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EFFECT OF TILLAGE PRACTICES ON GROWTH AND YIELD OF SAFFLOWER UNDER RAINFED MIDLAND CONDITION OF CHHATTISGARH

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ABSTRACT

A field experiment was conducted during *rabi* season of 2014-15 to study effect of tillage practices on growth, development and yield of safflower under rainfed midland condition of Chhattisgarh. The results revealed that significantly highest plant stand m^{-2} (37.78), branches $plant^{-1}$ (8.01) dry biomass (30.10 g $plant^{-1}$), at harvest under treatment T_2. But at 90 DAS plant height (108.30 cm), leaf area (cm^2), LAI,CGR and RGR was also recorded significantly highest under treatment T_2 (Minimum tillage and line sowing of seeds at 3[rd] DAH of rice) while, it was found *at par* with treatment T_1 (Zero tillage direct drilling of seeds at 2[nd] DAH of rice). Yield and yield attributes like capitulums $plant^{-1}$ (20), seeds $capitulum^{-1}$ (19.98), seed and stover yield (13.80 and 41.30 q ha^{-1}, respectively) significantly highest under treatment T_2. But it was found statistically similar with treatment T_1, except of stover yield, which was significantly highest over rest of the treatments. Seed index (g) and harvest index (%) did not exert significant difference due to tillage practices. All characters were found lowest under the treatment T_4 (Farmer's practices - seeds and fertilizers broadcasting at 12[th] DAH of rice).

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INTRODUCTION

Safflower (*Carthamus tinctorius)* is oneof the important oilseed crops of crops of world.The seeds contain 24 to 36 per cent oil, which isconsidered to be good for health as cooking oil (Manohakumar *et al.*, 2005).Its seed contain 35% oil and occupies unique position among oilseed crops due to high polyunsaturated fatty acid contents, which may reach up to 90% (Ba-almal *et al.,* 2008; Beyyavas *et al.*, 2011). Safflower can be grown under harsh climatic conditions due to high cold (Johnson and Li, 2008), salinity (Faraj *et al.,* 2013) and drought tolerance (Amini *et al.*, 2013). Safflower is bestowed with a unique feature of salt as well as drought tolerance due to partially xerophytic nature, in addition to deep and extensive root system making efficient use of reserved soil moisture. It can safely be grown as a potential *rabi* crop in unirrigated areas (Raju *et al.,* 2013). Though, safflower is reputed to be a drought tolerant crop, actually this would appear to be true so, as long as there is reserve moisture in the soil. In order to increase crop production in each country where the farming area is limited, it is necessary to increase a land utilization rate by introducing the double cropping system. Rice-based cropping system is most dominant cropping system of India. Thirty rice based cropping system are identified in different states of India. Indian agriculture is traditionally a system of rainfed farming.In Chhattisgarh, the existing practices of rice based rainfed double crops are rice-gram, rice-lathyrus, rice-linseed, rice-pea, rice-lentil etc. Double cropping system in based on growing of different short growth period crop in different period on the same land in one year (Pasary and Noormohamadi, 2011). A recent study showed that growing safflower brings in higher income than barley, lentil and chickpea (Yau, 2004). The benefits of double cropping included as optimum usage of land, water, agricultural machine, increasing of income farmers, and obtain ecological benefit as increasing biodiversity, maintaining the sustainability of agricultural production systems, breaking of pest and disease cycle, infiltration of soil, increasing of soil organic matter and decreasing weeds competition (Pasary and Noormohamadi, 2011). Tillage of the soil has been used to prepare a seedbed, make soil surface more permeable and favors a high rate of infiltration also, provide better seed contact, better root growth and reduce moisture loss, kill weeds, incorporate nutrients, and manage crop residues (FAO, 2014). Tillage plays an important role in the productivity of crop (Deva, 2015). Conventional tillage (CT) that involves ploughing followed by cultivation has been practiced for centuries. However, CT leads to soil erosion and loss of organic matter leading to unsustainability of agriculture. As a remedy, conservation tillage that includes minimum tillage (MT) and no tillage (NT) has been widely accepted by farmers in many developed countries. Many studies showed that NT has economic, ecological, environmental, and social benefits. These include erosion control, water conservation, nutrient cycling, time and fossil fuel saving, less wear and tear on machinery, and soil carbon sequestration (Lal, 2007).

