seed emergence}}$$

RESULTS AND DISCUSSION

The effect of plant density on growth and yield vary due to varietal characters of selected variety and management practices adopted. Thus the relationship of seed yield with different growth parameters and yield components under variable planting density is very important to understand the basic mechanism of yield-plant density relationship and this would also help in identification of suitable plant spacing for improving yield of soybean.

Growth and yield attributes

Analysis of pooled results of 2 years indicated that variety 'Asb 22' was superior with significantly more branches (8.81) and number of pods (155.00) per plant over variety 'JS 335' (Table 1). Number of branches and pods per plant differed more apparently with plant geometry. Highest number of branches per plant were produced at 45 cm × 45 cm (9.91), 45 cm × 30 cm (9.26), 30 cm × 30 cm (8.68) and 45 cm × 15 cm (8.42). It may be owing to more space available for plant to develop and less plant-to-plant competition for available resources. These results confirm the findings of Cox *et al*. (2010), who stated that soybean plants respond to environmental conditions and can compensate for lower plant populations by producing more branches. Lowest numbers were produced at 30 cm × 10 cm plant geometry (7.22) due to severe competition between plants for space and other sources. Similarly, more number of pods per plant were recorded at plant geometry 45 cm × 30 cm (210.05), followed by 30 cm × 30 cm (199.35) and 45 cm × 45 cm (190.49) and 30 cm × 15 cm (179.82). Ram *et al*. (2011) also reported the highest number of pods/plant with the seed rate of 50 kg/ha and significant decrease with each increment of 25 kg in seed rate. Ferreira *et al*. (2018) also described reduced the number of pods/plant with increasing seeding rate.

Seed yield

Seed yield was significantly influenced by varieties and spacing. Of the 2 varieties, 'Asb 22' was superior to 'JS 335', with a mean seed yield of 2.88 t/ha which was 12% higher than that of existing variety 'JS 335' which recorded seed yield of 2.21 t/ha (Table 1). Among plant geometry studied, 30 cm × 15 cm resulted in significantly higher yield (2.87 t/ha), closely followed by 45 cm × 10 cm (2.67 t/ha) and 45 cm × 15 cm (2.61 t/ha) over existing geometry 30 cm × 10 cm (2.50 t/ha).The ability of soybean to branch out and produce more pods if there is enough space (phenotypic plasticity) explains the minor reaction of soybeans to different plant establishments (Khurshid *et al.,* 2006; McHugh *et al.,* 2017). This was supported by Cox and Cherney (2011), who described that not only did soybean plants compensate with biomass, pods and seeds per plant at lower seeding rates but also compensated for wider rows (>38 cm) as well. They also found that though soybean plants do compensate for both lower seeding rates and wider rows, plants were less efficient at compensating for wider rows than for lower seeding rates, meaning that row spacing had a greater impact on yield than seeding rate. Chen and Wiatrak (2011) reported that, increasing seeding rate may improve soybean growth at early vegetative stages, which in turn can result in increase in yield. However, they found that seeding rates above 272,000 seeds/ha did not follow this trend and did not increase vegetative growth. Sowing soybean with plant geometry of 45 cm × 30 cm and 30 cm × 30 cm though produced more pods/plant, could not yield higher than plant geometry of 30 cm × 10 cm due to low plant population than the recommended optimum plant population due to which yield/plant increased but yield/unit area decreased. The results are in tune with findings of Rahman *et al*. (2004), who reported that, though per plant growth and yield components increased at lower densities, per unit area yield decreased as a result of less per unit area canopy photosynthesis and dry-matter accumulation. Similarly, it also confirms results of Ball *et al.* (2000); Edwards *et al.* (2005) confirmed that insufficient development of the canopy before the seed set at wider spacing (lower densities) limits the yield. In present study, equidistant planting of soybean at plant geometry of 30 cm × 30 cm (2.56 t/ha) with seed rate of 20 kg/ha recorded at par yield to that of 30×10 cm (2.50 t/ha) but may be risky in case of adverse abiotic and biotic stress.

Thus, the reduction in seed yield with plant geometry 30 cm × 10 cm to the extent 6 to 12% compared to 30 cm × 15 cm or 45 cm × 10 cm indicate more severe plant competition at closer spacing (higher plant densities). It is pertinent to consider that as plant population increases the available source (light)/plant decreases at the cost of yield per plant.

