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EFFECT OF TILLAGE AND NUTRIENT LEVELS ON GROWTH AND YIELD OF SOYBEAN BASED CROPPING SEQUENCE

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ABSTRACT

The field experiment was conducted during *kharif* and *rabi* seasons of 2014-15 and 2015-16 on clayey soil at the farm of AICRP on Integrated Farming Systems, VNMKV, Parbhani, to study the effect of tillage and nutrient levels on soybean, *rabi* sorghum and wheat in cropping sequence. Treatment consisted of twelve treatment combinations comprising two tillage practices (minimum tillage, conventional tillage) and two cropping systems (soybean-*rabi* sorghum, soybean-wheat) in main plot with three levels of nutrients (75, 100 and 125 per cent RDF) in sub plot for soybean in *kharif* and after that for *rabi* sorghum and wheat in *rabi* season were assigned in a split-split plot design. Application of conventional tillage increased the growth, yield attributes and yield of soybean, *rabi* sorghum and wheat. Cropping systems treatment to soybean was found to be non- significant to enhance the growth, yield attributes and yield of soybean. Use of 125 per cent RDF to soybean, *rabi* sorghum and wheat enhanced the growth, yield attributes, yield of soybean, *rabi* sorghum and wheat followed by 100 per cent RDF.

(Key words: Conventional tillage, minimum tillage, nutrient levels, *rabi* sorghum, soybean, wheat, yield etc.)

INTRODUCTION

Soybean-wheat and soybean-*rabi* sorghum are the most dominant cropping systems on the Vertisols of Central India. Cultivation of soybean in rainy season (June to October) has witnessed a phenomenal growth in the last two decades in the region, while wheat or *rabi* sorghum in winter season (November to April) has a considerable potential due to congenial climate. Besides including a legume (soybean) in sequence with a cereal crop (wheat or *rabi* sorghum) may prove beneficial for long term productivity and sustainability of the system. Rotation of soybean and wheat is practiced on 4.5 million ha on the Vertisols of Central India but the mean yields are only 0.9 t and 1.7 t ha^{-1}, respectively due to limited knowledge of resource conservation technologies.

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Tillage is the most important input, constituting about 25-30 per cent of energy requirement for crop production. In view of the continued energy crisis, there is a need for exploring the possibilities of reducing the tillage requirements for various crops and assessing their residual impact on the succeeding crops when grown in the system. In soybean-based cropping system, the productivity of succeeding *rabi* crops was considerably influenced by tillage across the country. There is ample scope for reducing the tillage operations in various *rabi* and *kharif* crops without significant reduction in their yields and without any adverse impact on succeeding crops in various systems at different locations, leading to energy saving in tillage practices in various cropping systems.

Nutrient management is the maintenance of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible resources. This approach of nutrient management aims at sufficient and efficient use of all the major sources of plant nutrients. So as to get maximum economic yield without any deleterious effect on physio-chemical and biological properties of the soil. Further to safeguard the environment from degradation and to maintain the purity of air, water and food. There

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should be careful usage of chemical fertilizers on sound scientific lines and alternatively ecological agriculture could be contemplated wherever there is shortage of chemical fertilizer and other sources of nutrients.

Research work on soybean based cropping system is lacking in Marathwada region. This project was designed to develop a feasible and economically viable soybean based cropping system by using Resource Conservation Technologies (RCTs) that could benefit the farmers as well as researchers in this locality. Therefore, keeping these facts in view, the present studies were planned to investigate the idea about soybean based cropping system for the area. The findings of these studies will result in increase in production in terms of economic yield, proper distribution of farm labour and irrigation water and nutrient status in soil, which will ultimately improve the living standard of the farmers of the area.

MATERIALS AND METHODS

The experiments were conducted at experimental farms of AICRP on Integrated farming systems, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS), during *kharif* and *rabi* seasons of 2014-15 and 2015-16. The topography of the experimental field was fairly uniform and levelled.The soil of the experimental plot was clayey in texture and slightly alkaline in reaction having low in organic carbon, available nitrogen and phosphorus, but marginally high in available potassium. The climate of Parbhani is semi-arid and characterized by three distinct seasons *viz.,* summer being hot and dry during March to May, warm and humid monsoon in June to October and winter with mild cold from November to February. Most of the rainfall received from south-west monsoon during June to October with mean annual normal precipitation of 964 mm received in 66.84 rainy days.

