

Growth, nutrient uptake and quality of soybean [*Glycine max* (L.) Merrill] as influenced by genotypes and seed rates

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ABSTRACT

A field experiment was conducted to study the effect of genotypes and seed rates on growth, nutrient uptake and quality of soybean during *kharif* 2023 at Punjab Agricultural University, Ludhiana, Punjab. Twelve treatment combinations comprising three soybean genotypes (NRC SL 3, NRC SL 5 and SL 958) and four seed rates (50.0, 62.5, 75.0 and 87.5 kg/ha) were laid out in a completely randomized block design (CRBD) with four replications. Results revealed that, the soybean genotype SL 958 exhibited highest plant stand, days taken to full flower and maturity, total nutrient uptake (305.0-45.2-135.5 kg N-P-K/ha), protein content (42%) and protein yield (1312 kg/ha). Genotype NRC SL 5 recorded significantly higher leaf area index, PAR interception, dry matter accumulation and seed thickness, while genotype NRC SL 3 had significantly higher oil content than the other genotypes. Seed rate of 50.0 kg/ha resulted in significantly higher dry matter accumulation (25.17 g/plant), whereas the 87.5 kg/ha seed rate led to significantly higher plant stand, leaf area index (6.6) and PAR interception (94.3%) than the other seed rates. Seed rate had no significant impact on seed thickness, total nutrient uptake or quality parameters (protein content, protein yield, oil content and oil yield). In conclusion, the genotype NRC SL 5 was found promising in terms of growth attributes (leaf area index, PAR interception and dry matter accumulation) and was early in flowering and maturity, while genotype SL 958 showed better nutrient uptake and quality at a moderate seed rate (62.5–75.0 kg/ha).

Key words: Genotypes, Growth attributes, Nutrient uptake, Seed rates, Quality

Soybean [*Glycine max* (L.) Merrill] is a globally cultivated legume crop that provides the largest supply of protein feed and the second largest supply of vegetable oil worldwide. Globally, soybean was cultivated on 133.8 million hectares, with a production of 348.9 million tonnes and productivity of 2608 kg/ha during 2022 (FAOSTAT, 2024). India ranks as the fifth largest producer and sixth largest consumer of soybean. In India, soybean cultivation covered 12.07 million hectares, with a production of 13.98 million tonnes with a productivity of 1158 kg/ha during the 2022-23 (Anonymous, 2024). Legumes like soybean, can be a strong candidate crop for diversification in water scarce areas, as they are capable of generating profitable yields with minimal agricultural inputs and management. Despite its potential, the average soybean yield in India

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remains low as compared to its possible production. This can be attributed to several factors, such as low plant density, reliance on traditional local varieties and inadequate crop management practices. Seed rate selection is a key management strategy that influences plant spacing and promotes better crop growth by facilitating quicker canopy closure, maximizing biomass and improving seed yield (Haddadchi and Gerivani, 2009). Choosing the right genotype is also critical for maximizing yield, as it helps efficiently utilize limited resources like light, water, nutrients and space. Soybean genotypes may differ in seed size, plant height and maturity, and larger-seeded varieties require a higher seed rate than smaller-seeded ones. Achieving the ideal plant stand is essential for high-yielding genotypes, highlighting the importance of seed rate as a non-monetary input (Lone *et al.*, 2010; Ram *et al.*, 2011; Swati and Singh, 2018). Therefore, an experiment was conducted to study the effect of genotypes and seed rates on growth, nutrient uptake and quality of soybean.

The research trial was conducted at Research Farm of Pulses Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana during *kharif* 2023. The experimental site featured sandy loam soil,

characterized by normal pH and electrical conductivity. Organic carbon, available nitrogen and potassium were rated as medium, whereas available phosphorus levels were considered high. Twelve treatment combinations comprised of three soybean genotypes (NRCSL 3, NRCSL 5 and SL 958) along with four seed rate levels (50.0, 62.5, 75.0 and 87.5 kg/ha) laid out in with four replications. The crop was planted at row spacing of 45 cm apart. Data on plant stand at 30 days after sowing (DAS), leaf area index (LAI), photosynthetically active radiation (PAR) interception at 90 DAS, dry matter accumulation at harvest, phenological stages- days to full flowering (R2) and maturity (R8), seed thickness, total nutrient uptake and quality parameters (protein and oil content) were recorded. Data generated from the field experiment were analyzed using “Analysis of Variance” (ANOVA) in RCBD as suggested by Cochran and Cox (1967). The standard error of the mean (SEM±) and critical difference (CD) at a 5% level of significance was calculated for each character to compare the treatment difference.

