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Production potential and economics of soybean (*Glycine max* (L.) Merrill) under different resource constraints

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Abstract
The experimental trail was performed out at the Experimental Farm belonging to the Agronomy Section, Agriculture College, Latur, during the *Kharif* season of 2021 in order to assess the losses resulting from production restrictions in soybeans and to analyze the impact of different constraints on the growth and yield attributes of soybeans. The pH of the clay-textured, somewhat alkaline soil in the experimental plot was 7.8, and its chemical composition included available nitrogen (125.30 kg per ha) at low levels and medium levels of available phosphorus (18.20 kg per ha) as well as high levels of available potassium (498.58 kg per ha). Because of its good drainage, it was ideal for growth. Due to its good drainage, the soil was ideal for growth. Eight treatments, each with replicated thrice, were included in the Randomized Block Design trial setup. The adoption of the whole package of procedures (T_1) resulted in improved growth, yield attributes, and seed yield (2148 kg ha^{-1}) in soybean production, according to the results. When compared to the whole package of activities, weeding was shown to be the most important limitation of the single production element, causing yield losses of up to 33%. Plant protection came in second with 25% and RDF with 20%. RDF + weeding (T_5), RDF + plant protection (T_6), and weeding + plant protection (T_7) were shown to be the two main resource limitations among the two factor production constraints, resulting in yield losses of up to 45%, 35%, and 60%, respectively.

Keywords: RDF, soybean, weeding, plant protection, constraints, yield reduction

Introduction

Soybean (*Glycine max* (L.) Merrill) is a legume crop belonging to the family Leguminaceae. It is a crucial crop for animal and human nutrition. It is a significant source of vegetable oil and has between 40% and 42% high-quality protein. It is also high in minerals, vitamins, and oil (20%). The protein found in soybeans is high in the essential amino acid lysine (5%) which is most lacking in grains. It has 60 percent poly unsaturated fatty acids, of which 52.8% are linoleic and 7.2% are linolenic. Every year, around 85% of the world's soybeans are processed to make oil and meal. Because oil dries quickly, around 80% of it is used in industry to prepare paints, varnishes, printing ink, oil cloth, soap, patent leather, and waterproof fabrics. The most lucrative and possibly most popular feed for cattle is soybean oil cakes.

One major contributor to the edible oil pool in India is soybean. Soybeans currently make up 43% of all oilseeds and 25% of all oil produced in the nation. Agronomic techniques and climate variables are the primary determinants of crop productivity. In order to maximize the seed output of the soybean crop, weed control and plant protection are essential agronomic practices while applying fertilizers. Fertilizer, weeding, and plant protection are some of the components that help establish and grow crop stands, which in turn contribute to the final crop seed production. To support efforts to overcome and discover solutions, it is essential to understand the restrictions that affect production. The limitations on the basic inputs that are available are known as resource constraints. By identifying the main production constraints for soybeans, resource constraints can be used to place restrictions on essential agricultural inputs as well as cultural practices like weeding, fertilizer, and plant protection, all of which are essential for the crop's better growth and development, higher yield, and profits. Keeping these facts in view, the present investigation entitled “Production potential of soybean (*Glycine max* L. Merril) under resource constraints” in vertisol was carried out to analyse the effect of various constraint on growth and yield attributes of soybean and to access the losses due to constraint.

