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EFFECT OF TILLAGE ON GROWTH, YIELD AND YIELD COMPONENTS IN SOYBEAN

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ABSTRACT

A field investigation was carried out in the farm of Integrated Farming System Research Project, Dr. P.D.K.V., Akola during the *kharif* season of 2016-2017. The experiment was laid out in randomized block design with six treatments and four replications.The tillage treatments constituted of T_1 (No-tillage - sowing without cultivation and weed control by chemical), T_2(Minimum tillage - 1 harrowing + 1hoeing at 15 DAS), T_3(conventional tillage --- 2 harrowing + 2 hoeing at 15 and 30 DAS), T_4(broad bed and furrow sowing - 1 harrowing + 2 hoeing at 15 and 30 DAS),T_5 (minimum tillage + opening of furrow after every 3 rows) and T_6(minimum tillage + opening of furrow after every 6 rows). Experimental results revealed that growth characters *viz.,* final plant stand, plant height(cm), number of branches plant^{-1}, number of leaves plant^{-1}, number of root nodules plant^{-1}, leaf area plant^{-1}, leaf area index and dry matter production plant^{-1} were significantly higher with treatment broad bed and furrow (T_4) sowing - 1 harrowing + 2 hoeing at 15 and 30 DAS. This treatment was followed by conventional tillage (T_3) --- 2 harrowing + 2 hoeing at 15 and 30 DAS, which is statistically similar to minimum tillage + opening of furrow after every 3 rows (T_5). Minimum growth was recorded in no-tillage (T_1) - sowing without cultivation and weed control by chemical. The number of root nodules plant^{-1} was significantly increased with treatment of broad bed and furrow (T_4). The values of yield attributes, seed yield and straw yield were significantly higher with treatment broad bed and furrow (T_4) as compared to other treatments. Broad bed and furrow (T_4), conventional tillage (T_3), minimum tillage + opening of furrow after every 3 rows (T_5) tillage practices recorded 40.91%, 35.38% and 32.69% higher seeds yield compared to no-tillage (T_1). From this study it is inferred that treatment broad bed and furrow (T_4) was the most suitable method of tillage by recording significantly highest soybean plant height, number of branches plant^{-1}, number of functional leaves plant^{-1}, leaf area plant^{-1}, leaf area index and number of root nodules plant^{-1}. Significantly highest soybean seed yield, stover yield and biological yield were also recorded with treatment broad bed and furrow (T_4) which proved as the most suitable method for cultivating the soybean crop. Maximum B : C ratio was found with treatment of broad bed and furrow (T_4) and proved as the most economic and remunerative tillage practices.

(Key word: Soybean, tillage, productivity)

INTRODUCTION

Soybean (*Glycine max.* L.) is one of the important oilseed as well as a leguminous crop. Soybean is the most popular oilseed after groundnut and soybean oil is the largest produced oil in the country. Soybean as a miracle "Golden Bean" of the 21st century mainly due to its high protein (40%) and oil content (20%) and is now making headway in Indian Agriculture. In India, it is mainly grown as oilseed crop. The area covered under soybean in India was 109.10 lakh ha which produced 103.37lakh MT with the productivity of 951 kg ha^{-1} whereas, in Maharashtra the area under cultivation was 35.81 lakh ha which produced 39.45 lakh MT with the productivity of 1102 kg ha^{-1}. In Vidarbha, area under soybean was 19.32 lakh ha which produced 14.76 lakh MT with the productivity of 776 kg ha^{-1} (SOPA, 2016).

Tillage is the mechanical manipulation of the soil and incorporation of plant residues to prepare an appropriate seedbed for crop planting, which have several advantages such as loosening soil, regulating the circulation of water and air within the soil, increasing the release of nutrient elements from the soil for crop growth, and controlling weeds by burying weed seeds and emerged seedlings (Reicosky and Allmaras, 2003).

