E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(6): 474-477
Received: 26-03-2024
Accepted: 30-04-2024

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Effect of different tillage methods on growth parameters and economics of pulse crops grown in mechanically harvested lowland rice

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6Sg.919

Abstract
A field experiment was conducted during *rabi* season of 2022-23, at siddapur research farm, Regional Agricultural Research Station (RARS), Warangal, Telangana, India to study the "Effect of different tillage methods on growth parameters and economics of pulse crops grown in mechanically harvested lowland rice". The experiment was laid out in split plot design replicated thrice having three tillage practices (Zero tillage T_1: Reduced tillage T_2: Minimum tillage T_3) in main plots and four *rabi* pulse crops (Chickpea S_1; Greengram S_2; Blackgram S_3; Cowpea S_4) in sub-plots with total twelve treatment combinations. Results of the experiment revealed that economics of pulse crops were influenced by tillage practices, significantly higher gross returns (Rs 184814 ha^{-1}), net returns (Rs 106639 ha^{-1}) and B:C ratio (2.36) was obtained with reduced tillage (T_2). Whereas, among sub-plot treatments significantly higher gross returns (Rs 192284 ha^{-1}), net returns (Rs 116067 ha^{-1}) and B:C ratio (2.52) was generated by rice-greengram sequence.

Keywords: Tillage, rice fallows, greengram, chickpea, blackgram, cowpea

1. Introduction
Pulses are known for their great role in soil fertility, human health and providing global food security as well as nutritional security. Pulses form an integral part of the Indian diet, providing much needed protein to the carbohydrate rich diet. The total world acreage under pulses is about 93.18 M ha, with a production of 89.82 Mt at 964 kg ha^{-1} yield level (DPD 2021-22). India, with >28 M ha of pulse cultivation area, is the largest pulse producing country in the world. It ranks first in area with 31% and production with 28% respectively.

At present rice is producing in excess of requirements in many states of our country especially in Telangana but facing shortage of other crops like pulses. In India, around 30% of the area under rice production remains fallow in the subsequent winter *rabi* season (DAC, 2011) [4]. Large areas are left fallow during *rabi* season in India after harvest of rice crop in India. Therefore, the goal of agriculture scientists should be to study and identify suitable cropping sequences for rice fallows through crop diversification (Pratibha *et al.*, 1997) [7].

There is a need for diversification of rice crops with suitable pulse crops by bringing more area under pulses as they are best suitable for rice based cropping system because of their shorter duration and ability to grow by utilizing residual moisture in fallows. Pulses endowed with unique characteristics of biological N-fixation (BNF), deep rooted, and soil-fertility restoration property, hence they can be best fitted in rice fallows (Ali *et al.*, 2014).

For successful cultivation of pulse crops after harvest of rice, a suitable conservation tillage is required for conserving residual moisture, successful seed germination and supporting growth and development of crops. Higher yield and economics in pulses were reported with reduced tillage after harvest of rice (Pratibha *et al.*, 1997) [7]. This experiment was intended to study and find out the suitable tillage practice and pulse crop which can benefit farmers economically.

2. Materials and Methods
The experiment was carried out at at siddapur research farm, Regional Agricultural Research Station (RARS), Warangal.

The site is situated at an altitude of 351m and geographical bearing of 18°05'35.9"N latitude and 79°35'48.6"E longitude. According to Troll's climatic classification, it falls under Semi-Arid Tropical region (SAT). The experimental site is in Southern Telangana Agro-Climatic Zone. There was no rainfall recorded during the crop growth period. The results of the chemical analysis of the soil showed that the soil test site with pH of 7.66 and EC of 0.38 d Sm^{-1}. The experiment comprised 12 treatment combinations laid out in a split-plot design with three replications. There were three different tillage methods *viz*., T_1: Zero tillage (Herbicide spray + seed dibbling) T_2: Reduced tillage (Twice cultivator and once rotavator) T_3: Minimum tillage (once cultivator and once rotavator) included as main-plot treatments and four pulse crops (S_1: Bengalgram, S_2: Greengram, S_3: Blackgram and S_4: Cowpea) included as sub-plot treatments. This experiment was carried out in total of 36 plots and each plot having gross plot size 6.0 m x 4.0 m and net plot size 4.2 m x 3.6 m by having 0.15 m distance between each plot and 1m distance between each replication. Immediately after harvest rice the land was prepared as per the treatments and sowing was done. Recommended dosage fertilizers were applied as Urea, DAP and MOP and seeds were sown with prescribed seed rates according to crops. All crops were sown with spacing of 30 cm between rows and 10 cm between plants. Data on growth parameters were taken in due time and economics were calculated on the basis of prevailing market price of the produce.

