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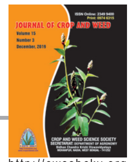

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Effect of tillage practices and mulching on growth and yield of chickpea (*Cicer arietinum* L.) in rice-chickpea based cropping system under rainfed condition of Assam

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ABSTRACT

A field experiment was conducted during winter (Rabi) season of 2016-17, 2017-18 and 2018-19 in medium low rice fallow lands of Regional Agricultural Research Station, Shillongani, Nagaon, Assam to study the effect of tillage practices and mulches on growth, yield and economics of chickpea in rice-chickpea based cropping system under rainfed condition. In this experiment, 3 tillage practices viz., conventional tillage, reduced tillage and zero tillage with mulching and no mulching treatments were tested in split plot design with four replications. As per different tillage practices, the chickpea crop (var. JG 14) was sown on different dates after harvest of winter rice (var. Ranjit sub 1). Results revealed that all the tillage practices with mulching resulted in better growth and yield attributes of chickpea over no mulching. However, the highest seed yield (1169 kg ha^{-1}) was recorded in conventional tillage with mulching as compared to reduced (1104 kg ha^{-1}) and zero (1094 kg ha^{-1}) tillage with mulching. Conventional tillage recorded significantly higher rice equivalent yield (REY) of chickpea (4347 kg ha^{-1}), net monetary return (Rs. 39303/-) and B:C ratio (2.42) compared to other two tillages. Application of mulches with rice straw @ 2.5 tones ha^{-1} to chickpea recorded significantly higher number of branches plant^{-1}, pods plant^{-1}, seed yield (1122 kg ha^{-1}), REY of chickpea (1315 kg ha^{-1}), stover yield (2412 kg ha^{-1}), harvest index (33%), gross monetary return (Rs. 67349 ha^{-1}), net monetary return (Rs. 39132 ha^{-1}),soil available N, P_2O_5 and K_2O content (286.21, 19.94 and 150.47 kg ha^{-1}, respectively), soil fungal and bacterial populations and soil moisture content as compared to no mulching.

***Keywords*:** Chickpea, economics, mulching, seed yield and tillage practice

Chickpea (*Cicer arietinum* L.) is one of the most important *rabi* pulse crops of India. It is a low water requiring crop and can be grown as rain-fed crop in India and Assam also (Ali and Kumar, 2005). During 2018-19, the area, production and productivity of chickpea in India was 9.44 million ha, 10.13 million tonnes and 1073 kg ha^{-1}, respectively (Anonymous, 2019a). The area of 2244 ha under chickpea in Assam is very less with production of 1575 tones and productivity of 699 kg ha^{-1} only (Anonymous, 2019b). To increase chickpea production, the cultivated land area cannot be increased directly, as the land is fixed. Therefore, to increase the area and production under chickpea, the crop has to be grown in winter after the harvest of winter rice in Assam by utilizing the residual soil moisture of *kharif* season. Winter rice being the major crop is grown in an area of 18.79 lakh hectare (Anonymous, 2019b) in Assam and substantial area of winter rice remains fallow during *rabi* season. Rice lands receive considerable amount of rainfall during the *kharif* season in Assam and the amount of rainfall received during *rabi* season is low and erratic. Due to very low or scanty rainfall in *rabi* season, there is gradual decline in water table depth and residual soil moisture with the advancement of *rabi* season. This results in soil moisture deficit at the later stages of chickpea growth and thereby adversely affecting its productivity.

For successful cultivation of *rabi* crops, conservation of residual soil moisture of *kharif* season is very important and necessary. Soil moisture is very important for seed germination, seedling establishment, growth and development of chickpea crop (Bohnert and Jensen, 1995; Rajak and Prasad, 2017). However, application of mulches on soil surface may conserve soil moisture and bring overall improvement in resource management. Mulching can conserve soil moisture by checking evaporation and facilitating moisture distribution. It also helps in building up of organic matter in the soil and thereby can improve soil physical, chemical and biological properties as well as crop productivity (Bhan, 1976, Bhardwaj, 2013; Rathore *et al.*, 1998 and Hatfield *et al.*, 2001). Different types of mulches such as plastic mulch, paddy straw, crop residues are used to conserve moisture, moderate soil temperature, reduce insects and diseases problem and increase crop yield (Samaila *et al.*, 2011; Sarkar and Sarkar, 2019). However, no work has been reported on conservation agriculture in chickpea in Assam. Keeping all these in view, the

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experiment was undertaken to evaluate suitable tillage and mulching practices for successful cultivation of chickpea in rice-chickpea based cropping system under rain-fed condition of Assam.