Tillage options available to farmers have proliferated in recent years due to the availability of reliable chemical weed control, new tillage and planting equipment designs, desire to reduce production inputs and costs, and an increased emphasis on soil and water conservation. More

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than 30% of the soil surface covered with crop residue is one of the most effective and least costly methods of reducing soil erosion. Soil tillage, as a necessary practice in crop production, can affect the soil physical properties that are important for plant growth. Improvements of root penetration, water infiltration and soil moisture storage, weed control, and supply of nutrients from rapid decomposition of organic matter are considered the most beneficial contributions of tillage to crop production.

To find out suitable method for tillage practices in soybean growth and yield and to study the economics of tillage practices, the present study was undertaken.

MATERIALS AND METHODS

The experiment was laid out in randomized block design with six treatments; replicated four times having net plot size of 4.6 m X 2.7 m. The tillage treatments were-

T_1 -	NT	:	No tillage - Sowing without cultivation and weed control by chemical
T_2 -	MT	:	Minimum tillage - 1 Harrowing + 1Hoeing at 15 DAS
T_3 -	CvT	:	Conventional tillage --- 2 Harrowing + 2 Hoeing at 15 and 30 DAS
T_4 -	BBF	:	Broad bed and furrow Sowing - 1 Harrowing + 2 Hoeing at 15 and 30 DAS
T_5 -	MT+OFAE3R	:	Minimum tillage + Opening of furrow after every 3 rows
T_6 -	MT+OFAE6R	:	Minimum tillage + Opening of furrow after every 6 rows

Soybean crop (Var. JS-335) was sown on 28th June, 2016. Prior to sowing, the six tillage treatments were applied to the selected site of field experimentation. Fertilizer dose to the crop was made as per recommended dose of fertilizer. Crop was harvested on 10th October, 2016. Periodically observations were recorded on growth and yield contributing character of soybean to evaluate treatment effect. The row to row distance of 45 cm and plant to plant distance of 5 cm, as per treatments was maintained by gap filling and thinning so as to get expected plant stand. The observations on plant stand (%), plant height (cm), number of branches plant^{-1}, dry matter accumulation plant^{-1} (g), number of pods plant^{-1}, number of grains pod^{-1}, weight of grains plant^{-1} (g), weight of pods plant^{-1} (g), seed yield (q ha^{-1}), straw yield (q ha^{-1}), grain to straw ratio, test weight (g), harvest Index (%) were recorded at harvest. Observations on number of functional leaves plant^{-1}, number. of root nodules plant^{-1}, leaf area plant^{-1}(dm^2) and leaf area index plant^{-1} were also recorded at 80 DAS. B:C ratio was also calculated. The statistical analysis of data was carried out through the procedure appropriate to the design of the experiment that is Randomized Block Design. The significance of difference was tested by the 'F' test (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

The data pertaining to effect of tillage on traits related to growth, yield and yield components in soybean are presented in table 1.

Growth related traits

Final plant stand were measured just to reduce experimental error and to study the effect of different tillage practices. The data related to final plant stand of soybean did not differ significantly in response to applied tillage treatments. The results indicated that the treatment differences obtained under various growth and yield of soybean parameters are only due to the treatments imposed and not due to the variation in plant population.

Plant height is a character which can be modified very easily with the management practices. The values depict that there was significant variation in the plant height due to changes in magnitude of tillage. Treatment broad bed and furrow (T_4) proved to be the most effective tillage practices with significantly highest values of plant height (46.72 cm). Similarly the other tillage treatments viz., conventional tillage (T_3) and minimum tillage + opening of furrow after every 3 row (T_5) both being at par every other, recorded second best values of plant height. However, treatment of no-tillage (T_1) did not performed well by recording significantly lowest values of plant height (35.67cm at harvest). Remaining tillage treatments were found moderate in terms of plant height.