Treatment consisted of twelve treatment combinations comprising two tillage practices, minimum tillage (*kharif*- 1 moghda + 1harrowing, *rabi*- 2 harrowings) and conventional tillage (*kharif*- 1 ploughing + 1 moghda + 1 harrowing, *rabi*- 1 moghda + 2 harrowings), two soybean-based cropping systems (soybean-*rabi* sorghum, soybean-wheat) in main plot with three nutrient levels (75,100,125 per cent RDF) in sub plot for soybean in *kharif* season and *rabi* sorghum, wheat in *rabi* season. The treatments were assigned in a split-split plot design with three replications.

Certified seed for each crop under experimentation was used. Sowing was done by drilling method. The plant spacing was 45cm x 5 cm for soybean crop.The seed rate used for soybean cv. MAUS-71 was 62.5 kg ha^{-1}. During *rabi* season the seed rate used for *rabi* sorghum cv. SPV-1595 was 10 kg ha^{-1}. The distance in between two rows was 45 cm and in between two plants was 15 cm and in case of wheat the seed rate used (wheat cv. NAIW-301) 100 kg ha^{-1}. The distance in between two rows was 22.5 cm.

The recommended dose of fertilizer (RDF) used for soybean was 30: 60: 30 kg N, P_2O_5 and K_2O ha^{-1} respectively. Full dose of N, P_2O_5 and K_2O was applied at the time of sowing as basal dose to soybean crop. In *rabi* season also the *rabi* sorghum and wheat crop received fertilizer dose as per the treatments. The recommended dose of fertilizer for the *rabi* sorghum was 80:40:40 kg N, P_2O_5 and K_2O ha^{-1} and for wheat crop was 100:50:50 kg N, P_2O_5 and K_2O ha^{-1} respectively. Half dose of N and full dose of P_2O_5 and K_2O was applied at the time of sowing and remaining half dose of N was applied at 45 days after sowing for both crops. The source of nutrients was urea, single super phosphate and murate of potash and ferrous sulphate.

Soybean is grown as *rainfed* crop therefore it does not require any irrigations but in case of dry spell one or two life saving irrigation were given as protective irrigation. In *rabi* season three irrigations were given to *rabi* sorghum at vegetative growth, flowering and grain filling stage and five irrigations were given to wheat at CRI, tillering, late jointing stage, flowering and dough stage as per the necessity during the total period of investigation during both the years.Five plants from each net plot were selected randomly to represent the population in each net plot and labelled for recording growth observations. (The growth attributes of soybean like plant height, number of functional leaves, leaf area, number of branches and total dry matter accumulation, growth attributes of *rabi* sorghum plant height, number of leaves, leaf area and dry matter accumulation and growth attributes of wheat of plant height, number of leaves, leaf area and dry matter accumulation). Various observations were recorded on these plants periodically after 30 days of sowing at an interval of 15 days for soybean and wheat and at an interval of 30 days for *rabi* sorghum crop till maturity of the crops, respectively. Observations on yield components (soybean-number of pods, seeds $plant^{-1}$ and pods weight $plant^{-1}$, hundred grain weight, r*abi* sorghum yield contributing characters *viz*., length of earheads, breadth of earhead, weight of earhead $plant^{-1}$, weight of grains $plant^{-1}$ and thousand grain weight, wheat yield contributing characters *viz*., length of panicles, weight of panicles, weight of grains $panicle^{-1}$ and thousand grain weight) were recorded after harvest of crop.

The soybean, *rabi* sorghum and wheat yield was considered for converting in to soybean equivalent yield in kg ha^{-1} on the basis of prevailing market price in respective year of both the economic yield commodities under consideration. The soybean equivalent yield (SEY) was calculated by the following formulae for respective treatments for both the years of experiment (Ganajaxi *et al.,* 2013).

$$\text{SEY (kg ha}^{-1}\text{)} = \frac{\text{*Yield of } \textit{kharif} \text{ crop (kg ha}^{-1}\text{)} \times \text{price (Rs. kg}^{-1}\text{)} + \text{Yield of } \textit{rabi} \text{ crop (kg ha}^{-1}\text{)} \times \text{price (Rs. kg}^{-1}\text{)}}{\text{Price of soybean (Rs. kg}^{-1}\text{)}}$$

