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Effect of methods of sowing and spacing on yield, quality and chemical studies of soybean (*Glycine Max* L.)

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Abstract
A field experiment entitled "Effect of methods of sowing and spacing on yield, quality and chemical studies of soybean (*Glycine max* L.)" was conducted at Agronomy Farm, College of Agriculture, Nagpur, during *kharif* season of 2021-22 in Factorial Randomized Block Design (FRBD) with eight treatments and three replications. Treatment combinations were comprised of two sowing methods *viz*., ridges and furrow and broad bed furrow and four treatments of spacing *viz*., 45 cm x 5 cm, 45 cm x 10 cm, 45 cm x 15 cm and 45 cm x 20 cm. Results revealed that, seed and straw yield (q ha^{-1}), gross monetary returns, net monetary returns (Rs. ha^{-1}) were significantly higher due to sowing on broad bed furrow. As regards spacing, seed and straw yield (q ha^{-1}), gross monetary returns, net monetary returns (Rs. ha^{-1}) were significantly maximum at spacing 45 cm x 5 cm. The interaction effect between methods of sowing and spacing was found non-significant. Protein, oil content (%) and available N, P, K in soil after harvest did not differed significantly due to different sowing methods and spacing.

Keywords: sowing, spacing, yield, protein, oil, NPK, soybean

Introduction

Among the pulses grown in India and Maharashtra, soybean is important pulse growing crop. Soybean (*Glycine max* L.) is most important legume crop belonging to the family Leguminosae, subfamily Papilionaceae and genus *glycine*. Soybean was cultivated in China from 3000 B.C. It has witnessed phenomenal growth in production, processing and trade from last few years and has revolutionized the rural economy and improved socio-economic status of the farmers. It is one of the important oilseed crops, commonly used as pulse, oilseed, vegetarian meat and soya milk and has been rightly known as "Wonder crop" or "Golden Bean" of the 21st century. It is a reach source of protein (40 to 42%) and oil (20%). It also contains 30% carbohydrates, 5% minerals, 4-5% crude fibers, 0.5% lecithins and 4% saponin. Nutritionally soybean is a good source of vitamin and amino acid (lysine, glycine and tryptophan). It is also a good source of isoflavones and therefore it helps in preventing heart diseases and cancer (Anusha *et al*. 2021) [2]. Due to multiple use of soybean is also known as wonder crop. In Maharashtra, Vidarbha region has attained the highest production of crop, as the average rainfall ranges between 800 to 1000 mm, also black cotton soil of the region is more suitable for the production. In the year 2019-2020, the total production of soybean in Vidarbha was 48.25 lakh tonnes and area sown was 41.24 lakh ha. indicating the productivity 853 kg ha^{-1}. Sowing is an art of placing the seeds in soil to have good germination in the field. There are different methods of sowing adopted for soybean such as drilling, dibbling, ridge and furrow and broad bed furrow (BBF). Among these, ridges and furrow and broad bed furrow (BBF) method are adopted to conserve soil moisture and increase seed yield (Kinge *et al*. 2020) [6]. Ridges and furrow comprise ridges and furrows to sow the seeds and store the water respectively and broad bed furrow (BBF) is another method of sowing, newly adopted technology consist of 3-4 rows of crop on bed and furrows for water conservation. Both methods are adopted to increase the growth and yield of crop than normal sowing methods. Spacing is the distance between two rows and two plants. It is an important factor for any crop production because it determines the initial and final plant population in field, provide proper aeration in crop canopy and reduce competition for nutrient, sunlight and moisture which may be optimized by suitable plant density enhancing the growth and yield of crop (Kumar *et al*. 2018) [7].

Materials and Method

The present field experiment entitled "Effect of sowing methods and spacing on yield, quality and chemical studies of soybean (*Glycine max* L.)" was carried out during *kharif* season 2021-22. The experiment was laid out in FRBD with two levels of sowing methods as one factor and four levels of spacing as another factor with eight treatment combination replicated three times. Seeds were obtained from Head, Regional Research Centre, Amravati of Dr. P.D.K.V, Akola. Soybean variety of AMS-100-39 (PDKV Amba) used for experiment. The seed of soybean variety AMS-100-39 was treated with thiram @ 3 g kg^{-1} of seed and inoculated with *rhizobium* before sowing in order to keep the crop from seed born diseases. Seed rate of soybean was used as per recommended. Sowing of seed as per treatment was done on 28th June 2021 at an optimum soil moisture level. Appropriate and timely plant protection measures for control of leaf eating caterpillar were followed. Before harvesting the crop from each net plot, five plants from each