Under the treatment broad bed and furrow (T_4), initially moisture status was high in root zone as compared to other treatments; this is probably due to the largest amount water stored in the beds of the furrow. Adequate availability of moisture in the root zone depth of soil might have improved the nutrient availability, thereby increasing cell division and cell expansion, which in turn increased the plant height. In case of treatment no-tillage (T_1), there were many hindrances in the proper growth and development of plant root. Due to inadequate availability of moisture in the root zone depth with treatment no-tillage (T_1), stunted root growth might have reflected in inferior plant growth during later stages of crop development. Fassil and Eyebru (2008) also reported the highest plant height of wheat crop at different growth stages. The highest plant height was recorded on broad bed and furrow tillage system. They further reported that this treatment also possess high soil moisture content, indicating more conservation of water.

Overall, plant growth is reflected in the production of branches over a plant. Therefore, the counting of branches provides an adequate basis for measuring the treatment differences owing to various tillage practices. Significantly highest number of branches plant^{-1} was found with treatment broad bed and furrow (T_4) with the value of 7.06, however, significantly lowest values of branches (5.59) were recorded with treatment no-tillage (T_1). Remaining tillage treatments recorded medium values in terms of number of branches plant^{-1}. The maximum production of branches with treatment broad bed and furrow (T_4) may be due to better root growth and thereby highest uptake of moisture and nutrient from the soil profile. Adequate availability of soil moisture throughout the vegetative growth period; might have increased the production of branches with treatment broad bed and furrow (T_4). In case of no-tillage (T_1), at the time of both vegetative and flowering stage, plant suffered from moderate dry spell that was occurred during experimental period; which may reduce the number of branches plant^{-1} due to inadequate availability of moisture and uptake of nutrient. The detrimental effect of no-tillage (T_1) might have reflected in formation of compact sub surface layer, reducing the in-soak of rain water and restricting the root growth.

The production of functional leaves has a direct relationship with the availability of major nutrient in balance amount. Therefore, it provides a tool for measuring treatment differences when various tillage practices are imposed. Highest number of functional leaves plant^{-1} (25.55) were recorded with treatment broad bed and furrow (T_4), while significantly lowest values (20.75) were recorded with treatment no-tillage (T_1). Rest of tillage treatments were found with moderate values in terms of number of functional leaves plant^{-1}. The adequate moisture availability during vegetative growth period significantly increased the number of leaves plant^{-1} with treatment broad bed and furrow (T_4), throughout the period of the experiment. Also optimum moisture availability at flowering period resulted in significantly higher number of leaves plant^{-1}. It may have increased the translocation of photosynthates and uptake of nutrients. The number of leaves plant^{-1} produced was significantly increased by availability of soil moisture especially during the vegetative stage. The no-tillage (T_1) did not favor the probable proliferation of plant roots affecting lesser moisture and nutrient translocation through the shallow rooting pattern. Hence, this might result to lower down the photosynthetic activity in the leaves. The overall effect in the treatment no-tillage (T_1) is a decrease in the rate of new leaf initiation and increase in leaf shedding thereby resultant reduction in number of green leaves plant^{-1}.

In general, the number of root nodules plant^{-1} indicates the density of potential infection point capable of synthesizing available nitrogen through the process of biological nitrogen fixation. Significantly highest number of root nodules plant^{-1} (56.50) was found with treatment broad bed and furrow (T_4). While, significantly lowest values (29.75) were recorded with treatment no-tillage (T_1). Remaining tillage treatments were found moderate in terms of number of root nodules plant^{-1}. The higher number of root nodules plant^{-1} with treatment broad bed and furrow (T_4) might have been due to favorable soil moisture condition, soil aeration and better crop growth at initial stage. The initial delay in nodule growth with treatment no-tillage (T_1) may be due to the time-lag in photoassimilate transported from the shoot to nodules.

Significantly highest leaf area plant^{-1} was found with treatment broad bed and furrow (T_4) with the value of 24.30 dm^2. While, significantly lowest values 9.41 dm^2 were recorded with treatment no-tillage (T_1) Remaining tillage treatments recorded moderate values in terms of leaf area plant^{-1}. At the time of initial growth stage, rainfall was received in higher amount. Due to higher amount of rainfall, the status of soil moisture content was consistently greater with treatment broad bed and furrow (T_4). Due to higher availability of soil moisture, the nutrient release might have been increased; thereby better translocation of nutrients might have resulted in maximizing the leaf area plant^{-1} with treatment broad bed and furrow (T_4). Whereas in treatment no-tillage (T_1), the inferior soil physical status might have reflected in producing least leaf area plant^{-1}.