Materials and Methods

The field trail was carried out in *mansoon* season of 2021-2022 at department Farm, College of Agriculture Latur, to identified the impact of different constraint on vegetative improvement and yield attributes of soybean and calculate the losses due to constraints in soybean production. The experimental plot's soil had a clayey texture, was somewhat alkaline in reaction (125.3 kg ha^{-1}), had a pH of 7.8, was well-drained, and was favorable for maximum growth. Additionally, it had low available nitrogen (125.3 kg ha^{-1}) and very high available potassium (498.58 kg ha^{-1}). It also had very low available phosphorus (18.2 kg ha^{-1}). The design of the experiment was a Randomized Block Design. There were three replications of the eight treatments. The treatments were T_1: Full package of practices, T_2: T_1- RDF, T_3: T_1- Weeding. T_4: T_1 - Plant Protection, T_5: T_1- (RDF + Weeding), T_6: T_1- (RDF + Plant Protection), T_7: T_1- (Weeding + Plant Protection), T_8: T_1 - (RDF + Weeding + Plant Protection). The gross and net plot size of each experimental unit was 5.40 m x 4.50 m and 4.5 m x 3.9 m, respectively. Sowing was done by dibbling method by using seed rate 65 kg ha^{-1}. The recommended dose of fertilizer for soybean crop was 30: 60: 30 kg NPK ha^{-1}. Prior to seeding, the fertilizers were applied in accordance with the treatments. The seeds were sown on July 9, 2021. The suggested cultural practices were followed. In accordance with the treatments, RDF, weeding, and plant protection measures were implemented. Using the fertilizers urea, DAP, and MOP, the dose of fertilizers (phosphorus, potassium, and nitrogen) was applied in accordance with the treatments. The analysis of variance method was used to examine data collected on a variety of variables (Panse and Sukhatme, 1967) [8].

Results and Discussion

Yield Attributes

Number of pods per plant: Data on mean number of pod per plant of soybean presented in table 1. The mean number of pod per plant was 28.26 and it was significantly influenced by various treatments.

Compared to the other treatments, the full package adaptation (T_1) produced a significantly higher number of pods per plant (38.10). The T_8 treatment yielded the comparatively smallest number of pods per plant (19.00). The full package (T_1) was found to be substantially superior to the other treatments and produced a significantly higher number of pods per plant (38.10). The T_8 treatment yielded the least amount of pods per plant (19.00). These results may result from applying the full recommended dosage of NPK and from fewer infestations of weeds, insects, and diseases on the plants. Gite RV discovered similar outcomes (2016) [4].

Table 1: Mean number of pod $plant^{-1}$, number of seed pod^{-1}, seed yield $plant^{-1}$ and seed index (g) of soybean as influenced by various treatments

Treatments	Number of pods $plant^{-1}$	Number of seed pod^{-1}	Seed yield $plant^{-1}$ (g)	Seed index (g)
T_1: Full Package	38.10	3.00	12.45	10.90
T_2: T_1 – RDF	32.00	2.55	8.64	10.60
T_3: T_1 – Weeding	29.00	2.33	6.62	9.80
T_4: T_1 - Plant protection	31.00	2.40	7.58	10.20
T_5: T_1 - (RDF + Weeding)	26.00	2.25	5.49	9.40
T_6: T_1 - (RDF + Plant protection)	28.00	2.30	6.11	9.50
T_7: T_1 - (Weeding + Plant protection)	23.00	2.00	4.18	9.10
T_8: T_1 - (RDF + Weeding + Plant protection)	19.00	1.70	2.90	9.00
S.Em ±	1.70	0.11	0.31	0.42
CD @ 5%	4.98	NS	0.90	NS
General mean	28.26	2.32	6.75	9.81

Number of seed per pod: Data on the effects of various treatments on the average number of seeds per pod are displayed in Table 1. In soybeans, the average number of seeds per pod was (2.32). In comparison to the other treatments, the application of the entire package of practices resulted in the highest number of seeds per pod (3), and the lowest number of seeds per pod at control (T_8) was RDF, weeding, and plant protection was not applied. In terms of statistics, it was insignificant. Gite R.V. (2016) [4] discovered comparable outcomes.

Seed yield per plant (g): The average seed yield per plant of the soybean crop was affected by various treatments, as shown by the data in Table 1. The total package T_1 recorded a significantly higher seed yield per plant of soybean than the other treatments, while the control T_8 had the lowest seed yield per plant. 6.75 g of seeds were produced on average per plant.

