

Effect of tillage and fertilizer doses on growth and growth indices of soybean (*Glycine max* L.) under conservation tillage systems

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ARTICLE INFO

Received : 19 May 2021

Revised : 20 July 2021

Accepted : 14 September 2021

Available online: 9 December 2021

Key Words:

Conventional tillage
Crop residues
Efficiency
Fertilizer
Growth indices
Minimum Tillage

ABSTRACT

A field experiment was conducted during *kharif* season of 2019 at the Research Farm, Department of Agronomy, CSKHPKV, Palampur to study the effect of tillage and fertilizer doses on growth and growth indices of soybean under conservation tillage systems. The experiment consisted of twelve treatment combinations which included three tillage systems minimum tillage, minimum tillage with crop residue and conventional tillage and four fertility levels viz; 25 % recommended dose of fertilizer (RDF) , 50 % (RDF) , 75 % RDF and 100% RDF and which were tested in split plot design with tillage system in main plots and fertility levels in sub plots. The soil texture of experimental site was silty clay loam. Minimum tillage along with crop residues (T₂) recorded significantly taller plants and higher dry matter accumulation followed by conventional tillage. Absolute growth rate, crop growth rate, dry matter efficiency, relative growth rate and unit area efficiency were significantly higher with minimum tillage + crop residue treatment. Application of 100 % followed by 75 % recommended dose of fertilizer resulted in significantly higher growth parameters and growth indices.

Introduction

Soybean (*Glycine max* L.) also known as 'golden bean' is the second most important *Kharif* oilseed crop being grown in various parts of the state. It is cultivated as sole crop as well as an intercrop with maize, ragi etc. In India, area under soybean crop is 11.4 million hectares with production and productivity of 13.5 million tonnes and 1185 kilogram per hectares, respectively (Anonymous 2019). The area under soybean crop in Himachal is 0.55 thousand hectares with an average production of 931 tonnes (Anonymous 2018). The conventional tillage methods are easy to adopt and provide clean cultivation. They have been used to

grow many crops including soybean since a long time but are considered as expensive operations in terms of work and fuel consumption. Conventional tillage leads to high erosion hazards. It completely inverts the soil and buries crop residues, making the land much more exposed to erosive forces of wind and water. Erosion eventually reduces the productivity of land (Mathew et al., 2012). The alternate for all these problems is conservation tillage. Tillage systems such as ridge-till, minimum tillage and no-till leave more crop residues and offer greater erosion control. Fuel and labour requirements are also less with conservation tillage.

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Doi: <https://doi.org/10.36953/ECJ.2021.22322>

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To solve all said problems considerable attention has been diverted towards conservation tillage methods i.e. minimum tillage or reduced tillage or zero tillage. On the other hand, plant residues used as mulching not only cover the soil surface but also help to supply plant nutrients on decomposition by micro-organism.

Besides appropriate selection of tillage practices, the improvement in average yield per hectare can be obtained if soil fertility is maintained through proper dose and application method of fertilizers. Application of fertilizers is widely recognized as a way of improving crop productivity and sustainability. Imbalanced use of chemical fertilizers deteriorates the soil health. It is, therefore, necessary to develop a suitable production system with maximum productivity and minimum environmental pollution.

Material and Methods

A field experiment was conducted during *kharif* season of 2019 to study the effect of tillage and fertilizer doses on growth and growth indices of soybean at the Research Farm, Department of Agronomy, CSK HPKV, Palampur located at 32°6'N latitude, 76°3'E longitude and at an altitude of 1290.8 m above mean sea level.

Each treatment was located randomly in plots by using random number table and replicated thrice. The soil of experimental area was found silty clay loam in nature having pH 4.5. The soil values were found low in nitrogen (218 kg/ha), medium in phosphorus (11.4 kg/ha) and high in potassium (240 kg/ha) during the course of study.

The meteorological data during the crop season revealed that the weekly maximum and minimum temperature ranged from 23.57 to 31.64 °C and 10.14 to 20.39 °C respectively. The mean relative humidity ranged from 51.79 to 91.57 % and total rainfall was 197.80 mm. The total sunshine hours were 94.16 (Anonymous 2021, Crop weather outlook). The experiment was laid out in split plot design with three replications. There were twelve treatment combinations which included three tillage systems minimum tillage, minimum tillage with mustard crop residue (3 t/ha) and conventional tillage and four fertility levels viz; 25 % recommended dose of fertilizer (RDF), 50 % (RDF), 75 % RDF and 100% RDF, which were tested in split plot design with tillage system in main plots