Note: Observations on growth parameters were compared on mean basis without statistical analysis as different crops having genetically distinct characteristics cannot be compared in sub plots, while influence of tillage and crops on economics were analysed statistically and interpretation of the data was done as per the split plot design specified by Fisher (1988) [9].

3. Results and Discussion

3.1 Growth parameters

The data from Table.1 revealed that growth parameters were influenced by tillage practices. On a mean comparative basis, in chickpea, greengram, blackgram and cowpea reduced tillage (T_2) recorded highest initial population (3.14, 3.21, 3.13 and 3.18 Lakhs ha^{-1}) and final population (3.11, 3.08, 3.08 and 2.96 Lakhs ha^{-1}) respectively. Plant height and leaf area of pulse crops were not varied much at vegetative stage, however at harvest stage, on mean basis higher plant height (35.1, 43.4, 39.2 and 55.4 cm) and leaf area (458.5, 563.3, 454.3 and 769.6 cm^2 $plant^{-1}$) were recorded with reduced tillage (T_2) in chickpea, greengram, blackgram and cowpea respectively. These results are in line with Abid *et al.* (2018) [1].

From Table. 2 it was clear that reduced tillage (T_2) consistently recorded higher number of nodules at 30 DAS (8.0, 29.5, 29.0 and 34.3) and at 40 DAS (19.6, 52.1, 41.8 and 45.9) in chickpea, greengram, blackgram and cowpea respectively. In a similar study by Vaishnav *et al.* (2023) [8], it was observed that intensive tillage produced more active nodules than zero tillage in blackgram. There were minimal differences in dry matter production among tillage practices in all crops at vegetative stage. However, reduced tillage recorded higher dry matter accumulation at flowering and harvest stages on mean comparative basis in all crops. These results are supported by earlier findings of Aikins *et al.* (2010) [2], who reported that treatment with intensive tillage recorded higher dry matter compared to zero tillage in cowpea. Days to 50% flowering and days to maturity were not influenced by tillage practices and nearly same with minimal differences among tillage practices in all crops.

3.2 Economics

Experimental findings revealed that, among tillage practices highest gross returns was obtained with reduced tillage (Rs 184814 ha^{-1}) followed by minimum tillage (Rs 179455 ha^{-1}) and lowest was obtained with zero tillage (Rs 171062 ha^{-1}). Higher gross return in reduced tillage was due to higher seed yields recorded with this tillage practice. The gross return was increased as the intensity of tillage among treatments increased. These results are in line with Kumar *et al.* (2016) [6]. Among sub plot treatments, rice-greengram sequence recorded higher gross returns (Rs 192284 ha^{-1}) followed by rice-blackgram (Rs 188913 ha^{-1}) and rice-chickpea (Rs 174866 ha^{-1}) while rice-cowpea (Rs 157713 ha^{-1}) recorded the least gross returns. Higher production potential of greengram coupled with the high selling price resulted in higher gross returns.

Similarly, higher net returns were generated with reduced tillage (Rs 106639 ha^{-1}) followed by minimum tillage (Rs 102055 ha^{-1}) and zero tillage (Rs 95162 ha^{-1}). Higher net reruns in reduced tillage could be attributed to higher seed yield and gross returns associated with this treatment. These results are in line with Kumar *et al.* (2016) [6]. Among rice based cropping systems, rice-greengram system generated highest net returns (Rs 116067 ha^{-1}) compared other systems, followed by rice-blackgram (Rs 110713 ha^{-1}) and rice-chickpea (Rs 95432 ha^{-1}). Whereas, lowest net returns (Rs 82930 ha^{-1}) was generated in rice-cowpea system. Higher gross returns, combined with lower cost of cultivation and a higher selling price, resulted in higher net returns in the rice-greengram system.