MATERIALS AND METHODS

Three-year field experiment was carried out at Regional Agricultural Research Station, Shillongani, Nagaon, Assam ($26^0 0^/$ N latitude and $90^0 45^/$ E longitude and 50.2 m above MSL) during *rabi*. The climate is sub-tropical with hot humid summer as well as dry and cold winter. During the crop growth period, the total rainfall received was 306.7, 354.1 and 375.2 mm during 2016-17, 2017-18 and 2018-19, respectively. The mean maximum and minimum temperature experienced were in the range of 24.5 to 30.7^{0}C and 11.7 to 21.9^{0}C, respectively (mean of three years); mean relative humidity ranged from 87.7 to 93.3 per cent (morning) and 60.0 to 77.0 per cent (evening) in the crop season (Source: Gramin Krishi Mausom Sewa, RARS, Shillongani, Nagaon). The soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.58), high in organic C (0.82%), medium in available N (280.42 kg ha^{-1}) and K_2O (146.64 kg ha^{-1}), as well as low in available P_2O_5 (19.20 kg ha^{-1}). The treatments comprised 3 tillage practices *viz.,* conventional tillage (two harrowings + one planking), reduced tillage (one harrowing + one planking) and zero tillage (direct seeding in untilled field using tractor drawn Zero Till Drill machine) with mulching and no mulching. The experiment was laid out in a split plot design with four replications. All the recommended package of practices was followed in the chickpea crop. The rice variety "Ranjit Sub 1" was used and sown in the month of June, transplanted in the month of July and harvested in 2nd week of November in each year. After *Sali* rice, chickpea was sown as per different tillage practices. The chickpea variety 'JG-14' was used and the sowing and harvesting date of it varied due to variation of tillage practices every year (Table 1). The 'JG-14' is desi chickpea variety of medium seed size, suitable for rice-fallow situation. It takes about 120-125 days to mature with yield potential of 14 to 16 q/ha. Rice straw mulch @ 2.5 t ha^{-1} was applied at one day after sowing of chickpea.

In all the treatments, fertilizer @ 20:40:15 N, P_2O_5 and K_2O kg ha^{-1} was applied. The seeds were sown at the rate of 70 kg ha^{-1} in lines at a row spacing of 30 cm in all the tillage practices. First weeding at 30-35 days after sowing and second at 60-70 days after sowing were done. Data on growth and yield attributes were taken in due time and yield was calculated from net plot area.

Table 1: Sowing and harvesting dates of chickpea under different treatments

Treatment	Date of sowing			Date of harvest		
	2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Conventional tillage	03.12.16	01.12.17	02.12.18	08.04.17	04.04.18	06.04.19
Reduced tillage	03.12.16	01.12.17	02.12.18	08.04.17	04.04.18	06.04.19
Zero tillage	30.11.16	27.11.17	26.11.18	29.03.17	30.03.18	31.03.19

The rice equivalent yield (REY) of chickpea was calculated by using the following formula.

$$\text{REY of chickpea} = \frac{\text{Yield of chickpea } \left(\text{q ha}^{-1}\right) \text{ x price of chickpea } \left(\text{Rs. q}^{-1}\right)}{\text{Price of rice } \left(\text{Rs. q}^{-1}\right)}$$

Initial and final soil samples were collected during 2016-17 and 2018-19, respectively through core method of soil sampling and analysed for chemical properties following standard procedures. Soil moisture content (%) was recorded at sowing and upto 90 days after sowing at 30 days interval by digital soil moisture meter. For counting of soil fungal and bacterial populations, soil samples from 0-15 cm depth in three spots of each plot were collected before sowing chickpea in 1st year and at harvest of chickpea in 3rd year. The fungal and bacterial populations in soil were enumerated by following the standard serial dilution technique and pour-plate method using different media (Aneja, 2003). Nutrient agar media was used for enumeration of bacterial population and potato dextrose agar media was used for fungal population. At first 10 g representative soil sample was transferred to conical flask containing 90 ml sterile water and shaked thoroughly for 30 minutes to get 10^{-1} dilution from which serial dilutions were prepared up to 10^{-6} by transferring 1 ml to 9ml water blank from each dilution serially. The dilution 10^{-4}, 10^{-5} and 10^{-6} were selected for enumeration. From each dilution, 0.1ml aliquot was transferred into the sterilized petriplates in triplicate. After that the melted solid media