and fertility levels in sub plots. 'Harit Soya' was used as test variety sown at 45cm × 10cm spacing. The size of each plot was 4.5 × 3.0 m². Seeds of soybean were treated with bavistin @ 2.5 g/kg of seed before sowing to protect from seed borne diseases. Recommended dose of fertilizers (20:60:40) (Package of practices, kharif, 2019) in the state was applied @ 25 %, 50 %, 75% and 100 % at the time of sowing. The nutrients were applied through urea, single super phosphate and muriate of potash respectively. Pendimethalin (Stomp 30 EC) was applied @ 4.5 l/ha within 48 hours of sowing for weed control. Plant height and dry matter accumulation were recorded at thirty days interval of each month for evaluating different growth indices. Five randomly selected plants in each plot were tagged for height measurement. Plant height was measured in centimetres from the base of plant to the top. The average height of the five plants were calculated and expressed as plant height. For dry matter accumulation, five plant samples from the sampling row next to border rows were taken from each plot at 30 days interval up to harvest. The plants were cut close to the ground and kept in oven at 70°C for 3 hours after sun drying of samples. Plant samples were weighed down when they attained constant weight and the dry weight was calculated and expressed as g/ plant.

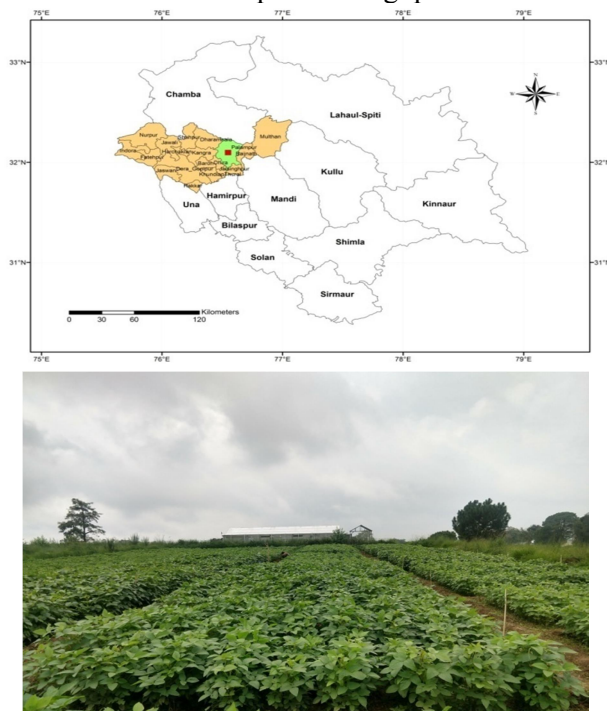


Figure 1: Sampling locations (32°6'N, 76°3' E)

The following formulae were used to determine various growth indices:

Absolute growth rate was determined by using the formula given by Radford (1967).

$$AGR(\text{ cm/day}) = \frac{h_2 - h_1}{t_2 - t_1}$$

Where, h_1 and h_2 were plant height at t_1 and t_2 times, respectively.

Crop growth rate was determined by using the formula given by Watson (1956):

$$CGR(\text{ g/plant/day}) = \frac{w_2 - w_1}{p(t_2 - t_1)}$$

Where, w_1 and w_2 were whole plant dry weight at t_1 and t_2 time, respectively. p is the ground area on which w_1 and w_2 were recorded.

Relative growth rate was determined by using the formula given by Fisher (1921).

$$RGR(\text{ g/g/day}) = \frac{(\log w_2 - \log w_1)}{t_2 - t_1}$$

Where, w_1 and w_2 were dry weight of whole plant at times t_1 and t_2 respectively.

Dry matter efficiency expressed as the percent of dry matter accumulated in the grain from the total dry matter produced over the crop growth period.

$$\text{Dry matter efficiency (\%)} = \frac{\text{GrainYield (kg/ha)}}{\text{BiologicalYield (kg/ha)} \times \text{Duration of crop (days)}} \times 100$$

Unit area efficiency expressed as the quantum of grain yield produced over a unit land area for a specified crop growth period (kg/ha/day).

$$\text{Unit area efficiency (\%)} = \frac{\text{GrainYield (kg/ha)}}{\text{Land area (ha)} \times \text{Duration of crop (days)}} \times 1$$