The objective of this study was to identify suitable tillage practices for better growth and yield of safflower under rain fed midland farming of Chhattisgarh since no study has been reported.

MATERIALS AND METHODS

A field experiment was carried out on midland sandy loam (*Inceptisols*) in rainfed rice-based cropping system during *rabi* 2014-2015 at research cum instructional farm IGKV Raipur, Chhattisgarh. The soil of the experimental field was sandy loam in texture (*Inceptisols*), bulk density 1.48 g m^3 (0-15 cm), particle density 2.57 g m^3 and porosity 41%. Neutral in soil reaction (6.6 pH) and had medium organic carbon (0.72%), low available nitrogen (219 kg ha^{-1}), medium available phosphorus (16.70 kg ha^{-1}) and medium exchangeable potassium (322.2 kg ha^{-1}) with normal electrical conductivity.The experiment was laid out in randomized block design with three replications. The treatment consisted of four tillage practices *viz.* T_1- Zero tillage direct drilling of seeds and fertilizers at 2nd days after harvesting of rice, T_2 - Minimum tillage and line sowing of seeds at 3rd days after harvesting of rice, T_3-Minimum tillage at 6th days after harvesting of rice, T_4-Farmer practice broadcasting seeds and fertilizer at 12th days after harvesting of rice. The sowing of different crop in treatment T_1, T_2,T_3 and T_4 was done on 31 October, 1st, 4th and 10th November 2014, respectively and harvesting of crop done 18 February 2015. All recommended package of practices of linseed crop were adopted during study period. Five plants were sampled representing each replicated treatment for all pre and post harvest observations. LAI, CGR and RGR were calculated by using the formulae described by Radford (1967):

LAI = Leaf area / Land area

CGR (g day^{-1} $plant^{-1}$) = W_2-W_1/ t_2 –t_1

RGR (g g^{-1} day^{-1} $plant^{-1}$) = $L_n w_2$- $L_n w_1$/ t_2-t_1

Where, W_2-W_1 = Difference in oven dry biomass at the interval, t_2 –t_1 = time interval in days and $L_n w_1$ and $L_n w_2$ are the natural logarithm of total dry weight of plant at the time interval t_2 and t_1 respectively.

The data obtained from various characters under study were analyzed by the method of analysis of variance as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant population and growth characters

Plant population was observed at 25 DAS and at harvest and data are presented in Table 1. The findings revealed that the plant population was significantly influenced by different tillage practices. At both the periods of observation significantly higher plant population (42.78 plants m^{-2} at 25 DAS and 37.78 plants m^{-2} at harvest, respectively) was recorded under treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice), but it was statistically similar with treatment T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice). Significantly lowest plant population (33.20 and 30.00 plants m^{-2} at 25 DAS and at harvest, respectively) was recorded under treatment T_4 (Farmer's practice - seeds and fertilizers broadcasting at 12th

Table 1: Plant population and plant height (cm) as influenced by tillage practices

Treatment	Plant population (m^{-2})		Plant height (cm)			
	25 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	41.37	35.00	15.57	85.50	106.63	115.60
T_2	42.78	37.78	16.53	85.65	108.30	114.77
T_3	37.50	32.80	14.74	77.97	101.43	113.01
T_4	33.20	30.00	13.05	71.20	96.53	108.51
SEm ±	1.38	1.21	0.50	1.10	1.49	3.81
CD (P=0.05)	4.78	4.17	1.72	3.81	5.18	NS

Table 2: Branches $plant^{-1}$ and dry biomass $plant^{-1}$ (g) as influenced by tillage practices

Treatment	Branches $plant^{-1}$				Dry biomass $plant^{-1}$ (g)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	1.33	4.14	7.60	7.63	4.14	10.50	20.74	25.20
T_2	1.44	4.32	7.80	8.01	4.17	11.12	23.03	30.10
T_3	1.40	4.02	6.57	6.63	4.15	10.62	22.05	24.77
T_4	1.33	3.87	5.90	5.93	4.11	9.69	17.78	21.27
SEm ±	0.05	0.08	0.28	0.39	0.05	0.13	0.26	1.31
CD (P=0.05)	NS	0.28	0.96	1.36	NS	0.45	0.88	4.5

Table 3: Leaf area (cm^{-2}) and Leaf area index of Safflower as influenced by tillage practices