*Yield = Yield of both main and byproduct

RESULTS AND DISCUSSION

Growth attributes of soybean

The growth attributes of soybean like plant height, number of functional leaves, leaf area, number of branches and total dry matter accumulation was significantly influenced by tillage practices at various stages of crop growth. The conventional tillage practices recorded significantly higher growth attributes in soybean as compared to minimum tillage during both years. This increase in growth attributes might be due to better pulverization of soil which helped in the better aeration, nutrient availability, better crop, higher water and nutrient use efficiency and less weed crop competition over minimum tillage. The beneficial effect of conventional tillage in producing taller plants might be due to less weed infestation and higher nutrient uptake and adequate soil moisture prevailing during the growth period, proper availability of nutrients with favorable soil physicochemical conditions. Higher fertility level enhanced the growth attributes of soybean over the lower dose it might be due to more uptake of nutrients in soybean plant which in turn might have resulted more synthesis of photosynthates in growing region reported by Bothe *et al*. (2000) and Jha *et al*. (2014). The soybean based cropping systems had no significant influenced on growth attributes of soybean crop during both the years of experimentation. Application of 125 per cent RDF produced significantly higher growth attributes as compared to lower nutrient levels.

Growth attributes of *rabi* sorghum

Conventional tillage with 125 per cent RDF to *rabi* sorghum recorded higher values in respect of all the growth attributes (plant height, number of leaves, leaf area and dry matter accumulation) at all the growth stages during both years of study. This was closely followed by conventional tillage with 100 per cent RDF to *rabi* sorghum and preceding soybean in *kharif* .The minimum tillage with 75 per cent RDF application recorded minimum tillage lower value during both the seasons

Growth attributes of wheat

The overall growth and development of wheat crop measured in terms of plant height, number of leaves, leaf area and dry matter accumulation of wheat crop. Conventional tillage with 125 per cent RDF to wheat recorded higher values in respect of all the growth attributes at all the growth stages during both the years of study. This was closely followed by conventional tillage with 100 per cent RDF to wheat and preceding soybean in *kharif* .The minimum tillage with 75 per cent RDF application treatment was recorded lower value during both the seasons.

Yield attributes of soybean

Conventional tillage recorded more number of pods, seeds plant^{-1} and pods weight plant^{-1}followed by minimum tillage during both the years. Hundred grain weight and number of seeds pod^{-1} were not influenced due to tillage during both the years.This might be due to more number of leaves and leaf area (source) contributed in translocation of assimilates towards developing pods (sink). Monsefi *et al.* (2014) reported that Conventional tillage at 75 DAS recorded higher plant height, number of leaves, leaf area and dry matter ultimately resulted into better pods exertion and recorded maximum number of pods plant^{-1} amongst all the tillage practices.

The soybean based cropping systems was not significantly influenced on yield attributes of soybean crop during both the years of experimentation.

Yield contributing characters i.e. number of pods plant^{-1}, weights of seeds plant^{-1} (g), weight of pods plant^{-1} (g) were significantly higher with the application of 125 per cent recommended dose of fertilizer level. Hundred grain weight and number of seed pods^{-1} were not influenced due to fertilizer levels during both the years. Kausadikar *et al.* (2003) reported that the successive increase in N application significantly increased the grain and straw yields up to 90 kg N ha^{-1} in both the years.

Yield of soybean

Conventional tillage recorded significantly higher soybean grain (1637, 1490 and 1563 kg ha^{-1} grain yield in 2014-15, 2015-16 and in pooled analysis, respectively) and straw yield (2597 2382, 2393 kg ha^{-1} straw yield in 2014-15,2015-16 and in pooled analysis respectively) over the minimum tillage practices during both years and pooled analysis. Higher biological yield and harvest index also noted in conventional tillage practices.The soybean based cropping systems was not significantly influenced yield attributes, yields of soybean crop during both the years of experimentation. Highest yield of soybean recorded in conventional tillage over minimum tillage by Parlawar *et al.* (2018).

The significantly higher in grain and straw yield of soybean was observed with the application of 125 per cent levels of RDF over 75 per cent RDF application but 100 per cent RDF produced comparable yields to it. Whereas, the biological yield and harvest index was also higher in 125 per cent RDF levels applied to soybean during both years. These findings are in conformity with those of Thakur *et al.* (2011) and Kang *et al.* (2012). They reported that increased application of N, P and K improved the uptake of N, P and K by the crop plants and ultimately photosynthetic activities, resulting in growth and yield attributes which laid down the foundation of higher yield.