Seed index (g): Data on seed index (g) for the different treatments are shown in Table 1.

In comparison to the other treatments, the soybean crop received the full package (T_1), which resulted in a numerically higher seed index (10.90). The mean seed index was 9.81g. The seed index for each treatment was non-significant, according to statistics.

Table 2: Seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) as influenced by various treatments

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield(kg ha^{-1})	Harvest Index (%)
T_1 : Full Package	2148.00	2963.00	5111.00	42.02
T_2 : T_1 – RDF	1719.00	2460.00	4179.00	41.13
T_3 : T_1 – Weeding	1440.00	2200.00	3640.00	39.56
T_4 : T_1 - Plant Protection	1611.00	2330.00	3941.00	40.87
T_5 : T_1 - (RDF + Weeding)	1182.00	1850.00	3032.00	38.98
T_6 : T_1 - (RDF + Plant protection)	1397.00	2100.00	3497.00	39.94
T_7: T_1 - (Weeding + Plant protection)	860.00	1550.00	2410.00	35.68
T_8: T_1 - (RDF + Weeding + Plant protection)	645.00	1295.00	1940.00	33.24
S.Em±	81.00	123.50	207.86	-
CD @ 5%	242.00	361.31	608.11	-
General Mean	1375.00	2093.00	3469.00	38.92

Seed yield (kg ha^{-1}): The data on seed yield as influenced by different treatments are presented in Table 2. The data on mean seed yield of soybean was 1375 kg ha^{-1}. The seed yield of soybean was varied significantly due to different treatments. Application of full package of practices (T_1) noted considerably maximum seed yield of 2148 kg ha^{-1} which was superior over the rest of the treatments.

The lowest seed yield 645 kg ha^{-1} was observed with the treatment T_8 where RDF, weeding and plant protection was excluded. It might be due to the suppressed growth and development of plants that inclined to lower seed yield, straw and biological yield. These outcomes may be related to the crops struggle with weeds for sunlight, moisture, nutrients and space, which eventually results in poor photosynthetic uptake and lower seed output. Similar results were given by Gite R.V., (2016) [4], Gajbhiye *et al.*, (2011) [3], Bonde and Gawande (2017) [2].

Straw yield (kg ha^{-1}): Information shown in Table 2. It revealed that the average soybean straw yield was 2093 kg ha^{-1}. Different treatments had a significant impact on the amount of straw produced per hectare. The soybean crop that received the full package of practices (T_1) showed the highest straw yield (2963 kg ha^{-1}) and was found to be significantly better than the other treatments. When RDF, weed control, and plant protection were not used, the lowest straw yield 1295kg ha^{-1} was achieved (T_8). Gite R.V. (2016) [4], Gajbhiye *et al.* (2011) [3], Bonde and Gawande (2017) [2], and Bainade *et al.* (2019) [1] all reported findings that were similar.

Biological yield (kg ha^{-1})

Mean data regarding on biological yield as influenced by various treatments are presented in Table 2 and Data shown in Table 2 indicated that the mean biological yield of soybean was 3469 kg ha^{-1}. The biological yield per hectare was considerably affected by different treatments.

The full package of practices T_1, produced the highest biological yield of soybeans (5111 kg ha^{-1}) and was found to be significantly better than the other treatments. The condition where RDF, weed control and plant protection were not applied resulted in the lowest biological yield (1940 kg ha^{-1}) (T_8). Gite RV (2016) [4] found that the full package of practices led to an increase in biological yield.

Harvest index (%): Data on harvest index is shown in Table 4.12 and showed that the mean harvest index of soybean crop was 38.92% and which was influenced due to effect of various treatments. The application of full package of practices (T_1) showed higher harvest index (42.02%), whereas minimum harvest index (33.24%) was recorded with treatment T_8.

Economics of soybean cultivation: Table 3 showed data on gross monetary returns (GMR), net monetary returns (NMR), cost of cultivation, B:C ratio as influenced by different treatments.