plot were taken for recording post harvest observation. Then net plot rows were harvested, winnowed and cleaned separately plot wise. The produce was sun dried and weight was recorded. Yield ha^{-1} was calculated. Standard method of analysis of variance was used for analyzing the data for FRBD design (Panse and Sukhatme, 1967) [8]. The "F" test of significance was used for testing the null hypothesis and a standard error of mean in order to determine whether the result of treatment real and discernible from chance effects and where the treatment effects were found to be significant, the critical difference (C.D.) at 5 per cent probability level was calculated for comparison of treatments.

The harvested seed samples were cleaned and determined the total nitrogen content (%) by Micro-Kjeldahl"s digestion and distillation method. The protein content (%) was then obtained by multiplying nitrogen content (%) of seed with the conversion factor of 6.25. Protein yield was calculated as per following formula.

$$\text{Protein yield (kg ha}^{-1}) = \frac{\text{Protein (\%) x Seed yield (kg ha}^{-1})}{100}$$

The harvested seed samples of soybean were cleaned and determined oil content by using Soxhlet apparatus method in term of percentage. Oil yield was calculated as per following formula.

$$\text{Oil yield (kg ha}^{-1}) = \frac{\text{Oil (\%) x Seed yield (kg ha}^{-1})}{100}$$

The soil sample was taken from 0-30 cm depth from each net plot after harvest of the crop. This sample were air dried and grinded in mechanical grinder, sieved, labeled and stored in cloth bag. Chemical analysis of residual status of available nitrogen, phosphorus, potassium (Kg ha^{-1}) by alkaline permanganate method, Olsen's method and flame photometer method respectively for observing residual effect of nitrogen (N), phosphorus (P) and potassium (K) in soybean field by adoption of various sowing methods and spacing.

Results and Discussion (Table 1)

Grain yield (q ha^{-1})

Effect of sowing methods

The seed yield (q ha^{-1}) of soybean was significantly influenced due to different sowing methods. The sowing of soybean on broad bed furrow gave significantly highest seed yield (20.38 q ha^{-1}) over the sowing of soybean on ridges and furrow (18.81 q ha^{-1}). This might be due to efficient utilization of moisture and nutrients under sowing of soybean on broad bed furrow favorably enhanced the growth attributes which resulted into increase in total seed yield (q ha^{-1}) under sowing of soybean on broad bed furrow. Asewar *et al*. (2017) [3] and Swapna *et al*. (2020) [11] also reported similar results who recorded highest yield of crop with BBF.

Effect of spacing

The seed yield (q ha^{-1}) was significantly influenced due to different spacings at harvest of soybean. Seed yield (21.84 q ha^{-1}) was registered significantly highest at spacing of 45 cm x 5 cm as compared to other spacings. However, it was at par with the spacing of 45 cm x 10 cm (20.01 q ha^{-1}) and lowest seed yield (17.53 q ha^{-1}) was recorded at the spacing of 45 cm x 20 cm. This might be due to at narrow spacing higher plant population per unit area resulted into highest seed yield (q ha^{-1}). Similar results were recorded by Kumar *et al*. (2018) [7] who reported more seed yield due to narrow spacing.

The seed yield (q ha^{-1}) of soybean was found to be non-significant due to interaction with sowing methods and spacing.

Straw yield (q ha^{-1})

Effect of sowing methods

The straw yield (q ha^{-1}) of soybean was significantly influenced by different sowing methods at harvest. The sowing of soybean on broad bed furrow gave significantly highest straw yield (27.11 q ha^{-1}) over the sowing of soybean on ridges and furrow (25.07 q ha^{-1}). This might be due to enhanced vegetative growth as resulted into highest straw yield (q ha^{-1}) on broad bed furrow due to better soil aeration, scope for more space, light interception and benefit for more moisture conserved on broad bed furrow than other sowing methods. Similarly, these results were correlated with Kinge *et al*. (2020) [6] who also reported higher straw yield due to sowing on broad bed furrows.