Yield attributes of *rabi* sorghum

Rabi sorghum yield contributing characters *viz*., length of earhead, breadth of earhead, weight of earhead plant^{-1}, weight of grains plant^{-1} and thousand grain weights were higher in practice of conventional tillage with 125 per cent RDF application for soybean crop followed by conventional tillage with 125 per cent RDF to *rabi* sorghum during both the years of experimentation. This might be due to conventional tillage with higher nutrient levels in *rabi* sorghum crop which resulted in availability of N, P and

K as well as improved soil pulverization caused more amount of rainwater conserved which favoured better crop growth and development. Patil (2013) observed the maximum yield attributes of *rabi* sorghum under conventional tillage practices over three years. This might be owing to conserved more rainwater and high water use efficiency resulting in better plant growth and yield attributes.

Yield of *rabi* sorghum

Practice of conventional tillage with the application of 125 per cent to *rabi* sorghum produced higher grain yield of *rabi* sorghum during 2014-15 (2421 kg ha^{-1}) and 2015-16 (2209 kg ha^{-1}) respectively, followed by conventional tillage with 100 per cent RDF application it was superior over other treatments during both the seasons. Similar trend was noted in fodder, biological yield and harvest index during both the years. This might be to owing conserved more rainwater and high water use efficiency resulting in better plant growth and yield attributes. This might be due to conserved more rainwater and high water use efficiency resulting in better plant growth and yield attributes. Tiwari (2013) revealed that better soil properties were responsible for proper root growth, higher uptake of nutrients and left the lower amount of available nutrient in conventional tillage. This could be related to increase nutrient mineralization promoted by conventional tillage.

Yield attributes of wheat

Wheat yield contributing characters *viz*., length of panicles, weight of panicles, weight of grains $panicle^{-1}$ and thousand grain weight notably influenced by different tillage and nutrient levels. Practice of conventional tillage with 125 per cent RDF application for soybean crop followed by conventional tillage with 125 per cent RDF to wheat showed higher yield attributing characters of wheat during both the years of experimentation. Conventional tillage recorded significantly higher yield attributes due to better seed bed *viz*., better physical environment in terms of lower bulk density, penetration resistance in turn there was an enhanced growth and productivity of wheat. Application of higher levels of nutrient increased growth and development of wheat crop was due to availability of nutrients in balanced form in sufficient quantity. The highest yield of soybean and wheat in cropping was recorded with the application of 150% NPK over 100% and 50% NPK noted by Khamparia *et al.* (2018)

Yield of wheat

The effect of tillage practices with nutrient levels showed considerable impact on grain, straw, biological yield and harvest index during both the years. Practice of conventional tillage with the application of 125 per cent RDF to wheat crop produced higher grain yield (3101 and 2880 kg ha^{-1} during 2014-15 and 2015-16 respectively), straw yield (4471 and 4201 kg ha^{-1} during 2014-15 and 2015-16 respectively), biological yield (7572 and 7081 kg ha^{-1} during 2014-15 and 2015-16 respectively) and harvest index (40.95 and 40.67 kg ha^{-1} during 2014-15 and 2015-16 respectively). This might be due to the beneficial effect of conventional tillage during *kharif* season followed by conventional tillage of wheat in *rabi* resulted in better growth and yield attributes and reflected in higher grain and straw yield. Similar higher yield attributes *viz*., length of spike, number of spikes, grains $spike^{-1}$ and test weight of wheat recorded under conventional tillage practices reported by Tuti *et al.* (2011).

Soybean equivalent yield

The soybean equivalent yield of the cropping system was significantly higher with the practice of conventional tillage for soybean in *kharif* and *rabi* sorghum, wheat in *rabi* (3154, 2877 and 3015 kg ha^{-1} in 2014-15, 2015-16 and in pooled results, respectively) than the minimum tillage treatments during both the years and in pooled results also. Billore *et al.* (2005) reported from trend analysis that soybean-wheat system was more productive, stable and profitable compared to soybean-chickpea. Soybean-wheat cropping systems recorded the significantly higher soybean equivalent yield over the soybean-*rabi* sorghum cropping systems during both the years and pooled study.

