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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 5353-5357

www.thepharmajournal.com
Received: 21-09-2022
Accepted: 24-10-2022

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Effect of tillage and crop residue management on growth and yield of soybean under conservation agriculture

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Abstract
The field experiment was conducted during *Kharif* 2019 at Experiment farm of Agronomy Department, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, to study the effect of tillage and crop residue management on growth and yield of soybean under conservation agriculture. The experiment was laid out in a split plot design with the combinations of three tillage practices in main plots and five crop residue management practices in sub plots with three replications on fixed site. Results indicated that the reduced tillage and crop residue application @ 5 t/ha + consortia @ 5 kg/ha was found significantly superior over the rest of treatments in respect of growth, yield and yield attributes.

Keywords: Conservation agriculture, tillage practices, crop residue management, soybean, growth, yield and yield components

Introduction
Soybean is basically a pulse crop but is gaining importance as an oilseed crop too and is the world's first ranking crop as a source of vegetable oil and in India too. Soybean is of paramount important in human and animal nutrition, because it is a major source of edible vegetable oil and high protein feed as well as food in the world. It is an excellent health food and contains about 40 per cent quality protein, 23 per cent carbohydrates and 2 per cent cholesterol free oil. Soybean protein is rich in valuable amino acid viz., lysine (5%) which is deficient in most of the cereals. Soybean is the cheapest source of proteins and it is called "Poor man's meat". (Dixit *et al.*, 2011) [3].

Among the edible oilseeds, soybean [*Glycine max* (L.) Merrill.] is the leading oilseed crop in the world with an area of 145 million ha. In India too, it is the most important oilseed crop with an area of 12 million ha and a production of 12.23 MT with an average productivity of 1017 kg ha (www.sopa.org). Some of the major limiting factors for low productivity of soybean are limiting moisture conditions as this is mostly grown under rainfed conditions during *Kharif.*

Today, in the country, the area under conservation tillage has increased to more than 2 million ha. However, there has been little corresponding change in the application rates and management of nutrients, especially phosphorus. Conservation tillage or zero tillage may have positive, negative or no effect on grain yield of crops depending on soil, crop, cropping system and climatic conditions. Therefore, site-specific suitability of various crops and cropping systems for conservation agriculture needs extensive investigations. (Pradhan *et al.*, 2011) [6].

The concept of CA has evolved from the zero tillage (ZT) technique. In ZT, seed is put in the soil without any soil disturbance through any kind of tillage activity or only with minimal soil disturbance, with time soil life takes over the functions of traditional soil tillage like loosening the soil and mixing the soil components. In addition, increased soil biological activity creates a stable soil structure through accumulation of organic matter. As against this, mechanical tillage disturbs this process.

Crop residues are those parts of the plants left in the field after the harvestable parts of the crops (grain, tubers, roots, etc.) have been removed. Crop residues at times have been regarded as waste materials that require disposal, but it has become increasingly realized that they are important natural resources and not wastes. The recycling of crop residues has the advantage of converting the surplus farm waste into useful products for meeting nutrient requirements of crops. It also maintains the soil physical and chemical condition and improves the overall ecological balance of the crop production system. (CTIC, 2004) [2].

Conservation of various resources is major challenge under rainfed conditions. Therefore, Tillage and Crop Residue Management as a component of conservation agriculture for major crops like soybean in Marathwada is essential where predominant soils are vertisols. Keeping in view all the above point, for efficient use of costly inputs, beside reduction in production cost, for instance residual effect of manures and fertilizers applied and nitrogen fixed by legumes can considerably bring down the production cost. The field experiment was executed to investigate the interventions of tillage and crop residue management on growth and yield of soybean (*Glycine max* (L.)Merrill) under conservation agriculture.