Experimental findings revealed that, among main plot treatments, reduced tillage was found to be more profitable compared to others, with a B:C ratio of 2.36 for every extra rupee spent. On the other hand, minimum tillage (2.32) was next best, followed by zero tillage (2.25). These results are in line with Pratibha *et al.* (1997) [7]. Among rice based cropping systems, rice-greengram (2.52) system recorded higher B:C ratio, followed by rice-blackgram (2.41), rice-chickpea (2.20) and rice-cowpea (2.11). Higher gross monetary returns with lower cultivation costs in the rice-greengram system resulted in a higher B:C ratio, making it the most profitable system for every rupee spent. On the other hand, with the lowest B:C ratio, the rice-cowpea system was found to be less profitable than other cropping systems, making cowpea the least suitable for rice fallows.

4. Conclusion

From the research results of the present study, it is clear that zero tillage (T_1) is not at all suitable in mechanically harvested lowland rice, which might be due to high soil compaction, negative impact on nutrient uptake and growth of pulse crops. On the other hand, crops grown in reduced tillage performed very well and recorded higher growth parameters. By this results we can conclude that reduced tillage have good potential to generate higher monetary returns provide and better growth conditions for pulse crops grown under mechanically harvested lowland rice. Rice fallows can be efficiently diversified with greengram, due to higher net returns and B:C ratio with this sequence.

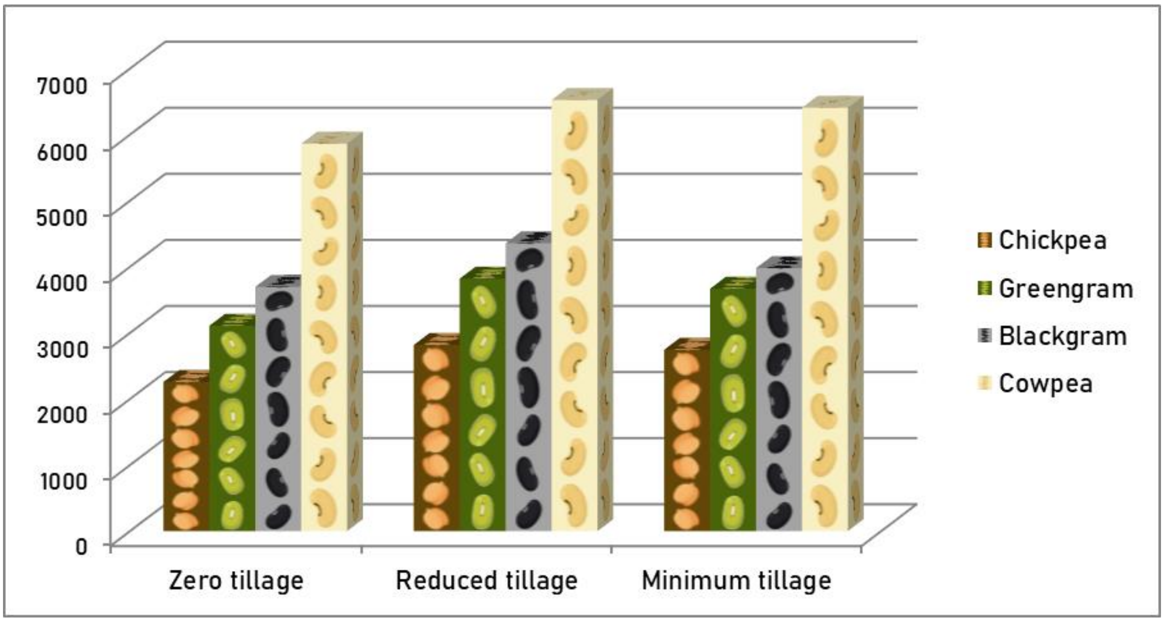

Fig 1: Dry matter production (kg ha^{-1}) at harvest stage under different tillage methods in pulse crops