In respect of nutrient levels, soybean equivalent yield was increased with the increase in fertiliser levels to soybean in *kharif* followed by *rabi* sorghum and wheat in *rabi*. It was significantly higher when crop was supplied with 125 per cent RDF (3348 and 3011 kg ha^{-1} in 2014-15 and 2015-16 , respectively and 3179 kg ha^{-1} in pooled analysis) over 75 per cent RDF and was at par with 100 per cent RDF during both the years and pooled results.

Table 1. Growth attributes of soybean as influenced by different treatments during 2014-15 and 2015-16

Treatments	Plant height (cm)		No. of functional leaves plant^{-1}		leaf area plant^{-1} (dm^2)		No. of branches plant^{-1}		Total dry matter plant^{-1}(g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Tillage										
T_1: Minimum tillage	49.37	37.85	20.62	19.96	17.83	16.12	4.30	3.69	11.20	9.74
T_2: Conventional tillage	53.56	41.06	23.05	21.94	19.98	17.65	4.81	4.22	12.61	11.30
S.E. (m) ±	0.89	0.74	0.40	0.32	0.33	0.34	0.08	0.06	0.27	0.27
C.D. at 5%	**3.09**	**2.55**	**1.37**	**1.12**	**1.13**	**1.18**	**0.29**	**0.21**	**0.93**	**0.93**
Cropping system										
C_1:Soybean-*Rabi* sorghum	50.47	38.62	21.67	20.57	18.72	16.84	4.42	3.84	11.96	10.50
C_2:Soybean-Wheat	52.46	40.17	22.01	21.33	19.09	16.93	4.69	4.08	11.85	10.54
S.E. (m) ±	0.89	0.74	0.40	0.32	0.33	0.34	0.08	0.06	0.27	0.27
C.D. at 5%	-	-	-	-	-	-	-	-	-	-
Nutrient levels										
N_1: 75 % RDF	46.64	36.10	19.55	19.13	16.55	14.57	3.99	3.41	10.01	8.98
N_2: 100 % RDF	51.71	39.80	21.96	20.96	19.19	16.79	4.65	4.01	12.21	10.66
N_3: 125 % RDF	56.05	42.46	24.01	22.74	20.98	19.30	5.02	4.45	13.55	11.92
SE (m) ±	1.44	1.09	0.65	0.46	0.52	0.47	0.12	0.15	0.44	0.38
CD at 5%	**4.31**	**3.26**	**1.94**	**1.38**	**1.55**	**1.40**	**0.37**	**0.45**	**1.31**	**1.14**
Interaction										
T X C										
SE (m) ±	1.26	1.04	0.56	0.46	0.46	0.48	0.12	0.08	0.38	0.38
CD at 5%	-	-	-	-	-	-	-	-	-	-
C X N										
SE (m) ±	2.03	1.54	0.91	0.65	0.73	0.66	0.17	0.21	0.62	0.54
CD at 5%	-	-	-	-	-	-	-	-	-	-
T X C X N										
SE (m) ±	2.88	2.18	1.29	0.92	1.03	0.93	0.25	0.30	0.88	0.76
CD at 5%	-	-	-	-	-	-	-	-	-	-
General mean	**51.47**	**39.46**	**21.84**	**20.95**	**18.90**	**16.88**	**4.55**	**3.96**	**12.33**	**10.52**

Table 2. Growth attributes of *rabi* sorghum as influenced by different treatments during 2014-15 and 2015-16

Treatments	Plant height (cm)		No. of functional leaves plant^{-1}		Leaf area plant^{-1} (dm^2)		Total dry matter plant^{-1} (g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1: Minimum tillage with 75 % RDF	138.97	134.99	2.83	2.41	2.14	2.1	52.19	47.31
T_2: Minimum tillage with 100 % RDF	162.15	150.12	3.24	3.12	2.31	2.77	63.19	58.12
T_3: Minimum tillage with 125% RDF	171.02	161.17	4.10	3.69	3.49	3.43	71.87	66.15
T_4: Conventional tillage with 75 % RDF	**152.65**	**144.12**	**3.29**	**2.97**	**2.18**	**2.33**	**58.44**	**51.89**
T_5: Conventional tillage with 100 % RDF	174.56	168.01	4.13	3.66	3.35	3.68	76.82	72.05
T_6: Conventional tillage with 125% RDF	182.29	179.68	4.80	4.20	3.58	3.96	84.89	80.12
General mean	**163.61**	**156.34**	**3.73**	**3.34**	**2.84**	**3.05**	**67.90**	**62.61**