Material and Method

Experimental site and soil

An experiment was laid out at the farm of the Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS) during *Kharif* seasons of 2019. The soil of experimental field was medium deep black, clay in texture, well drained, low in available nitrogen (179.00 kg ha^{-1}), medium in available phosphorus (12.50 kg ha^{-1}), high in potash (478 kg ha^{-1}), organic carbon (0.58%) and slightly alkaline in reaction (pH 7.90). The topography of the experiment field was fairly uniform and leveled. The total rainfall during the study period was 949.6 mm.

Layout and experiment design

The field layout was done in Split plot design with three replications in a fixed lay out. The treatments were consisting of three tillage methods as main plot treatments and five crop residue management practices as sub plot treatments. The main plot treatments consisted of 3 tillage practices, viz zero tillage (T_1), reduced tillage (T_2) and conventional tillage (T_3) ,while the subplot treatments were five crop residue management practices, viz. crop residue @ 2.5 t/ha (R_1), crop residue @ 5t/ha (R_2), crop residue @ 2.5 t/ha + consortia @ 5 kg/ha (R_3), crop residue @ 5t/ha + consortia @ 5 kg/ha (R_4) and without crop residue i.e. control (R_5).

Field management practices

Soybean variety (MAUS-162) was sown on 5th July, 2019 in various tillage practices with recommended seed rate at a row spacing of 45 cm. Seeds were inoculated with *Rhizobium* culture (*Bradyrhizobium japonicum*) and PSB. The N, P and K were given in the form of urea, single super phosphate and muriate of potash at the time of sowing. In zero tillage the crop was sown without any tillage operation with zero-till-seed-drill without disturbance of soil, by just opening a narrow furrow, putting the seeds into furrow and covering the seeds in one operation. In reduced tillage sowing operation was done with tractor drawn BBF planter. The bed making (180 cm), furrow opening (15 cm) and planting (placement of seed) at 45×5 cm was done in one operation at a time with BBF planter. While in conventional tillage, the plots were ploughed 1 time followed by 2 harrowing, intercultural and sowing was done with seed drill. The crop residue management treatments were applied to the soybean crop at 25 DAS and immediately consortia (a microbial decomposer) spraying was done in treatments crop residue @ 2.5 t/ha + consortia @ 5 kg/ha (R_3) and crop residue @ 5 t/ha + consortia @ 5 kg/ha (R_4). Other crop management practices were performed as per recommended package of practices.

Data collection and analysis

The observations on growth, yield and yield attributes were taken on five randomly selected plants from each treatment. After harvest and threshing of crop, seed yield was recorded in net plot wise and converted to grain yield per hectare basis. Data were analyzed by ANOVA at critical difference (CD) p=0.05 to determine the significance among the treatment means.

Results and Discussion

The results as well as discussions of the various tillage and crop residue management practices have been presented under following heads:

Effect of tillage

Growth

Growth characters like mean plant height(cm), number of functional leaves, mean number of branches, leaf area (dm^2) and dry matter accumulation (g) per plant of soybean showed a significant variation for different tillage practices (Table 1). Treatment reduced tillage (T_2) produced more plant height than conventional tillage (T_3) and zero tillage (T_1). This might be due to favorable seed bed, aeration, more conservation of runoff water in reduced tillage consisting of broad bed furrow and initial vigorous growth resulted in more height of the crop. These results are conformation with the results of Jadhav *et al*., (2011) [4]. The mean number of functional leaves over plant directly indicates the behavioral adaption due to changes in the frequency of tillage. Treatment reduced tillage (T_2) proved superior over all the treatments in producing more functional leaves $plant^{-1}$. This might be due to good availability of moisture. It was observed that treatment reduced tillage (T_2) had maximum leaf area $plant^{-1}$ (dm^2) than conventional tillage (T_3) and zero tillage (T_1). This might be due to overall favourable growth and more number of functional leaves produced in treatment reduced tillage (T_2) which in turn resulted in more leaf area $plant^{-1}$. Number of branches $plant^{-1}$ differed with the different treatments. Tillage practice reduced tillage (T_2) recorded the maximum number of branches $plant^{-1}$ at all the stages of crop growth but it was found statistically on par with treatment conventional tillage (T_3). Treatment zero tillage (T_1) recorded the lowest number of branches $plant^{-1}$. Similar results were reported by Banjara *et al*., (2017) [1]. Tillage practice reduced tillage (T_2) recorded more dry matter accumulation than conventional tillage (T_3) and zero tillage (T_1) in soybean. This might be due to increased in height, branches, leaves and developed pods due to which luxurious growth and higher growth attributes recorded in reduced tillage than rest of the tillage practices and thus overall growth reflected in higher dry matter in reduced tillage practice. Similar results were found by Banjara *et al*., (2017) [1].