Treatment	Leaf area (cm^{-2})			Leaf area index		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	9.43	392.66	1509.71	0.031	2.02	5.42
T_2	13.75	476.01	1667.03	0.044	2.49	5.92
T_3	12.08	417.27	1622.12	0.032	1.97	5.64
T_4	7.92	298.79	1232.32	0.024	1.40	3.62
SEm ±	0.46	13.45	79.35	0.002	0.09	0.16
CD (P=0.05)	1.59	46.56	274.60	0.006	0.32	0.56

Table 4: Yield attributes and yields of safflower crop as influenced by tillage practices

Treatment	Number of capitulum plant^{1}	Number of seeds capitulum^{-1}	Seed index (g)	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	HI(%)
T_1	19.60	19.27	5.45	13.00	37.98	25.54
T_2	20.00	19.98	5.46	13.80	41.30	25.04
T_3	18.41	18.37	5.39	11.05	33.37	24.88
T_4	15.08	17.95	5.30	8.56	26.00	24.77
SEm ±	0.42	0.29	0.081	0.32	0.84	0.59
CD (P=0.05)	1.46	0.99	NS	1.10	2.91	NS

T_1 – Zero tillage direct drilling of seeds 2nd DAH of rice; T_2 – Minimum tillage and line sowing of seeds at 3rd DAH of rice; T_3 – Minimum tillage and line sowing of seeds at 6th DAH of rice; T_4 – Farmer's practice- seeds and fertilizers broadcasting at 12th DAH of rice

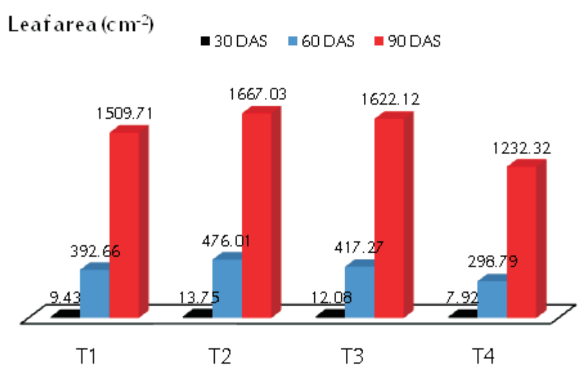

Figure 1: Leaf area of safflower

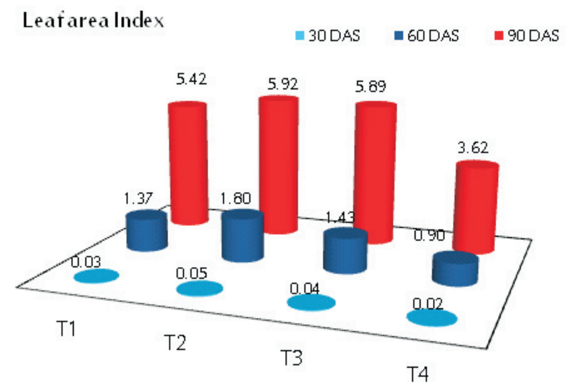

Figure 2: Leaf area index of safflower

DAH of rice). The highest plant population recorded under T_2 might be owing to good placement of seeds and higher moisture content in soil for better germination of seeds. Present investigation is more or less similar to the reports of Rathore *et al.* (1998).

Plant height was measured at 30, 60, 90 DAS and at harvest and data are presented in Table 1. Significantly tallest plant (16.53, 85.65 and 108.30 cm at 30, 60 and 90 DAS respectively) was recorded under treatment T_2 (Minimum tillage and line sowing of seeds at 3rdDAH of rice). But, it was found *at par* with treatment T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice). But, at harvest, plant height was not significantly influenced due to tillage practices. The tallest plant was observed under treatment T_2 might be due to good availability of moisture and nutrients in this treatment which proved better than treatment T_3 (Minimum tillage and line sowing of seeds at 6th DAH of rice) because loss of moisture during sowing time. These observations are also in agreement with the results given by earlier workers (Rathore *et al.,* 1998 and Kumar *et al.,* 2006).The number of branches plant^{1} was observed at 30, 60, 90 DAS and at harvest and data are presented in Table 2. At 30 DAS, branches were not significantly varied by tillage practices. While, at 60 DAS (4.32 branches plant^{1}), 90 DAS (7.80 branches plant^{1}) and at harvest (8.01 branches plant^{-1}), significantly highest number of branches was observed in treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice) However, it was statistically *at par* with treatment T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice). Least number of branches plant^{1} was observed throughout the crop growth period under the treatment T_4 (Farmer's practice - seeds and fertilizers broadcasting at 12th DAH of rice). Higher number of branches plant^{1} in T_2& T_1 mainly because of favorable soil conditions to the plant. Data with respect dry biomass (g plant-1) was presented in Table 2. No significant difference on dry biomass of plant by tillage practices was noted at 30 DAS. But at 60 DAS (11.12 g plant^{1}), 90 DAS (23.03 g plant^{1}) and at harvest (30.10 g plant^{1}), it was significantly higher under treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice) as compared to others. Least dry biomass of plant was noticed in treatment T_4 (Farmer's practice - seed and fertilizers are broadcasting at 12th DAH of rice) throughout the crop growth period. Higher dry biomass plant^{1} recorded under treatment T_2 is also supported by higher LAI under this treatment. Similar result was also reported by Yau *et al.* (2010)