Table 3. Growth attributes of wheat as influenced by different treatments during 2014-15 and 2015-16

Treatments	Plant height (cm)		No. of functional leaves plant^{-1}		Leaf area plant^{-1} (dm^2)		Total dry matter plant^{-1} (g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1: Minimum tillage with 75 % RDF	69.01	67.42	10.20	9.55	4.21	4.03	4.22	3.94
T_2: Minimum tillage with 100 % RDF	77.14	75.12	10.51	9.95	5.07	4.74	5.62	5.13
T_3: Minimum tillage with 125% RDF	80.27	78.49	12.31	10.98	5.60	5.49	6.39	6.12
T_4: Conventional tillage with 75 % RDF	**74.67**	**72.44**	**10.49**	**9.82**	**4.89**	**4.71**	**5.12**	**4.56**
T_5: Conventional tillage with 100 % RDF	81.58	80.53	12.80	12.67	6.02	5.82	6.95	6.66
T_6: Conventional tillage with 125% RDF	84.71	82.95	13.76	13.23	7.47	6.71	8.64	7.74
General mean	**77.90**	**76.16**	**11.68**	**11.03**	**5.54**	**5.25**	**6.16**	**5.69**

Table 4. Yield attributes of soybean as influenced by different treatments during 2014-15 and 2015-16

Treatments	Weight of pods plant^{-1} (g)		Weight of seeds plant^{-1} (g)		Number of seeds pod^{-1}		Seed index (g)	
	2014-15	**2015-16**	**2014-15**	**2015-16**	**2014-15**	**2015-16**	**2014-15**	**2015-16**
Tillage								
T_1: Minimum tillage	5.14	4.67	4.48	3.90	2.27	2.30	7.9	7.9
T_2: Conventional tillage	5.69	5.36	5.01	4.54	2.35	2.28	8.0	8.1
SE (m) ±	0.12	0.09	0.09	0.08	0.05	0.05	0.06	0.07
CD at 5%	**0.43**	**0.32**	**0.32**	**0.28**	-	-	-	-
Cropping system								
C_1:Soybean-*Rabi* sorghum	5.34	4.98	4.70	4.21	2.23	2.29	8.0	7.9
C_2:Soybean-Wheat	5.50	5.05	4.79	4.22	2.40	2.29	8.0	8.1
SE (m) ±	0.12	0.09	0.09	0.08	0.05	0.05	0.06	0.07
CD at 5%	-	-	-	-	-	-	-	-
Nutrient levels								
N_1: 75 % RDF	4.61	4.14	4.03	3.58	2.21	2.15	7.9	7.9
N_2: 100 % RDF	5.36	5.09	4.86	4.27	2.33	2.32	8.0	8.0
N_3: 125 % RDF	6.29	5.82	5.35	4.80	2.40	2.40	8.0	8.1
SE (m) ±	0.17	0.16	0.14	0.15	0.07	0.07	0.06	0.09
CD at 5%	**0.52**	**0.48**	**0.42**	**0.44**	-	-	-	-
Interaction								
T X C								
SE (m) ±	0.18	0.13	0.13	0.11	0.07	0.06	0.08	0.10
CD at 5%	-	-	-	-	-	-	-	-
T X N								
SE (m) ±	0.25	0.23	0.20	0.21	0.09	0.10	0.09	0.13
CD at 5%	-	-	-	-	-	-	-	-
C X N								
SE (m) ±	0.25	0.23	0.20	0.21	0.09	0.10	0.09	0.13
CD at 5%	-	-	-	-	-	-	-	-
T X C X N								
SE (m) ±	0.35	0.32	0.28	0.29	0.13	0.14	0.13	0.19
CD at 5%	-	-	-	-	-	-	-	-
General mean	**5.42**	**5.02**	**4.74**	**4.22**	**2.31**	**2.29**	**8.0**	**8.0**

Table 5. Mean seed yield of soybean (kg ha^{-1}) as influenced by different treatments during 2014-2015 and 2015-2016 with pooled