Effect of spacing

The straw yield (q ha^{-1}) was significantly influenced due to different spacings at harvest of soybean. Straw yields (28.82 q ha^{-1}) were found significantly highest at the spacing of 45 cm x 5 cm as compared to other spacing. However, it was at par with the spacing of 45 cm x 10 cm (26.56 q ha^{-1}) and lowest straw yield (23.62 q ha^{-1}) at the spacing of 45 cm x 20 cm. This might be due to at narrow spacing obtained higher plant population per unit area which resulted into highest straw yield (q ha^{-1}) but straw yield plant^{-1} was recorded more at wider spacing. Similar findings were also noticed by Ali *et al*. (1999) [1] and Rahman *et al*. (2013) [10].

The straw yield of soybean (q ha^{-1}) was found to be non-significant due to interaction with sowing methods and spacing.

Protein content (%)

Effect of sowing methods

The protein content (%) of soybean after harvest was recorded higher with broad bed furrow sowing method.

Effect of spacing

The treatment with spacing of 45 cm × 20 cm spacing recorded higher protein content (%) of soybean.

Protein yield (kg ha^{-1})

Effect of sowing method

Method of sowing showed significant effect on protein yield (kg ha^{-1}) where broad bed furrow method recorded maximum and significantly higher protein yield (821.15 kg ha^{-1}) compared to ridges and furrow method. This might be due to higher seed yield, which also reported by Gunjal *et al*. (2021) [5].

Effect of spacing

Spacing adopted recorded significant effect on protein yield (kg ha^{-1}). The spacing of 45 cm × 5 cm recorded superior protein yield (871.88 kg ha^{-1}) as compared to other spacings, but found at par with 45 cm × 10 cm (804.30 kg ha^{-1}). This

might be due to higher seed yield. These results lend support to those reported by Patel *et al*. (2022) [9].
The interaction effect of methods of sowing and spacing was found to be non-significant.

Oil content (%)
Effect of sowing methods
It is evident from the data that the oil content (%) of soybean after harvest recorded more (20.10%) by broad bed furrows followed by ridges and furrow method.

Effect of spacing
The oil content (%) of soybean after harvest found more (20.25 %) by 45 cm × 20 cm compared to others and closely followed by 45 cm x 15 cm.

Oil yield (kg ha^{-1})
The oil yield was significantly influenced by sowing methods. The oil yield was maximum and significantly due to broad bed furrow (408.79 kg ha^{-1}) over ridges and furrow method. The higher oil yield obtained on broad bed furrow due to favorable condition of bed for growth and development of crop which resulted into higher seed yield which directly responsible for obtaining of higher oil yield. The results are in close conformity with the findings of Gunjal *et al*. (2021) [5].

Effect of spacing
Spacings showed significant effect on oil yield (kg ha^{-1}). The treatment of 45 cm × 5 cm spacing recorded more superior oil yield (433.36 kg ha^{-1}) compared to others, but was found to be at par with 45 cm × 10 cm (398.81 kg ha^{-1}). The higher oil yield achieved at narrow spacing due to higher seed yield, which is directly responsible for higher oil yield. Almost similar findings were also reported by Ganvit *et al*. (2019) [4] and Patel *et al.* (2022) [9].
The interaction effect of sowing methods and spacing on yield (kg ha^{-1}) was found to be non-significant.

Available nitrogen (kg ha^{-1})
Effect of sowing method
The available nitrogen (kg ha^{-1}) in soil after harvest did not significantly influenced by different sowing methods.

Effect of spacing
The available nitrogen (kg ha^{-1}) in soil after harvest did not significantly influenced by different spacings.
The available nitrogen (kg ha^{-1}) in soil after harvest was found to be non-significant due to interaction with sowing methods and spacings.

Available phosphorus (kg ha^{-1})
Effect of sowing methods
The available phosphorus (kg ha^{-1}) in soil after harvest did not significantly influenced by different sowing methods.

Effect of spacing
The available phosphorus (kg ha^{-1}) in soil after harvest did not significantly influenced by different spacings.
The available phosphorus (kg ha^{-1}) in soil after harvest found to be non-significant due to interaction with sowing methods and spacings.

Available potassium (kg ha^{-1})
Effect of sowing method
The available potassium (kg ha^{-1}) in soil after harvest did not significantly influenced by different sowing methods.

Effect of spacing
The available potassium (kg ha^{-1}) in soil after harvest did not significantly influenced by different spacings.
The available potassium (kg ha^{-1}) in soil after harvest found to be non- significant due to interaction with sowing methods and spacings.

Conclusion
For getting higher grain yield and net monetory returns, oybean should be sown on broad bed furrow with the spacing of 45 cm x 5 cm.

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