Leaf area and leaf area index

Leaf area (cm^2 plant^{1}) and leaf area index (LAI) of safflower was recorded at 30, 60 and 90 DAS (Table 3 and Fig. 1 and 2).The data revealed that the leaf area plant^{1} and leaf area index increased up to the 90 DAS. Treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice) resulted significantly higher leaf area (13.75, 476.01 and 1667.03 cm^2 plant^{1} at 30, 60 and 90 DAS, respectively) as compared to rest of the treatments. However, at 60 and 90 DAS it was found statistically *at par* with treatment T_3 (Minimum tillage and line sowing of seeds at 6thDAH of rice). The higher leaf area under treatments T_1 and T_2 might be due to higher number of leaves plant^{1}. On contrary Chitale (2005) they reported reduced leaf area under seeding of wheat after one ploughing and planking.

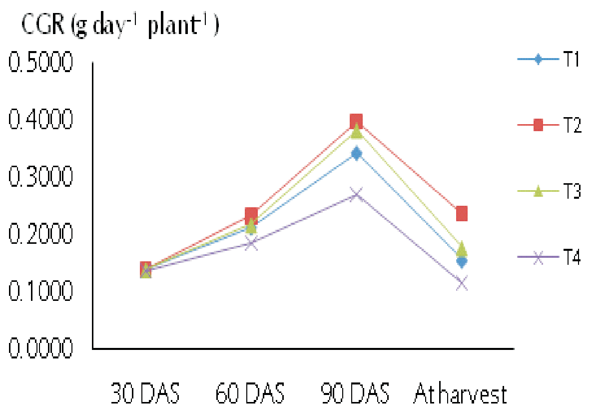

Figure 3: CGR (g day^{-1} plant^{-1}) of safflower

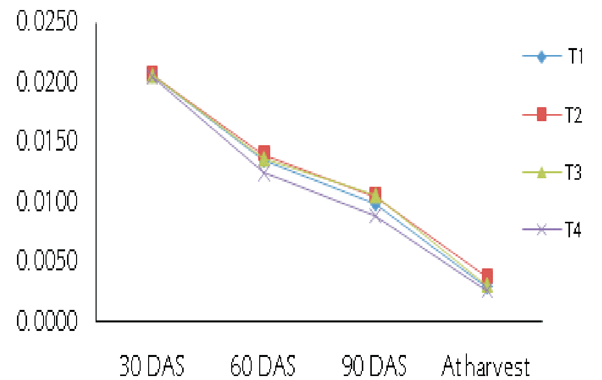

Figure 4: RGR (g g^{-1} day^{-1} plant^{-1}) of safflower

Significantly higher LAI (0.04, 2.49 and 5.92 at 30, 60 and 90 DAS, respectively) was recorded under treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice) as compared to other tillage practices, but at 90 DAS, it was found *at par* with treatment T_3 (Minimum tillage and line sowing of seeds at 6th DAH of rice) and T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice). The higher LAI under these treatments might be due to higher number of leaves plant^{-1} and higher number of branches plant^{-1}. On the contrary Savu (2007) reported that the two irrigations at 35 and 70 DAS and conventional tillage produced significantly higher leaf area and leaf area index in different *rabi* crops. Conventional tillage produces significantly higher LAI in sunflower than minimum tillage Thakur (2014).