Leaf area index (LAI) is the ratio of upper leaf surface area to ground area; in the context that plant with higher leaf area index (LAI) is capable to intercepting the maximum amount of solar radiation which was otherwise vested by encountering the ground areas. Thus, the leaf area can be used as an indicator of probable rate of photosynthesis by the plant leaves. Photosynthesis is the fundamental basis of competitive success in green plant through its leaves. The carbon and sugar thus formed in the process of photosynthesis, is used by the plant to build the structural unit. Root growth also determines the plant's actively photosynthesizing leaf area; since the root depends on energy capture by the leaves. Therefore, the overall plant growth and development can be indicated through LAI. Treatment broad bed and furrow (T_4) proved to be the most effective treatment with significantly highest values of LAI (10.80). Similarly the other tillage treatments viz., conventional tillage (T_3) and minimum tillage + opening of furrow after every 3 row (T_5) both being at par with each other, recorded second best values of LAI. However, treatment of no-tillage (T1) did not perform well by recording significantly lowest values of LAI (4.18). Remaining tillage treatments were found to be moderate in production of LAI plant^{-1}. At the initial growth stage, the availability of soil moisture was high with treatment broad bed and furrow (T_4) and soil aeration was high in the same treatment. The plant root that developed effectively at initial stage was helpful in better plant growth. The plant produced higher leaf area index due to continuous availability of soil moisture during both vegetative and reproductive stage of crop and higher nutrient uptake by plant with treatment broad bed and furrow (T_4), which affected plant growth significantly as compared to other tillage treatments.

Dry matter production plant^{-1} is considered as the best index of the growth put forth by the crop. The total dry matter plant^{-1} increased continuously up to maturity. Significantly highest value of total dry matter accumulation (29.26 g) was recorded with treatment broad bed and furrow (T_4). It was followed by treatment conventional tillage (T_3)

and minimum tillage + opening of furrow after every 3 row (T_5) with the corresponding values of 27.78 and 26.88 g, respectively. Other tillage treatments i.e. minimum tillage (T_2) and minimum tillage + opening of furrow after every 6 row (T_6), were found to be moderate and yielded 23.85 and 25.20 g total dry matter plant^{-1}, respectively. Significantly lowest total dry matter accumulation was recorded with treatment no-tillage (T_1); where the production of dry matter was to the tune of 21.15 g plant^{-1}. Under the condition of heavily intense rains, the status of soil moisture content was consistently greater with treatment broad bed and furrow (T_4). Thus, under better availability of soil moisture, the nutrient release might have been increased, thereby better translocation of nutrients might have resulted in maximum accumulation of dry matter with treatment broad bed and furrow (T_4). Whereas in treatment no-tillage (T_1), the inferior soil physical status might have reflected in producing lower amount of total dry matter production.

Yield attributes of soybean

The important yield contributing characters i.e. number of pods plant^{-1}, number of grains pod^{-1}, weight of pods plant^{-1}, weight of grains plant^{-1}, test weight etc. provides a precise reflection of treatments under study. Hence, any significant differences observed in these values are directly correlated with the treatment effects. Therefore, an effort has been made to measure all these characters to the highest extent of accuracy.

Number of pods plant^{-1} was found significantly highest with treatment broad bed and furrow (T_4). Total pods plant^{-1} with this treatment was 64.5, followed by treatment conventional tillage (T_3) with the value of 59.4. However, this treatment was found to be statistically similar with treatment minimum tillage + opening of furrow after every 3 row (T_5) with production of 56.3 pods plant^{-1}. Statistically lowest number of pods was registered with treatment no-tillage (T_1) with the value of 40.1. Remaining tillage treatments i.e. minimum tillage + opening of furrow after every 6 row (T_6) and minimum tillage (T_2) recorded intermediate number of pods plant^{-1} (51.9 and 46.6, respectively).