Results and Discussion

Growth

Plant Height: Different tillage treatments significantly affected the plant height at 30, 60 days after sowing and at harvest. Minimum tillage along with mustard residues (T_2) recorded tallest plants (91.52 cm) of soybean followed by conventional tillage (T_3)(88.54 cm) and minimum tillage(T_1) (86.60 cm) respectively at all the growth stages. Among different fertilizer doses, tallest plants (91.97 cm) were recorded with 100 % NPK (F_4)

followed by 75 (F_3) (89.43 cm) and 50 % NPK (F_2) (87.43 cm). Significantly, shorter plants (86.31 cm) were recorded with 25 % NPK (F_1) fertilizer dose. Enhancement in soybean growth under minimum tillage with residue treatment might be due the reason that the soil water was conserved and used for soybean growth rather than evaporation. Similar results were found by Sikka *et al.* (2018) in soybean. They reported that plant height tended to increase with the application of wheat straw mulch over no mulch treatment. Another reason for enhancement in soybean growth was the result of soil water being used for plant growth and yield rather than the evaporation of soil water.

Dry Matter Accumulation: Significantly higher dry matter accumulation (44.93 g/plant) was recorded in T_2 followed by T_3 (35.91 g/plant) and T_1 (35.71 g/plant) at all the growth stages. Different fertilizer doses significantly affected the dry matter accumulation of soybean at 30, 60, and 90 days after sowing. Similar results were found by Singh *et al.*, 2018 in soybean. Different fertilizer doses significantly affected the dry matter accumulation. Highest dry matter accumulation (43.46 g/plant) was recorded with F_4 followed by F_3 (40.42 g/plant) and F_2 (37.42 g/plant). Significantly, lower accumulation of dry matter (34.09 g/plant) was recorded with 25 % NPK (F_1) fertilizer dose. Higher dry matter accumulation of soybean with minimum tillage and crop residues might be due to availability of moisture for longer period without disturbing the soil, which results in better crop growth and supply of nutrients in adequate amount. Similar results were found by Singh *et al.*, (2018). They reported that mulching enhance the moisture availability of soil. Sufficient moisture in soil, helped plant to extract sufficient nutrients from root zone which enhanced the overall health of plant.

Growth Indices

Absolute Growth Rate: Different tillage treatments significantly affected the absolute growth rate at different stages of crop growth. Among them, T_2 significantly recorded higher absolute growth rate (1.504 cm/day) followed by T_3 (1.492 cm/day) and T_1 (1.458 cm/day) at 30 and 60 days after sowing. Different fertilizer doses significantly affected the absolute growth rate of soybean at 30 and 60 days after sowing. Highest absolute growth rate (1.581 cm/day) was recorded with F_4 followed by F_3 (1.520 cm /day). Retention of crop residues on minimum tillage plots in addition to normal application of chemical fertilizers enhances growth indices of crop

Table 1: Effect of tillage and fertilizer doses on plant height, dry matter accumulation, dry matter efficiency and unit area efficiency of soybean.

Treatment	Plant Height (cm)				Dry matter accumulation (g/plant)				Dry matter efficiency (%/day)		Unit area efficiency (kg/ha/day)
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest			
Tillage Practices											
T1	33.55	77.29	84.01	86.60	0.94	4.38	32.32	35.71		0.237	6.94
T2	34.40	79.53	86.32	91.52	1.21	7.72	42.80	44.93		0.275	9.34
T3	33.93	78.90	85.22	88.54	1.13	5.30	30.89	35.91		0.271	8.86
SEM ±	0.10	0.05	0.73	0.52	0.08	0.92	1.38	2.69		0.002	0.12
LSD (P= 0.05)	0.27	0.15	NS	1.46	NS	2.56	3.83	3.83		0.01	0.34
Fertilizer doses											
F1	32.74	74.07	81.32	86.31	0.86	3.56	29.96	34.09		0.264	8.00
F2	33.51	77.32	83.80	87.83	1.10	4.22	34.20	37.42		0.261	8.17
F3	34.44	80.06	86.66	89.43	1.18	7.10	38.09	40.42		0.259	8.55
F4	35.14	82.59	88.94	91.97	1.22	8.32	39.10	43.46		0.259	8.81
SEM±	0.15	0.07	0.77	0.35	0.12	0.66	1.63	4.07		0.003	0.16
LSD (P = 0.05)	0.31	0.15	1.63	0.74	0.24	1.39	3.43	3.43		NS	0.33

*T1= Minimum Tillage, T2= Minimum Tillage + Crop Residue, T3 = Conventional Tillage

*F1= 25% NPK, F2= 50% NPK, F3 = 75 % NPK, F4 = 100 % NPK

*DAS = Days after sowing

Table 2: Effect of tillage and fertilizer doses on growth indices of soybean.