Crop growth rate and relative growth rate

Crop growth rate computed between 0-30 DAS, 30-60 DAS, 60-90 DAS and 90 DAS-at harvest was significantly influenced due to different tillage practices (Fig. 3). At 30 DAS and at harvest, crop growth rate was not significantly differing by tillage practices. But, at 60 and 90 DAS crop growth was significantly highest under (MT and line sowing of seeds at 3rd DAH of rice) over the rest of all treatments. Significantly lowest crop growth rate recorded with treatment T_4 (FP and seed and fertilizers are broadcasting at 12th DAH of rice) throughout of crop period. Crop growth rate was increase upto 90 DAS thereafter decrease might be due to lower accumulation of dry mater in plants. Relative growth rate computed between 0-30 DAS, 30-60 DAS, 60-90 DAS and 90 DAS-at harvest (Fig 4). At 30 and 60 DAS and at harvest highest relative growth rate was computed under T_2 (MT and line sowing of seeds at 3rd DAH of rice) followed by T_1 (Zero tillage direct drilling of seeds 2nd day after harvest of rice). While, at 90 DAS it was highest under T_1 than T_2. Lowest crop growth rate recorded with treatment T_4 throughout of crop period.Leaf area increased with the age of crop as maximum light was intercepted up to a certain growth stage, beyond that mutual shading of leaves result in declined CGR. Reduction in active leaves and LAI at advanced growth phases resulted in reduced translocation of photosynthates from vegetative to reproductive parts depicting abridged crop growth rate (Hassan *et al.*, 1997). Nalayini and Kandasamy (2003).

Yield attributes

Data presented in Table 4 revealed that the Capitulums plant^{-1} and number of seeds capitulum^{-1} was significantly influenced by tillage practices. The maximum number of capitulums plant^{-1} and number of seeds capitulum^{-1} was recorded under treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice), but it was *at par* with treatment T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice). The higher number of capitulumsand number of seeds capitulum^{-1} under treatment T_1 and T_2 might be due to higher number of branches plant^{-1} and the higher number of seeds capitulum^{-1} might be due to bigger size of capitulum under treatments T_2 andT_1.Similar finding have also been recorded by Kumar *et al.* (2006) in chickpea crop but on contrary Chitale (2005) they reported reduced yield component under minimum tillage.Number of seeds head^{-1} was significantly higher under conventional tillage than minimum tillage Thakur (2014). Seed index(g) was not significantly influenced by tillage practices. However, the higher seed index (5.46 g) was observed under treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice) followed by treatment T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice). Whereas, the lowest seed index (5.30) g was recorded in treatment T_4 (Farmer's practice - seeds and fertilizers broadcasting at 12th DAH of rice).Yau*et al.* (2010) and Thakur (2014) they reported no significant difference in seed index in no-tillage and conventional tillage and minimum tillage. On contrary significantly higher test weight was observed under conventional tillagein *rabi* crops Savu (2007).

Yield

Different tillage practices brought significant difference in seed yield and stover yield(Table 4). Significantly higher seed yield (13.80 q ha^{-1}) stover yield (41.30 q ha^{-1}) was obtained under treatment T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice), but seed yield was found *at par* to treatment T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice). The lowest seed yield (8.56 q ha^{-1}) and stover yield (26.00 q ha^{-1}) was obtained under treatment T_4 (Farmer's practice - seeds and fertilizers broadcasting at 12th DAH of rice). The higher seed yield under treatments T_1 and T_2 might be due to higher plant population and other growth characters as well as yield attributing characters resulted due to better availability of moisture and nutrients during growth period. Similar finding was also reported by earlier workers (Mandal *et al.,* 1994, Nikam *et al.,* 1889 and Gangwar *et al.,* 2006). They noted the highest seed yield under zero tillage and minimum tillage. On the contrary, Yau *et al.* (2010) reported similar yield in no-tillage and conventional tillage. Harvest index (%) did not vary significantly due to tillage practices. However, the highest harvest index (25.54 %) was recorded under treatment T_1 (Zero tillage direct drilling of seeds at 2nd DAH of rice) followed by T_2 (Minimum tillage and line sowing of seeds at 3rd DAH of rice). This result was on contrary with Yau *et al.* (2010) who reported similar harvest index in no-tillage and conventional tillage.

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