Treatments	Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Biological yield (kg ha^{-1})		Harvest index (%)	
	2014-15	2015-16	pooled	2014-15	2015-16	Pooled	2014-15	2015-16	2014-15	2015-16
Tillage										
T_1: Minimum tillage	1507	1275	1391	2443	2151	2297	3950	3426	38.15	37.21
T_2: Conventional tillage	1637	1490	1563	2597	2382	2393	4234	3872	38.66	38.48
SE (m) ±	32.06	27.58	29.81	41.03	36.39	38.75	72.36	64.14	—	—
CD at 5%	**110.94**	**95.44**	**103.02**	**141.98**	**126.37**	**133.91**	**250.61**	**221.96**	**—**	**—**
Cropping system										
C_1:Soybean-Rabi sorghum	1569	1363	1465	2502	2266	2384	4071	3629	38.54	37.55
C_2:Soybean-Wheat	1576	1402	1488	2537	2267	2402	4113	3669	38.31	38.21
SE (m) ±	32.06	27.58	29.84	41.03	36.49	38.75	72.36	64.14	—	-
CD at 5%	-	-	-	-	-	-	-	-	-	-
Nutrient levels										
N_1: 75 % RDF	1366	1190	1277	2287	2035	2161	3653	3225	37.39	36.89
N_2: 100 % RDF	1595	1410	1502	2553	2283	2418	4149	3694	38.44	38.17
N_3: 125 % RDF	1756	1547	1651	2718	2481	2599	4474	4028	39.24	38.40
SE (m) ±	57.44	47.86	52.65	87.34	74.06	8069	133.90	120.03	—	—
CD at 5%	**172.23**	**143.48**	**152.50**	**261.87**	**222.03**	**244.15**	**401.45**	**359.85**	**—**	**—**
Interaction										
T X C										
SE (m) ±	45.34	39.00	42.17	58.02	51.60	54.81	102.33	90.71	—	—
CD at 5%									**—**	**—**
T X N										
SE (m) ±	81.24	67.68	74.45	123.52	104.73	114.12	189.36	169.74	—	—
CD at 5%	-	-	-	-	-	-	-	-	**—**	**—**
C X N										
SE (m) ±	81.24	67.68	74.45	123.52	104.73	114.12	189.36	169.74	—	—
CD at 5%	-	-	-	-	-	-	-	-	**—**	**—**
T X C X N										
SE (m) ±	114.89	95.71	105.30	174.69	148.11	161.40	267.80	240.05	—	—
CD at 5%	-	-	-	-	-	-	-	-	**—**	**—**
General mean	**1572**	**1382**	**1477**	**2520**	**2267**	**2379**	**4092**	**3649**	**38.39**	**37.84**

Table 6. Yield attributes of *rabi* sorghum as influenced by different treatments during 2014-2015 and 2015-16

Treatments	Length of earhead (cm)		Breadth of earhead (cm)		Weight of earhead plant^{-1}		Weight of grains plant^{-1}		Test weight (g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1: Minimum tillage with 75 % RDF	15.58	14.53	5.02	5.01	23.80	21.59	14.27	12.65	25.38	24.38
T_2: Minimum tillage with 100 % RDF	17.07	16.30	6.12	5.59	25.17	23.76	17.75	15.30	26.43	25.43
T_3: Minimum tillage with 125% RDF	18.38	18.30	8.20	6.88	28.74	25.68	19.61	17.60	26.06	26.51
T_4: Conventional tillage with 75 % RDF	**16.77**	**16.31**	**6.26**	**6.15**	**23.82**	**22.39**	**16.38**	**13.62**	**26.54**	**25.17**
T_5: Conventional tillage with 100 % RDF	20.22	19.00	7.17	6.56	29.83	26.56	19.71	17.67	27.03	25.70
T_6: Conventional tillage with 125% RDF	21.38	19.94	8.33	7.59	31.10	29.80	21.07	18.49	27.64	27.24
General mean	**18.23**	**17.40**	**6.85**	**6.30**	**27.08**	**24.96**	**18.13**	**15.89**	**26.51**	**25.74**

Table 7. Yield of *rabi* sorghum as influenced by different treatments during 2014-2015 and 2015-1