Table 1: Effect of tillage practices on plant population (Lakhs ha^{-1}), plant height (cm), leaf area (cm^2 plant^{-1}) of *rabi* pulse crops

Treatment	Plant population (Lakhs ha^{-1})		Plant height (cm)			Leaf area (cm^2 plant^{-1})	
	Initial	Final	Vegetative	Flowering	Harvest	Vegetative	Flowering
Chickpea							
T_1	3.04	2.85	13.8	21.9	29.4	97.0	412.4
T_2	3.14	3.11	16.1	26.4	35.1	98.3	458.5
T_3	3.16	3.00	15.8	25.6	32.7	95.9	437.4
Greengram							
T_1	3.10	2.94	17.4	28.8	36.5	249.3	509.5
T_2	3.21	3.08	18.6	35.8	43.4	243.9	563.3
T_3	3.18	2.98	18.6	32.6	41.9	257.4	528.3
Blackgram							
T_1	2.85	2.78	14.5	24.2	35.2	139.7	399.9
T_2	3.13	3.08	16.4	28.4	39.2	146.6	454.3
T_3	3.11	2.97	15.3	26.3	37.3	142.7	439.8
Cowpea							
T_1	2.91	2.75	30.5	45.8	49.2	435.4	701.1
T_2	3.18	2.96	31.8	49.4	55.4	443.3	769.6
T_3	3.04	2.87	30.9	47.8	53.8	437.7	721.3

Table 2: Effect of tillage practices on number of nodules (plant^{-1}), dry matter production (kg ha^{-1}), days to 50% flowering and days to maturity of *rabi* pulse crops

Treatment	No. of nodules (plant^{-1})		Dry matter production (kg ha^{-1})			Days to 50% flowering	Days to maturity
	30 DAS	45 DAS	Vegetative	Flowering	Harvest		
Chickpea							
T_1	5.3	13.5	419	1024	2256	46.5	82.0
T_2	8.0	19.6	436	1271	2816	45.5	81.2
T_3	6.9	17.2	427	1228	2742	45.5	82.3
Greengram							
T_1	23.5	38.9	613	1398	3107	31.1	66.0
T_2	29.5	52.1	630	1680	3819	30.6	64.2
T_3	27.7	43.4	586	1542	3668	31.0	64.5
Blackgram							
T_1	22.2	31.0	713.2	1489	3695	45.0	71.9
T_2	29.0	41.8	759.0	1688	4356	44.1	70.6
T_3	25.2	37.6	738.0	1645	3979	44.3	71.1
Cowpea							
T_1	27.5	35.7	1398	3462	5863	59.3	93.1
T_2	34.3	45.9	1535	3715	6524	59.1	91.9
T_3	31.8	41.7	1445	3587	6406	59.8	92.0

Table 3: Economics of *rabi* pulse crops under different tillage methods

Treatment	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Main plots (Tillage practices)				
T_1: Zero tillage	75900	171062	95162	2.25
T_2: Reduced tillage	78175	184814	106639	2.36
T_3: Minimum tillage	77400	179455	102055	2.32
SEM (±)	-	1235	1234.6	0.02
CD (p=0.05)	-	4847.7	4847.7	0.06
Sub plots (Rabi pulses)				
S_1: Chickpea	79433	174866	95432	2.20
S_2: Greengram	76217	192284	116067	2.52
S_3: Blackgram	78200	188913	110713	2.41
S_4: Cowpea	74783	157713	82930	2.11
SEM (±)	-	1579	1579.1	0.02
CD (p=0.05)	-	4691.8	4691.8	0.06
Sub treatment at same level of main treatment				
SEM (±)	-	2735.1	2735.1	0.04
CD (p=0.05)	-	NS	NS	NS
Main treatment at same level of sub treatment				
SEM (±)	-	2671.1	2671.1	0.03
CD (p=0.05)	-	NS	NS	NS

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