Table 1. Influence of seed rate and planting geometry on growth, yield and economics of soybean varieties (average of 2 years)

Treatment	Branches/ plant	Pods/ plant	Seed yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Varieties						
'JS 335'	7.88	134.3	2.21	64,153	41,774	1.86
'ASb 22'	8.81	155.0	2.88	81,417	58,519	2.56
SEm±	0.13	7.29	0.08	663.46	648	0.04
CD (P=0.05)	0.86	16.05	0.23	1,660	1,601	0.11
Plant geometry						
S_1, 30 cm × 10 cm (50 kg/ha)*	7.22	132.2	2.50	72,495	46,443	1.77
S_2, 30 cm × 15 cm (37.5 kg/ha)	7.34	179.8	2.87	83,363	59,361	2.45
S_3, 30 cm × 30 cm (20 kg/ha)	8.68	199.3	2.56	74,284	52,958	2.47
S_4, 45 cm × 10 cm (37.5 kg/ha)	7.62	160.4	2.67	77,570	53,569	2.31
S_5, 45 cm × 15 cm (25 kg/ha)	8.42	174.2	2.61	75,823	53,444	2.36
S_6, 45 cm × 30 cm (12.5 kg/ha)	9.26	210.0	2.27	65,830	45,450	2.21
S_7, 45 cm × 45 cm (7.5 kg/ha)	9.91	190.5	2.06	59,782	39,801	1.98
SEm±	0.21	4.64	0.07	1,679	1,044	0.07
CD (P=0.05)	0.65	16.57	0.24	4,930	3,128	0.22
Interaction						
Varieties at same level of plant geometry						
SEm±	0.32	8.78	0.07	1886	1,259	0.10
CD (P=0.05)	NS	25.64	0.23	6602	4,408	0.33
Plant geometry at same level of varieties						
SEm±	0.35	8.21	0.07	2213	2,237	0.10
CD (P=0.05)	NS	26.29	0.24	7084	6,712	0.31

*Figures in parentheses are seed rate corresponding to plant geometry

Ball *et al*. (2000) reported that, increasing plant population reduced yield of individual plants but increased yield per unit of area.

Economics

Cultivation of soybean variety 'Asb 22' was more found economic, with net returns of 58,519/ha, which was 40% higher over existing variety 'JS 335'. Benefit: cost ratio recorded with this variety was significantly superior (2.56) to that of 'JS 335' (1.86).

An important consideration would be that as agronomic management of soybean with plant geometry 30 cm × 15 cm was superior with net returns 59,361/ha. However, plant geometry of 45 cm × 10 cm or 45 cm × 15 cm was on a par with 30 cm × 15 cm with net returns of 53,569/ha and 53,444/ha, respectively. Cultivation of soybean with 30 cm × 10 cm was not economical due to less yield obtained because of more plant population than recommended optimum plant population. Similarly, plant geometry of 45 cm × 30 cm or 45 cm × 45 cm were also not economical due to less than recommended optimum plant population.

The results from above study indicate that plant geometry of 30 cm × 10 cm using 50 kg /ha seed rate is not fetching benefits to soybean growers in Telangana state due more severe plant competition producing taller plants with sparse branching and few pods/plant ultimately resulting in seed yield reduction. Contrary to this, sowing soybean with plant geometry of either 45 cm × 30 cm with 12.5 kg/ha or 45 cm × 45 cm with seed rate of 7.5 kg/ha is also not economical due to non uniform distribution of plants in field. However, at equidistant spacing of 30 cm × 30 cm with seed rate of 20 kg/ha soybean was able to offset yield loss by producing more branches and pods, resulting in yields at par to 30 cm × 10 cm, but it may result in lower pod height, lodging of lateral branches, and higher weed populations all of which may result in harvest losses. It is also to be considered that loss of a single plant due to any biotic or abiotic stress will have large impact on seed yield loss.

It is important to consider that not all of the seed sown will germinate or grow to reach plant maturity. The proper way to think about seeding rate is germination percentage and the number of plants that need to reach maturity to maximize yield. Hence mortality rate of plants has major emphasis in harnessing economic yields. Present study confirm these facts and it can be concluded that, soybean variety 'JS 335' can be replaced with variety 'Asb 22' with plant geometry of 30 cm × 15 cm or 45 cm × 10 cm or 45 cm × 15 cm over existing spacing of 30 cm × 10 cm. Seed rate can be reduced to 37.5 kg/ha with 30 cm × 15 cm and 45 cm × 10 cm spacing and further to 25 kg/ha in 45 cm × 15 cm considering standard 70% germination. The above recommendation has less mortality of plants due to more favourable growing conditions maintaining optimum population required to produce economic yield giving yield advantage of 15%, 7% and 5%, respectively, over present recommendation of 62.5 kg/ha, making soybean cultivation more economical. In Telangana state soybean is sown with seed-cum-fertill drill with provision of adjusting inter-and intra-row spacing. Hence present recommendation has wide range of adaptability for soybean growers.

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