Yield attributing characters and yield

Yield attributing characters like number of pods per plant, test weight (g) grain yield, straw yield, and biological yield kg per hectare and harvest index of soybean showed a significant variation for different tillage practices (Table 2). Results revealed that, the practice of reduced tillage (T_2) recorded the maximum number of pods $plant^{-1}$ over the treatment zero tillage (T_1). But it was found at par with conventional tillage

(T_3). Increase in number of pods plant^{-1} due to proper growth of crop, which might have resulted in greater translocation of food material to the reproductive part, which also reflected towards superiority in yield attributing characters. The increased number of branches and more reproductive growth and conversion of flowers in pods with the support of more conserved soil moisture at peak period of pod initiation might have resulted in increased number of pods plant^{-1}. This might be due to as moisture was available during dry spell and also safe removal of excess rainwater which favoured overall growth and development in reduced tillage consisting of broad bed furrow. The 100 grain weight (g) was not influenced significantly by different tillage practices, but numerically reduced tillage (T_2) recorded higher number of 100 grain weight (g) (10.81 g) followed by conventional tillage (T_3). Reduced tillage (T_2) method of planting consisting of BBF planter had also profound effect on seed, straw and biological yields (kg ha^{-1}) as presented in Table 2 and it was found at par with conventional tillage (T_3). The increase in yield kg ha^{-1} was attributed due to increased growth parameters and yield attributes of soybean. This might be due to more favoured overall growth due to favorable seed bed resulting from decreased bulk density, increased pore space, better aeration, increased infiltration rate, with scope for more space, light interception, benefit of more conserved moisture during dry spell period and its support at critical growth stages like flowering, pod initiation and development. This ultimately resulted in higher values of yield attributing characters and which in turn resulted in higher yields of soybean crop. Similarly highest harvest index 40.64 was observed in reduced tillage (T_2) followed by conventional tillage (T_3).

Table 1: Effect of tillage and crop residue management practices on growth parameters of soybean

Treatments	Plant height (cm)	Number of functional leaves plant^{-1}	Number of branches plant^{-1}	Leaf area (dm^2 plant^{-1})	Dry matter (g) plant^{-1}
Tillage practices (T)					
T_1-Zero tillage	58.16	17.51	5.24	7.92	14.41
T_2-Reduced tillage	64.07	19.12	6.61	8.32	17.47
T_3-Conventional tillage	62.22	17.59	6.09	8.14	15.85
S.E. ±	0.99	0.33	0.16	0.07	0.48
C.D. (0.05)	3.88	1.27	0.61	0.29	1.87
Residue management (R)					
R_1- crop residue @ 2.5 t/ha	60.63	17.72	5.79	7.87	15.37
R_2- crop residue @ 5 t/ha	63.74	18.79	6.43	8.58	17.05
R_3- crop residue @ 2.5 t/ha + consortia @ 5 kg/ha	62.11	17.81	5.87	7.97	15.65
R_4- crop residue @ 5 t/ha + consortia @ 5 kg/ha	65.49	19.14	6.67	8.89	17.90
R_5- without crop residue (control)	55.45	16.90	5.13	7.32	13.58
S.E. ±	1.17	0.42	0.16	0.21	0.59
C.D. (0.05)	3.40	1.23	0.46	0.62	1.72
Interaction (T × R)					
S.E. ±	2.02	0.73	0.28	0.37	1.02
C.D. (0.05)	NS	NS	NS	NS	NS
G.M	61.48	18.07	5.98	8.13	15.91