In case of weight of pods plant^{-1}, significantly highest weight of pods plant^{-1} (12.9 g) was observed with treatment broad bed and furrow (T_4), which was followed by treatment conventional tillage (T_3) with 12.1 g pods plant^{-1}. Treatment minimum tillage + opening of furrow after every 3 row (T_5) was found to be statistically similar with treatment conventional tillage (T_3) with production of 11.8 g of pods plant^{-1}. The other treatments i.e. minimum tillage (T_2) and minimum tillage + opening of furrow after every 6 row (T_6) registered intermediate weight of pods plant^{-1} (9.8 g and 10.9 g, respectively), whereas the least weight (9.0 g) of pods plant^{-1} was recorded with no-tillage (T_1) practice.

Number of grains pod^{-1} got significantly influenced due to different tillage practices. The highest number of grains pod^{-1} (2.66) was recorded with treatment broad bed and furrow (T_4), which was followed by treatment conventional tillage (T_3) with number of grains to the tune of 2.55 pod^{-1}. Treatment minimum tillage + opening of furrow after every 3 row (T_5) was found to be statistically similar with treatment conventional tillage (T_3) by producing 2.46 pod^{-1}, whereas significantly lowest number of grains pod^{-1} (2.17) was recorded with treatment no-tillage (T_1). Remaining tillage treatments i.e. minimum tillage + opening of furrow after every 6 row (T_6) and minimum tillage (T_2) recorded moderate number of grains pod^{-1} (2.34 and 2.29, respectively).

Weight of grains plant^{-1} is the most important aspect for obtaining higher grain yield ha^{-1}. This factor was significantly influenced due to different tillage practices. Significantly highest weight of grains plant^{-1} (6.96 g) was recorded with treatment broad bed and furrow (T_4), which was followed by treatment conventional tillage (T_3) with weight of grains to the tune of 6.46 g plant^{-1}, being statistically similar with treatment minimum tillage + opening of furrow after every 3 row (T_5) with the value of 6.18 g plant^{-1}. Significantly lowest performance in terms of weight of grains plant^{-1} (4.27 g) was recorded with treatment no-tillage (T_1), while remaining tillage treatments i.e. minimum tillage + opening of furrow after every 6 row (T_6) and minimum tillage (T_2) were found to be moderate with production of 5.68 and 5.19 g weight of pod plant^{-1}, respectively.

100 grain weight (test weight) of soybean did not get influenced by various tillage treatment practices. Though, the test weight is considered as genetic character, it seldom changes. Thus, it was recorded that test weight of soybean did not differ significantly in response to applied tillage treatments. However, numerically highest test weight (13.78 g) was recorded with treatment broad bed and furrow (T_4). While the lowest test weight of 12.78 g was registered with treatment no-tillage (T_1) and minimum tillage (T_2).

In the present investigation for the yield attributes of soybean, it is obvious that, there was a positive correlation between the different tillage practices and yield attributes as recorded during period of harvest, especially by way of modifying the soil and intensity of tillage treatments, which might have resulted in obtaining significant differences in the yield attributes of soybean crop. In the Broad bed and furrow (T_4) and Conventional tillage (T_3) practices, the status of soil moisture was consistently greater as compared to other tillage practices. Moreover, due to adequate moisture availability, there might be greater uptake of available nutrients which in turn get translocated in to the plants resulting in producing significantly greater yield attributes with treatment broad bed and furrow (T_4).

Seed yield, stover yield, biological yield (kg ha^{-1}), harvest index and grain to strover ratio of soybean

It revealed that, treatment consisting different tillage practices, exhibited significant response over soybean plant growth and yield, when estimated in terms of seed and strover yield. Seed yield of soybean was significantly influenced due to different tillage practices.