Table 2: Plant stand of chickpea under different treatments

Treatments	Plant stand m^{-2}					
	2016-17		2017-18		2018-19	
	Initial	Final	Initial	Final	Initial	Final
Tillage						
Conventional	30.63	24.50	31.00	25.62	31.55	25.47
Reduced	27.88	21.38	29.37	23.87	31.24	24.46
Zero	27.50	20.63	25.37	21.87	24.56	20.63
SEm (±)	**0.64**	**0.06**	**1.36**	**1.24**	**1.52**	**1.24**
LSD (0.05)	**2.53**	**0.24**	**5.34**	**NS**	**5.96**	**NS**
Mulching with rice straw @ 2.5 t ha^{-1} (dry wt. basis)						
With Mulching	30.92	24.67	29.83	24.41	31.13	24.39
No mulching	26.42	19.66	27.33	23.61	28.10	22.65
SEm (±)	**0.46**	**0.10**	**0.64**	**0.38**	**0.67**	**0.52**
LSD (0.05)	**1.60**	**0.35**	**2.21**	**NS**	**2.31**	**NS**

Table 3: Growth and yield attributes of chickpea under different treatments (pooled over 3 years)

Treatments	Plant height (cm)	Primary branches Plant^{-1}	Secondary branches plant^{-1}	Pod plant^{-1}	100- seed weight (g)
Tillage					
Conventional	55.74	4.25	26.09	29.70	21.25
Reduced	51.78	3.95	23.60	27.20	21.13
Zero	50.93	3.90	23.11	24.32	21.01
SEm (±)	**2.50**	**0.12**	**2.35**	**2.43**	**0.18**
LSD (0.05)	**NS**	**0.32**	**NS**	**NS**	**NS**
Mulching with rice straw @ 2.5 t ha^{-1} (dry wt. basis)					
With mulching	56.69	4.27	26.36	31.78	21.28
No mulching	48.94	3.79	22.17	22.36	20.96
SEm (±)	**1.66**	**0.13**	**1.06**	**1.62**	**0.12**
LSD (0.05)	**5.75**	**0.19**	**3.69**	**5.6**	**NS**

Table 4a: Seed yield (kg ha^{-1}) of chickpea under different treatments

Treatments	Seed yield (kg ha^{-1})			Pooled	REY of chickpea
	2016-17	2017-18	2018-19		(kg ha^{-1})
Tillage					
Conventional	1108	1110	1179	1123	4346.62
Reduced	1043	1056	1119	1064	4118.35
Zero	1047	1018	1099	1046	4048.86
SEm (±)	**21.66**	**16.12**	**19.24**	**18.28**	**82.76**
LSD (0.05)	**NS**	**63.27**	**75.52**	**71.75**	**324.85**
Mulching with rice straw @ 2.5 t ha^{-1} (dry wt. basis)					
With mulching	1120	1099	1175	1122	4345.10
No mulching	1011	1024	1089	1032	3997.46
SEm (±)	**15.65**	**12.25**	**16.19**	**14.69**	**69.93**
LSD (0.05)	**54.15**	**42.38**	**56.02**	**50.83**	**241.96**

Sale price of rice seeds = Rs.1550 q^{-1}
Sale price of chickpea seeds = Rs. 6000 q^{-1}

Table 4b: Seed yield (kg ha^{-1}) of chickpea under different treatments (3 years pooled)

Tillage practice		Conservation practice		Mean
		Mulching	No mulching	
Conventional		1169	1076	**1123**
Reduced		1104	1023	**1064**
Zero		1094	998	**1046**
Mean		**1122**	**1032**	
LSD (0.05)	**Tillage**		**71.75**	
	Conservation practice		**50.83**	
	Interaction		**NS**	