Effect of crop residue management practices

Growth

Results revealed that, growth parameters like mean plant height (cm), number of functional leaves, mean number of branches, leaf area (dm^2) and dry matter accumulation (g) per plant of soybean showed a significant variation for different crop residue management practices (Table 1). Plant height and its rate of increase were found to be significant amongst different treatments. Application of crop residue @ 5 t/ha + consortia @ 5 kg ha^{-1} (R_4) recorded maximum plant height compared with rest of the treatments. But it was on par with treatments crop residue @ 5 t/ha (R_2) and lowest value were recorded in control (R_5). The increase in plant height may be due to better absorption and conservation of more moisture by crop residue application which reflected in more plant height. These results are in line with Ravi *et al.*, (2019) [7], Sikka *et al.*, (2017) [9] and Ronanki *et al.*, (2018) [8]. Similarly number of functional leaves plant^{-1} and leaf area plant^{-1} (dm^2) increased with advancement in the age of the crop. Treatment crop residue @ 5 t /ha + consortia @ 5 kg ha^{-1} (R_4) proved to be superior in retaining more number of leaves plant^{-1} and leaf area (dm^2) plant^{-1} than other treatments. But it was on par with treatment crop residue @ 5 t/ha (R2) and lowest was recorded in control (R_5). This might be due to adequate moisture availability during vegetative growth period. Moreover, due to loose and porous seed bed, more nutrient uptake might have boosted the number of leaves and leaf area. Mean number of branches were influenced significantly by various treatments under study and treatment crop residue @ 5 t /ha + consortia @ 5 kg ha^{-1} (R_4) recorded maximum number of branches than rest of crop residue management practices. But it was at par with treatment crop residue @ 5 t/ha (R2) followed by crop residue @ 2.5 t/ha + consortia @ 5 kg ha^{-1}(R_3), crop residue @ 2.5 t/ha (R_1), and lowest was noted with control (R_5). These results are in conformity with Ravi *et al.*, (2019) [7]. Also in case of dry matter accumulation treatment crop residue @ 5 t /ha + consortia @ 5 kg ha^{-1} (R_4) recorded highest dry matter production plant^{-1} than the rest of treatments but found on par with treatment crop residue @ 5 t/ha (R_2). This may be due to addition of adequate quantity of crop residue along with microbial consortia. The microbial activity may have released the nutrient from crop residues, thus making them easily absorbed by the plant roots. Application of crop residue conserves higher soil moisture and improves soil physical condition and also improved microenvironment of soil, thus created conductive environment for plant growth development. Similar results were reported by Ronanki *et al*., (2018) [8].