With regard to the effect of different tillage practices, significantly maximum seed yield to the tune of 2896 kg ha^{-1} was recorded with treatment broad bed and furrow (T_4). The second maximum seed yield (2648 kg ha^{-1}) was recorded with treatment conventional tillage (T_3). Treatment minimum tillage + opening of furrow after every 3 row (T_5) remained statistically similar to conventional tillage (T_3) with the production of 2542 kg ha^{-1} of seeds. Significantly minimum seed yield of 1711 kg ha^{-1} was recorded with treatment no-tillage (T_1). Remaining tillage treatments, i.e. minimum tillage + opening of furrow after every 6 row (T_6) and minimum tillage (T_2) recorded moderate seed yield.

The same trend of treatment differences were noticed when the stover yield of soybean was measured after harvest of the crop. Significantly highest stover yield of 3031 kg ha^{-1} was recorded with treatment broad bed and furrow (T_4), which was followed by treatment conventional tillage (T_3) with the respective value of 2885 kg ha^{-1}. Treatment minimum tillage + opening of furrow after every 3 row (T_5) with the production of 2769 kg ha^{-1} remained statistically similar to treatment conventional tillage (T_3). Tillage treatment minimum tillage + opening of furrow after every 3 row (T_5) was followed by treatments minimum tillage + opening of furrow after every 6 row (T_6) and minimum tillage (T_2) with strover production of 2612 and 2432 kg ha^{-1}, respectively. Significantly minimum stover yield of 1907 kg ha^{-1} was recorded in treatment no-tillage (T_1).

Like grain and stover yield, tillage practices had significant influence on biological yield of soybean crop. Biological yield followed the same trend, as observed while recording the seed and strover yield of soybean. The maximum biological yield (5927 kg ha^{-1}) was recorded with treatment broad bed and furrow (T_4) and the minimum biological yield (3618 kg ha^{-1}) with treatment no-tillage (T_1).

The harvest index values obtained under different tillage practices did not affect significantly in soybean crop. It was numerically the highest (48.86) with broad bed and furrow (T_4) treatment, showing highest plant growth (i.e. vegetative and reproductive) potential.

The data on grain to strover ratio of soybean did not get influenced significantly in response to applied tillage treatment practices. However, numerically highest seed to strover ratio (1:1.11) was recorded in treatment no-tillage (T_1) and lowest seed to strover ratio (1:1.05) was noted with treatment broad bed and furrow (T_4).

Nagavallemma *et al.* (1998) reported that soybean crop produced maximum grain yield (3000 kg ha^{-1}) with broad bed and furrow tillage system. Selvaraju and Balasubramania (2001) also reported that broad bed furrow increased the grain yield of sorghum and pearl millet crops by 34% and 30%, respectively. They further reported that this treatment recorded higher soil moisture content, indicating more conservation of rain water under broad bed and furrow tillage system. Annonymous (2017) also reported that there was increase in yield of 11-18% with broad bed and furrow tillage system in pigeonpea. Prabhakar *et al.* (2011) also reported the higher crop yields in broad bed and furrow than in the traditional tillage system. They observed that in the broad bed and furrow system the sorghum and pigeonpea together recorded an average grain yield of 5.3 t ha^{-1} yr^{-1} compared with the 1.2 t ha^{-1} yr^{-1} in traditional system. Teklu *et al.* (2005) also reported that broad bed and furrow system, significantly increased the seed yield of lentil by 59%. Similar to this result Gadallah and Selim (2016) reported that soybean cv. Giza 35 was more compatible on ridges 30 cm x 70 cm under mixed pattern. Chattopadhayay *et al.* (2016) reported that planting soybean on broad bed and furrow system in districts of Madhya Pradesh and Maharashtra increased seed yield by 12 per cent fetching Rs. 4,555 ha^{-1} additionally over flat planting by the farmers.