Treatments	Seed yield (kg ha^{-1})		Fodder yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Harvest index (%)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1: Minimum tillage with 75 % RDF	1802	1532	6739	6068	6739	6068	14.27	12.65
T_2: Minimum tillage with 100 % RDF	2079	1774	7542	6630	7542	6630	17.75	15.30
T_3: Minimum tillage with 125% RDF	2273	2105	7950	7355	7950	7355	19.61	17.60
T_4: Conventional tillage with 75 % RDF	**1923**	**1607**	**7125**	**6498**	**7125**	**6498**	**16.38**	**13.62**
T_5: Conventional tillage with 100 % RDF	2339	2156	8114	7464	8114	7464	19.71	17.67
T_6: Conventional tillage with 125% RDF	2421	2209	8371	7700	8371	7700	21.07	18.49
General mean	**2139**	**1897**	**7640**	**6953**	**7640**	**6953**	**18.13**	**15.89**

Table 8. Yield attributes of wheat as influenced by different treatments during 2014-2015 and 2015-16

Treatments	Length of panicles (cm)		Weight of panicles (g)		Weight of grains panicle^{-1} (g)		Test weight (g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1: Minimum tillage with 75 % RDF	5.66	5.57	2.50	2.19	2.01	1.87	39.61	39.97
T_2: Minimum tillage with 100 % RDF	6.61	6.58	2.73	2.41	2.20	2.05	41.65	39.83
T_3: Minimum tillage with 125% RDF	7.04	7.00	2.90	2.57	2.27	2.12	41.81	40.95
T_4: Conventional tillage with 75 % RDF	**6.49**	**6.22**	**2.66**	**2.38**	**2.09**	**1.94**	**40.41**	**40.21**
T_5: Conventional tillage with 100 % RDF	7.13	6.89	2.95	2.68	2.29	2.08	41.38	41.08
T_6: Conventional tillage with 125% RDF	7.85	7.50	3.04	2.79	2.46	2.24	42.82	42.78
General mean	**6.80**	**6.63**	**2.80**	**2.50**	**2.22**	**2.05**	**41.28**	**40.80**

Table 9. Yield of wheat as influenced by different treatments during 2014-2015 and 2015-16

Treatments	Seed yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Harvest index (%)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1: Minimum tillage with 75 % RDF	2324	2125	6000	5457	6000	5457	39.61	39.97
T_2: Minimum tillage with 100 % RDF	2728	2430	6800	6103	6800	6103	41.65	39.83
T_3: Minimum tillage with 125% RDF	2882	2615	7135	6507	7135	6507	41.81	40.95
T_4: Conventional tillage with 75 % RDF	**2501**	**2281**	**6275**	**5764**	**6275**	**5764**	**40.41**	**40.21**
T_5: Conventional tillage with 100 % RDF	2930	2746	7207	6803	7207	6803	41.38	41.08
T_6: Conventional tillage with 125% RDF	3101	2880	7572	7081	7572	7081	42.82	42.78
General mean	**2744**	**2513**	**6831**	**6286**	**6831**	**6286**	**41.28**	**40.80**

Table 10. Soybean equivalent yield (kg ha^{-1}) as influenced by different treatments during 2014-15 and 2015-16

Treatments	Soybean equivalent yield (kg ha^{-1})		
	2014-15	2015-16	Pooled
Tillage			
T_1: Minimum tillage	2917	2538	2727
T_2: Conventional tillage	3154	2877	3015
SE (m) ±	53.43	50.10	49.85
CD at 5%	**184.89**	**173.38**	**172.01**
Cropping system			
C_1:Soybean-*Rabi* sorghum	2894	2547	2720
C_2:Soybean-Wheat	3177	2867	3022
SE (m) ±	53.43	50.10	49.85
CD at 5%	**184.89**	**173.38**	**172.01**
Nutrient levels			
N_1: 75 % RDF	2657	2336	2496
N_2: 100 % RDF	3102	2774	2938
N_3: 125 % RDF	3348	3011	3179
S.E. (m) ±	83.21	76.84	78.12
CD at 5%	**249.47**	**230.38**	**233.59**
Interaction			
T X C			
SE (m) ±	75.56	70.85	71.29
CD at 5%	-	-	-
T X N			
SE (m) ±	117.68	108.67	111.27
CD at 5%	-	-	-
C X N			
SE (m) ±	117.68	108.67	111.27
CD at 5%	-	-	-
T X C X N			
SE (m) ±	166.42	153.68	158.15
CD at 5%	-	-	-
General mean	**3036**	**2707**	**2869**

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