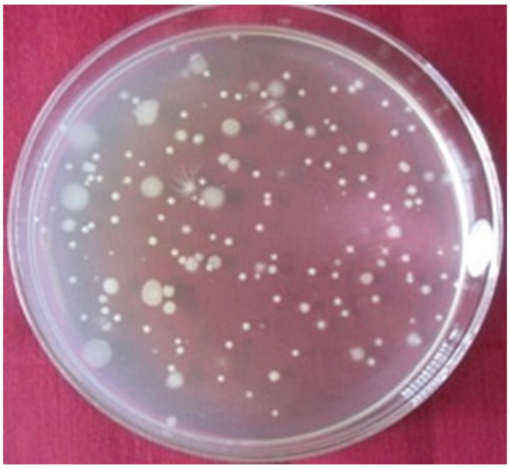
Table 5: Stover yield and harvest index of chickpea under different practice (pooled)

Treatments	Stover yield (kg ha^{-1})	Harvest Index (%)
Tillage		
Conventional	2403	32.88
Reduced	2334	32.38
Zero	2338	31.94
S. Em (±)	**28.89**	**0.68**
LSD (0.05)	**NS**	**NS**
Mulching with rice straw @ 2.5 t ha^{-1} (dry wt. basis)		
With mulching	2412	32.79
No mulching	2302	32.00
S. Em (±)	**18.67**	**0.26**
LSD (0.05)	**64.60**	**NS**

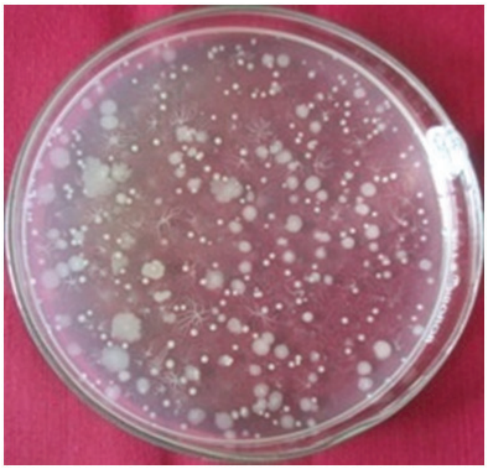
Table 6: Soil available nutrients at the end of experiment under different treatments

Treatment	Soil Available nutrients (kg ha^{-1})		
	N	P_2O_5	K_2O
Tillage			
Conventional	284.40	19.24	148.68
Reduced	282.70	18.82	147.65
Zero	282.62	18.71	147.13
S. Em (±)	**2.57**	**0.70**	**2.87**
LSD (0.05)	**NS**	**NS**	**NS**
Mulching with rice straw @ 2.5 t ha^{-1} (dry wt. basis)			
With mulching	286.21	19.94	150.47
No mulching	280.27	17.91	145.18
S. Em (±)	**1.26**	**0.26**	**1.40**
LSD (0.05)	**4.36**	**0.90**	**4.84**

was poured over the surface of aliquot and mixed with media by rotating clockwise and anti-clockwise direction to have uniform distribution. The plates were incubated in inverted position in BOD incubator at 30+1^{0}C for 2-5 days depending on the organisms. At the end of incubation period, the number of colonies appearing in each plate calculated and the average for each dilution was recorded. Plate having < 30 colonies and > 300 colonies were not counted. The bacterial and fungal populations were counted on third and fifth day

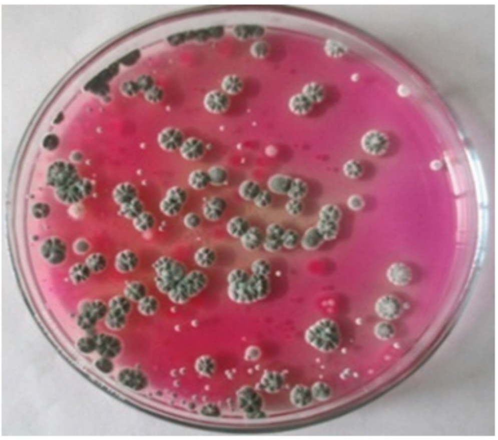


No mulching



With mulching

Plate 1: Soil bacterial populations at the end of experiment under conventional tillage



No mulching

With mulching

Plate 2: Soil fungal populations at the end of experiment under conventional tillage