Treatment	Absolute Growth Rate (cm/day)				Crop Growth Rate (g/plant/day)				Relative Growth Rate (g/g/day)			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Tillage Practices												
T1	1.118	1.458	0.225	0.086	0.031	0.115	0.931	0.113	-0.0015	0.021	0.029	0.0013
T2	1.147	1.504	0.227	0.173	0.040	0.217	1.169	0.071	0.0023	0.025	0.025	0.0007
T3	1.131	1.492	0.218	0.111	0.038	0.139	0.853	0.167	0.0014	0.022	0.026	0.0020
SEM ±	0.0033	0.0044	0.0244	0.0292	0.0026	0.0328	0.0692	0.1097	0.0013	0.003	0.003	0.0019
LSD(P= 0.05)	0.01	0.01	NS	NS	NS	NS	0.19	NS	NS	NS	NS	NS
Fertilizer doses												
F1	1.091	1.377	0.243	0.166	0.029	0.090	0.880	0.138	-0.0032	0.0209	0.0293	0.0022
F2	1.117	1.460	0.217	0.134	0.037	0.104	0.999	0.107	0.0013	0.0177	0.0296	0.0015
F3	1.148	1.520	0.221	0.093	0.039	0.197	1.033	0.078	0.0021	0.0258	0.0253	0.0005
F4	1.171	1.581	0.212	0.101	0.041	0.236	1.026	0.145	0.0028	0.0272	0.0232	0.0012
SEM±	0.0049	0.0057	0.0262	0.0296	0.0039	0.0219	0.0576	0.1664	0.0018	0.0026	0.0018	0.0019
LSD (P= 0.05)	0.0103	0.0119	NS	NS	0.0081	0.0461	NS	NS	0.0038	0.0055	0.0038	NS

as well as soil fertility also. Findings are similar with Karunakaran and Behera (2015). They reported that agricultural residues are retained on or near the soil surface reduce soil erosion, runoff of surface water, summer time soil temperatures and enhance water retention. All these factors, help to increase plant height of plant which in turns enhances the absolute growth rate Lower absolute growth rate (1.377 cm/day) was recorded with 25 % (F₁) dose of fertilizers.

Crop Growth Rate: Crop growth rate was significantly affected by different tillage treatments at 90 days after sowing only. Highest crop growth rate was recorded with T₂ (1.169g/plant/day). This might be due to the better nutritional environment for the crop because of decomposition of plant residues in mulch plots. Among fertilizer doses, 100 % recommended dose of fertilizer recorded significantly higher CGR (0.236 g/plant/day) at 30 and 60 days after sowing followed by 75 % (0.197 g/plant/day) and 50 % doses (0.104 g/plant/day). Balanced dose of nutrients help in better growth and development of plants. Improved root and shoot growth ultimately increased the dry matter, resulting in higher value of crop growth rate.

Relative Growth Rate: Different tillage treatments did not affect the relative growth rate significantly. Among different fertilizer doses, 100% recommended dose of fertilizer significantly recorded higher relative growth rate (0.0272 g/g/day) followed by 75 % (0.0258 g/g/day) at 30 and 60 days after sowing. Optimum dose of fertilizer helps in normal growth and development of plant. After 90 days, relative growth rate slightly decreased. Findings are same with Manhas *et al.*

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(2019). They reported that 100 % recommended dose of fertilizer, helps the plant to complete its lifecycle without any deficiency and provide normal growth and development to the plant.

Dry matter efficiency and Unit area efficiency: Different tillage practices significantly affected the dry matter efficiency and unit area efficiency of soybean. Highest dry matter efficiency of soybean was reported with T₂ (0.275 %/day) followed by T₃ (0.271 %/day) and T₁ (0.237 % /day) respectively. Unit area efficiency was also higher with T₂ (9.34 kg/ha/day) followed by T₃ (8.86kg/ha/day) and T₁ (6.94 kg/ha/day). Different fertilizer doses did not affect the dry matter efficiency but significantly affected the unit area efficiency. F₄ treatment recorded significantly higher unit area efficiency (8.81 kg/ha/day) followed by F₃ (8.55 kg/ha/day) and F₂ (8.17 kg/ha/day). Significantly lower unit area efficiency (8.00kg/ha/day) was reported in F₁ treatment. This might be due to balanced application of nutrients. Similar results were found by Swati and Singh (2018) in soybean.

Conclusion

From the above study it may be concluded that the research on conservation agriculture is a need of the hour. Farmer generally prefers clean cultivation and thus goes for conventional agriculture without caring about its ill effects. Conservation agriculture is a sustainable way alternative for maintaining soil resource base. In the present study, the results showed that minimum tillage + crop residue@ 3t ha⁻¹ along with 100 % recommended dose of fertilizer resulted in higher growth and growth indices.

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