Yield attributing characters and yield

Yield attributing characters like number of pods per plant, test weight (g) grain yield, straw yield, and biological yield kg per hectare and harvest index of soybean showed a significant variation for different crop residue management practices (Table 2). Application of treatment crop residue @ 5 t/ha + consortia @ 5 kg/ha (R_4) to soybean crop recorded higher mean number of pods plant^{-1} than rest of crop residue management treatments but it was at par with the treatment crop residue @ 5 t/ha (R_2) and followed by crop residue @ 2.5 t/ha + consortia @ 5 kg ha^{-1} (R_3), crop residue @ 2.5 t/ha (R_1) and treatment control (R_5) recorded least. This improvement in pod growth of soybean due to higher soil moisture conservation and improved soil physical conditions. Similar results were found by Patil *et al.*, (2010) [5], Ravi *et al.*, (2019) [7] and Sikka *et al.*, (2017) [9]. In case of test weight differences were not significant due to crop residue management practices but numerically treatment crop residue @ 5 t/ha + consortia 5 kg/ha (R_4) recorded significantly higher number 100 grain weight (g) (10.79 g) and found higher over the other crop residue management practices. Also treatment with application of crop residue @ 5 t /ha + consortia @ 5 kg ha^{-1} (R_4) produced more grain, straw and biological yields but it was found at par with crop residue @ 5 t/ha (R_2) followed by crop residue @ 2.5 t/ha + consortia @ 5 kg/ha (R_3), crop residue @ 2.5 t /ha (R_1), and lowest recorded in control (R_5). This increase in yields might be due to improvement in yield attributes with application of crop residue @ 5 t/ha + consortia @ 5 kg/ha in addition to its multiple roles in favored overall growth and yield attributing characters due to favorable seed bed, better aeration, scope for more space, light interception, higher microbial activity benefit of more conserved moisture in crop residues treatments. This ultimately resulted in higher values of yield attributing characters and which in turn resulted in higher yields of soybean crop. Similar results were reported by Patil *et al*., (2010) [5], Ravi *et al.*, (2019) [7] and Sikka *et al.*, (2017) [9] they observed that, treatment of mulching significantly increased grain yield of soybean which was 18.12% more over no mulch. Similarly highest harvest index 40.52 was observed in treatment crop residue @ 5 t/ha + consortia 5 kg/ha (R_4) followed by crop residue @ 5 t/ha (R_2) and treatment control (R_5) recorded lowest harvest index.

Table 2: Effect of tillage and crop residue management practices on yield attributing characters and yield of soybean

Treatments	Number of pods plant^{-1}	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
Tillage (T)						
T_1-zero tillage	29.21	9.59	1475.60	2279.21	3754.82	39.29
T_2-reduced tillage	33.84	10.81	2037.52	2974.87	5012.39	40.64
T_3-conventional tillage	32.16	10.28	1876.98	2806.30	4683.29	40.07
S.E.±	0.66	0.37	52.89	85.22	133.13	-
C.D.(0.05)	2.63	NS	207.6464	334.5788	522.6481	-
Crop residue management (R)						
R_1-crop residue @ 2.5 t/ha	29.75	9.90	1718.85	2596.18	4315.03	39.83
R_2-crop residue @ 5 t/ha	35.56	10.63	1959.67	2912.85	4872.52	40.21
R_3-crop residue @ 2.5 t/ha + consortia 5 kg /ha	30.96	10.40	1729.17	2601.81	4330.98	39.92
R_4-crop residue @ 5 t/ha + consortia 5 kg /ha	36.13	10.79	2072.67	3042.16	5114.82	40.52
R_5-Control	26.28	9.43	1503.14	2280.98	3784.12	39.72
S.E.±	1.17	0.48	67.86	106.08	136.61	-
C.D.(0.05)	3.45	NS	198.0811	309.6288	398.7478	-
Interaction (T×R)						
S.E.±	2.02	0.83	117.54	183.73	236.61	-
C.D.(0.05)	NS	NS	NS	NS	NS	-
G.M.	31.74	10.23	1796.70	2686.80	4483.50	40.02

Conclusions

This experiment illustrated that soybean growth parameters, yield and yield attributes were significantly influenced by various tillage and crop residue management practices. Soybean grown under reduced tillage (T_2) produced significantly higher plant height (cm), number of functional leaves plant^{-1}, mean number of branches plant^{-1}, leaf area (dm^2 plant^{-1}), dry matter accumulation (g plant^{-1}), and number of pod plant^{-1}, grain yield, straw yield and biological yield kg ha^{-1}. Among various crop residue management practices, treatment with application crop residue @ 5t/ha + consortia @ 5kg/ha had recorded higher plant height (cm), number of functional leaves plant^{-1}, mean number of branches plant^{-1}, leaf area (dm^2 plant^{-1}), dry matter accumulation (g plant^{-1}), and number of pod plant^{-1}, yield and yield attributes than rest of treatments. On the basis of single year experiment results, it can be concluded that, adoption of reduce tillage with crop residue @ 5t/ha + consortia @ 5kg/ha has significant positive effect on yield, yield attributing characters and economics of soybean crop as compared to rest of the treatments.

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