Gross monetary returns (Rs ha^{-1})

Table 3 presented data on the gross monetary returns (GMR) as impacted by various treatments. The average soybean yield in terms of gross monetary returns was Rs. 82516 ha^{-1}. The impact of various treatments has a considerable effect on the gross returns. By using the entire resources, the highest gross monetary returns (Rs.128880 ha^{-1}) were significantly recorded by full package (T_1), although treatment T_8 (which did not include RDF, weeding and plant protection) produced the lowest gross financial return (Rs.38700 ha^{-1}). Similar result found by Palve *et al.*, (2011) [7], Gite R.V. (2016) [4], Jadhav and Kashid (2019) [5].

Net monetary returns (Rs. ha^{-1}): Data relating to net monetary returns of various treatments are presented in Table 4.13 and depicted in Fig 4.10(a). The mean of net monetary returns of soybean was Rs. 52607 ha^{-1}. Different treatments had a substantial impact on the net monetary returns of soybean, and the adoption of the whole package (T_1) recorded the highest net monetary returns (Rs. 91215 ha^{-1}) than other treatments. The treatment with the lowest net financial return (Rs. 15650 ha^{-1}) was T_8, which excludes RDF, weed control and plant protection. Similar results were obtained by Palve *et al.*, (2011) [7], Gite R.V., (2016) [4], Jadhav and Kashid (2019) [5], Raj *et al.*, (2020) [9].

Benefit: Cost ratio

Information regarding B: C ratios as impacted by various treatments can be found in Tables 3 and A mean benefit: cost ratio of 2.69 was found.

The full package of practices (T_1) had the highest B: C ratio (3.42), followed by T_2 with a B:C ratio of 3.20 and no RDF. The treatments with the lowest B:C ratios were T_8 (missing RDF, weed control, and plant protection) and T_7 (no weed control and plant protection) (1.67 and 1.88, respectively). Kalal *et al.* (2018) [6], Gite R.V. (2016) [4], Jadhav and Kashid (2019) [5], Raj *et al.* (2020) [9] and others found similar results.

Table 3: Mean gross monetary returns, cost of cultivation, net monetary returns (Rs.ha^{-1}) and B:C ratio as influenced by various treatments

Treatments	Gross monetary returns (Rs.ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Net monetary Returns (Rs.ha^{-1})	B:C Ratio
T_1: Full Package	128880	37665	91215	3.42
T_2: T_1 – RDF	103140	32195	70945	3.20
T_3: T_1 – Weeding	86400	29965	56435	2.88
T_4: T_1 - Plant Protection	96660	33820	62840	2.85
T_5: T_1 - (RDF + Weeding)	70920	25695	45225	2.76
T_6: T_1 - (RDF + Plant Protection)	83820	29550	54270	2.83
T_7: T_1 - (Weeding + Plant Protection)	51600	27320	24280	1.88
T_8: T_1 - (RDF + Weeding+ Plant Protection)	38700	23050	15650	1.67
S.Em±	4835.51	-	2926	-
CD @ 5%	14506.53	-	8781	-
General mean	82516	29907	52607	2.69

Conclusion

The study showed that the application of full package of practices (T_1) to soybean crop recorded significantly highest seed yield (2148 kg ha^{-1}) and straw yield (2963 kg ha^{-1}).

The adaption of full package found to be maximum gross monetary returns (Rs.128880 ha^{-1}), net monetary returns (Rs.91215 ha^{-1}) and B: C ratio of 3.42. Among different production factors weed management found as the most crucial factor followed by plant protection and nutrient management showed seed yield reduction up to 33%, 25% and 20% respectively, as compared to full package (T_1). Where the lowest GMR, NMR and B: C ratio recorded in treatment T_8 where RDF, weed management and plant protection was not applied. So suggested to timely weeding operation undertaken on a priority basis followed by plant protection and RDF to soybean crop.

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