Genotypes showed a significant effect on growth attributes (Table 1 and Figure 1), phenological stages (Table 1), total nutrient uptake (Table 2) and quality parameters (Table 2). The genotype SL 958 showed significantly higher plant stand (21.7 plants/meter row length) than NRCSL 3 and NRCSL 5 genotypes. This variation could be attributed to differences in seed size. Smaller seeds result in a higher number of seeds per unit weight, leading to a greater plant stand at the same seed rate as compared to larger seeds. The genotype NRCSL 5, being bold-seeded, recorded the lowest plant stand due to its larger seed size. At 90 DAS, the NRCSL 5 genotype had a significantly

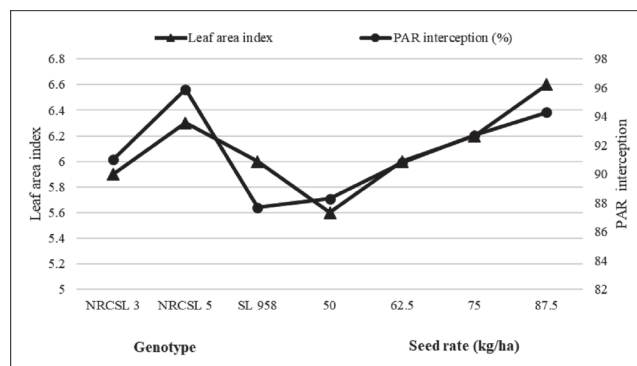


Fig. 1. Effect of different genotypes and seed rates on leaf area index and PAR interception at 90 DAS of soybean

higher leaf area index (6.3) and photosynthetically active radiation (PAR) interception (95.9%) than genotypes NRCSL 3 and SL 958. This could be due to the genotype’s genetic traits, as bold-seeded genotypes like NRCSL 5 tend to have more vigour, resulting in better plant establishment and greater resource availability, which supports larger leaves and a higher leaf area index. There is a direct relationship between leaf area index and PAR interception. Differences in plant stand and leaf area index due to genotypic characteristics have also been observed by Asif *et al.* (2021) in soybean. Furthermore, at harvest, NRCSL 5 showed significantly higher dry matter accumulation (24.18 g/plant) than genotypes NRCSL 3 and SL 958. This could be due to increased photosynthetic activity driven by the higher leaf area index and PAR interception, resulting in more carbohydrate accumulation and greater dry matter production. Rathwa *et al.* (2023) has also reported genotypic differences in dry matter accumulation in soybean.

Table 1. Effect of different genotypes and seed rates on growth, phenological stages and seed thickness of soybean

Treatment	Plant stand at 30 DAS (plants/m row length)	Dry matter accumulation at harvest (g/plant)	Days taken to full flower (R2 stage)	Days taken to full maturity (R8 stage)	Seed thickness (mm)
<i>Genotype</i>					
NRCSL 3	18.1	22.62	67.1	141.9	4.63
NRCSL 5	16.2	24.18	60.1	135.0	5.04
SL 958	21.7	21.49	69.3	146.2	4.65
SEm±	0.43	0.42	0.11	0.13	0.05
CD (p=0.05)	1.3	1.25	0.3	0.4	0.16
<i>Seed rate (kg/ha)</i>					
50.0	13.9	25.17	65.3	140.8	4.78
62.5	16.8	23.41	65.4	140.9	4.78
75.0	20.4	22.33	65.6	141.3	4.77
87.5	23.5	20.15	65.7	141.5	4.76
SEm±	0.5	0.48	0.13	0.15	0.06
CD (p=0.05)	1.5	1.45	NS	NS	NS

The genotype SL 958 took significantly more days to reach full flower (69.3 days) and to maturity (146.2 days), whereas genotype NRCSL 5 was significantly early in flowering and maturity (60.1 and 135.0 days respectively). Additionally, NRCSL 5 genotype recorded significantly higher seed thickness (5.04 mm) than NRCSL 3 and SL 958 genotypes. This difference was attributed to the bold-seeded nature of the NRCSL 5 genotype.