Benefit : cost ratio

The highest B:C ratio of 3.58 was noted with treatment broad bed and furrow (T_4). The second best treatment in the regard was that of minimum tillage + opening of furrow after every 3 row (T_5) with respective value of 3.45. However, irrespective of comparatively lower cost of cultivation with treatment no-tillage (T_1) recorded the lowest B:C ratio of 2.25. The remaining tillage treatments proved to be economical by recording the B:C values over 3.14. The significance of raised bed cultivation is emphasised during the present investigation, as treatment broad bed and furrow (T_4) proved to be most economical and highly remunerating treatment. The least B:C ratio with treatment no-tillage (T_1) signifies the non-suitability of no tillage practices under vertisol conditions.

Based on the present investigation, treatment broad bed and furrow (T_4) was found as the most suitable method of tillage by recording significantly highest soybean plant height, number of branches $plant^{-1}$, number of functional leaves $plant^{-1}$, leaf area $plant^{-1}$, leaf area index and number of root nodules $plant^{-1}$. Significantly highest soybean seed yield, stover yield and biological yield were recorded with treatment broad bed and furrow (T_4) which proved as the most suitable method for cultivating the soybean crop. Maximum B : C ratio was found with treatment of broad bed and furrow (T_4) and proved as the most economic and remunerative tillage practices.

Table 1. Effect of tillage on traits related to growth, yield and yield components in soybean

Treatments	Plant stand at harvest (%)	Plant height at harvest (cm)	Number of branches plant^{-1} at harvest	Number of functional leaves plant^{-1} at 80 DAS	Number of root nodules plant^{-1} at 60 DAS	Leaf area plant^{-1} at 80 DAS (dm^2)	Leaf area index plant^{-1} at 80 DAS	Dry matter accumulation plant^{-1} at harvest (g)
T_1 - No-tillage	94.92	35.67	5.51	20.75	29.75	9.41	4.18	21.15
T_2 - Minimum tillage	96.12	38.25	5.83	21.89	42.75	16.06	7.13	23.85
T_3 Conventional tillage	96.66	44.29	6.60	24.35	52.50	22.57	10.03	27.78
T_4 - Broad bed and furrow	97.19	46.72	7.06	25.55	56.50	24.30	10.80	29.26
T_5 - Minimum tillage + opening of furrow after every 3 row	96.39	44.07	6.54	24.20	51.00	21.29	9.46	26.88
T_6 - Minimum tillage + opening of furrow after every 6 row	96.26	41.80	6.17	23.02	47.25	19.72	8.76	25.20
S E (m) ±	-	0.725	0.062	0.351	1.086	0.431	0.192	0.391
CD at 5%	-	2.17	0.18	1.05	3.25	1.29	0.57	1.17
GM	96.25	41.80	6.34	23.29	46.63	18.89	8.39	25.68

Treatments	No. of pods plant^{-1}	Wt. of pods plant^{-1} (g)	No. of grains pod^{-1}	Wt. of grains plant^{-1} (g)	Test wt. (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biologic al yield (kg ha^{-1})	Harvest Index (%)	Grain to Straw ratio	B:C Ratio
T_1 - No-tillage	40.1	9.0	2.17	4.27	12.78	1711	1907	3618	47.29	1:1.11	
T_2 - Minimum tillage	46.6	9.8	2.29	5.19	12.78	2235	2432	4667	47.88	1:1.09	2.25
T_3 Conventional tillage	59.4	12.1	2.55	6.46	13.70	2648	2885	5533	47.85	1:1.09	3.14
T_4 - Broad bed and furrow	64.5	12.9	2.66	6.96	13.78	2896	3031	5927	48.86	1:1.05	3.58
T_5 - Minimum tillage + opening of furrow after every 3 row	56.3	11.8	2.46	6.18	13.65	2542	2769	5311	47.86	1:1.09	3.45
T_6 - Minimum tillage + opening of furrow after every 6 row	51.9	10.9	2.34	5.68	13.68	2407	2612	5019	47.95	1:1.08	3.31
S E (m) ±	1.330	0.257	0.034	0.136	-	41.620	46.826	68.784	-	-	
CD at 5%	3.99	0.77	0.10	0.41	-	124.86	140.47	206.35	-	-	
GM	53.13	11.08	2.41	5.79	133.92	2406	2606	5013	47.95	1:1.08	3.30

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