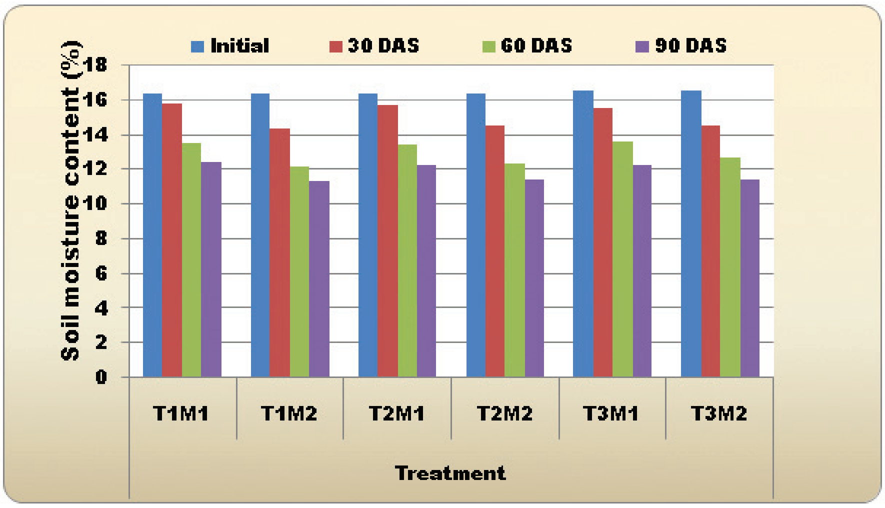


Fig. 1: Soil moisture (%) under different tillage practices (mean of 3 years)

Table 7: Economics of chickpea under different treatments (Pooled of 3 years)

Treatment	Economics			B:C
	Gross return (Rs.ha^{-1})	Cost (Rs.ha^{-1})	Net return (Rs.ha^{-1})	
Tillage				
Conventional tillage	67373	28070	39303	2.40
Reduced tillage	63834	26820	37014	2.38
Zero tillage	62756	26420	36338	2.37
S. Em (±)	**482.14**	**-**	**430.05**	**0.004**
LSD (0.05)	**1892.53**	-	**1688.06**	**0.016**
Mulching with rice straw @ 2.5 t ha^{-1} (dry wt. basis)				
With mulching	67349	28217	39132	2.39
No mulching	61961	25989	35972	2.38
S. Em (±)	**285.32**	**-**	**178.62**	**0.003**
LSD (0.05)	**987.22**	**-**	**701.13**	**NS**

of incubation, respectively. Counting of colonies was expressed as the number of colony forming unit (cfu) g^{-1} dry soil weight of the sample. Total viable count was calculated using the following formula.

Total viable count = Average number of colonies x size of Aliquot x Dilution Factor

Based on prevailing market prices of inputs and outputs, the economic parameters *viz.* gross return, net return and benefit:cost was calculated. The data recorded on different aspects were tabulated and analysis of variance for Spilt Plot Design was worked out as per the standard procedure (Panse and Sukhatme, 1985). The significance or non-significance of the variances due to treatment effects was tested by 'F' test. Whenever 'F' test was found significant, critical difference (CD) value was calculated at p=0.05 to compare the treatment means.

RESULTS AND DISCUSSION

Growth and yield attributes

Tillage practices had significant effect on initial plant stand m^{-2} of chickpea in all the years and on final plant stand m^{-2} in 2016-17 (Table 2). Higher plant stand m^{-2} under conventional tillage as compared to other two tillage practices was due to better seed germination and crop establishment because of better land preparation and proper seed placement associated with this tillage practice. However, the lowest plant stand in zero tillage was due to improper seed placement in some places and lower seed germination due to expose of seeds in no mulching plots, as some of the seeds have fallen on the soil surface outside the rows. In untilled winter rice fallow lands, when the land was suitable for operation of tractor drawn zero till seed drill machine, the soil became hard due to which the rows were not formed deeply and uniformly in whole area. Mulching treatment showed significant effect on plant stand m^{-2} (Table 2). Higher plant stands m^{-2} with mulching might be due to better seed germination and crop establishment because of better seed and soil coverage by mulching material, soil moisture conservation and also less infestation of insect-pest and diseases associated with mulching treatment over no mulching (Deka *et al.*, 2020).