The SL 958 genotype showed significantly higher total nitrogen (305.0 kg/ha) and phosphorus uptake (45.2 kg/ha) than NRCSL 5 genotype, which was statistically at par with NRCSL 3 genotype (281.9 and 42.4 kg/ha, respectively). Additionally, SL 958 had a significantly higher total potassium uptake (135.5 kg/ha) than NRCSL 3 and NRCSL 5 genotypes. This improved nutrient uptake in SL 958 is likely linked to its higher seed and stover yields. There were no significant differences in protein content and oil yield among the genotypes. Genotype SL 958 achieved a significantly higher protein yield (1312 kg/ha) than NRCSL 5 genotype, which was statistically at par with NRCSL 3 genotype (1213 kg/ha). This could be attributed to more seed yield in SL 958 genotype than other genotypes. In contrast, genotype NRCSL 3 exhibited significantly higher oil content (20.4%) than NRCSL 5 and SL 958 genotypes. This might be due to genotypic differences. Shahin *et al.* (2023) has also reported genotypic differences in oil content in soybean.

Seed rate of 87.5 kg/ha recorded significantly higher plant stand than 50.0, 62.5 and 75.0 kg/ha seed rates. This increase in plant stand might be due to higher number of seeds sown per unit area in the field for higher seed rate.

Nleya *et al.* (2020) also found that percent stand establishment decreased as seed rates increased in soybean. Higher seed rates led to an increase in leaf area index due to the closer plant population. The leaf area index was significantly higher with 87.5 kg/ha (6.6) seed rate than 50.0, 62.5 and 75.0 kg/ha seed rates at 90 DAS. This might be due to more canopy closer and higher solar radiation interception under higher seed rates than lower seed rates. Seed rate of 87.5 kg/ha resulted in significantly higher PAR interception (94.3%) than seed rates of 50.0 and 62.5 kg/ha, which was statistically at par to 75.0 kg/ha seed rate (92.7%). As seed rates increased, PAR interception also increased, likely due to a higher plant population and leaf area index, leading to more canopy closure and development. Increased leaf area index and PAR interception, which indicate increased photosynthesis and improved plant growth rate showed a positive correlation with higher dry matter accumulation (Basu *et al.*, 2014). Seed rate of 50.0 kg/ha achieved significantly higher dry matter accumulation (25.17 g/plant) than 62.5, 75.0 and 87.5 kg/ha seed rates. This might be attributed to the more resources (nutrients, moisture, space and light) available per plant under lower seed rate (50.0 kg/ha). Jassal and Singh (2020) also observed that leaf area index, PAR interception and dry matter accumulation increased with increase in seed rates in soybean.

The number of days to reach full flower (R2 stage) and maturity (R8 stage) remained unaffected by different seed rates, with no significant differences observed. Seed thickness also showed no significant variation, likely due to increased competition for essential resources at higher plant

Table 2. Effect of different genotypes and seed rates on total nutrient uptake and quality parameters of soybean

Treatment	Total nutrient uptake (kg/ha)			Quality parameters			
	Nitrogen	Phosphorus	Potassium	Protein content (%)	Protein yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)
<i>Genotype</i>							
NRCSL 3	281.9	42.4	124.5	41.3	1213	20.4	597
NRCSL 5	247.3	34.0	99.6	40.6	1158	19.9	566
SL 958	305.0	45.2	135.5	42.0	1312	19.7	616
SEm±	8.4	1.2	3.1	0.45	38.2	0.11	16.1
CD (p=0.05)	24.4	3.5	9.0	NS	110	0.3	NS
<i>Seed rate (kg/ha)</i>							
50.0	261.7	39.6	115.6	41.6	1141	20.2	553
62.5	278.2	40.6	120.2	41.4	1227	20.0	592
75.0	284.3	41.0	121.4	41.2	1262	19.9	609
87.5	287.9	41.0	122.2	41.0	1280	19.8	618
SEm±	9.8	1.4	3.6	0.52	44.1	0.22	18.6
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

densities, which may lead to limited seed development. Additionally, seed rates had no significant impact on total nutrient uptake (N, P, and K), protein content, protein yield, oil content and oil yield.

In conclusion, the soybean genotype SL 958 provides better plant stand, nutrient uptake, protein quality and took more days to maturity, while NRCSL 5 seems promising in terms of growth attributes (leaf area index, PAR interception and dry matter accumulation), seed thickness and early in flowering and maturity, while NRCSL 3 had the highest oil content. However, seed rate had no significant impact on seed thickness, total nutrient uptake or quality parameters (protein content, protein yield, oil content and oil yield). Based on the findings, soybean genotype NRCSL 5 exhibited better growth traits and early maturity, whereas SL 958 performed better in nutrient uptake and seed quality at a seed rate of 62.5–75.0 kg/ha.

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