Tillage practices had significant effect on number of primary branches plant^{-1} (Table 3). Conventional tillage recorded significantly higher number of primary branches plant^{-1}as compared to zero tillage. However, mulching had significant effect on all the growth and yield attributes except 100-seed weight over no mulching. Significantly higher values in plant height (cm), number of primary and secondary branches plant^{-1} and pods plant^{-1} were observed with mulching over no mulching.

Yield of chickpea

Both tillage and mulching practices had significant effect on seed yield and REY of chickpea (Table 4). Significantly higher seed yield and REY of chickpea was found in conventional tillage as compared to zero tillage and it was at par with reduced tillage . This might be attributed to higher plant stand m^{-2}, higher growth and yield attributes associated with this tillage practice. Conventional tillage with mulching recorded the highest seed yield (1169 kg ha^{-1}) as compared to reduced and zero tillage with mulching (Table 4a). Significantly higher values of seed yield and REY of chickpea were noted in mulching plot as compared to no mulching. The result is in agreement with the result of Rajak and Prasad (2017). This might be attributed to higher plant stand m^{-2}, higher values of growth and yield attributes, more soil moisture conservation, better soil microbial population and more availability of soil nutrient to plants. Mulching had significant effect on stover yield of chickpea (Table 5). Significantly higher stover yield (2412 kg ha^{-1}) was found with mulching over no mulching (2302 kg ha^{-1}).

Soil nutrient (NPK) status

Tillage practices had no significant effect on the available N, P_2O_5 and K_2O content in soil (Table 6). However, mulching brought about significant differences on these. Mulching recorded significantly higher values of soil available N, P_2O_5 and K_2O content (286.21, 19.94 and 150.47 kgha^{-1}, respectively) as compared to no mulching. This might be attributed to inclusion of more organic matter and higher soil microbial populations resulting in rapid breakdown of organic matter in the soil and availability of more nutrients to the plants (Dilip Kumar *et al*., 1990, Lal *et al.*, 1996 and Bhardwaj, 2013).

Soil microbial populations

Population of soil microorganisms (bacterial and fungal populations) were counted and are presented in Plate 1 and Plate 2. Higher number of soil bacteria (Plate 1) and fungi (Plate 2) were observed under mulching over no mulching and this might be attributed to better soil moisture conservation, higher organic matter content in soil and favourable soil environmental condition for proper growth and development of soil micro-organisms and their activities associated with mulching treatment (Ali *et al.,* 2012; Chakrabarty and Kalita, 2020; Deka, *et al.,* 2020). Bhardwaj (2013) reported that mulching stimulates soil micro-organisms due to loose, well aerated soil conditions, uniform soil moisture and temperature.

Periodical soil moisture content (%)

The effect of tillage practices and mulching on soil moisture content is presented by Fig. 1. The initial soil moisture in all the treatment combinations was almost same. However, periodical soil moisture depletion pattern revealed that tillage practices with mulching accounted for better soil moisture conservation throughout the crop growing period over no mulching. This might be attributed to coverage of soil surface by mulching materials that restricted the evaporation loss of residual soil moisture (Simon *et al.*, 2009; Bhardwaj, 2013; Rajak and Prasad, 2017; Chakrabarty and Kalita, 2020; Deka *et al.,* 2020).

Economics

Tillage practices and mulching had significant effect on economics of chickpea (Table 7). Conventional tillage recorded significantly higher gross (Rs. 67373/- ha^{-1}) and net monetary return (Rs. 39303/- ha^{-1}) as well as B:C ratio (2.40) as compared to other tillage practices. Mulching treatment recorded significantly higher gross (Rs. 67349/- ha^{-1}) and net monetary returns (Rs. 39132/ - ha^{-1}) over no mulching. The higher economic values recorded with conventional tillage and mulching treatment was owing to higher seed yield associated with these treatments.

CONCLUSIONS

From this study, it may be concluded that two harrowings followed by one planking and application of rice straw mulch @ 2.5 t ha^{-1} after sowing of chickpea is an effective agro-technique for growing of chickpea in rice-chickpea system under rain-fed condition. It will also help in increasing area and productivity of chickpea along with building up of microbial populations and nutrient status in soil.

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