Effect of tillage and residue management practices on blackgram and greengram under bael (*Aegle marmelos* L.) based agroforestry system

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ABSTARCT: A field experiment was initiated during *kharif* 2014 at Central Research Farm of ICAR- Central Agroforestry Research Institute (CAFRI), Jhansi (U.P.), India. Data on *kharif* crops (blackgram and greengram) of 2014 and 2015 are presented in paper from the ongoing experiment. During second year of experimentation bael has attained the average height of 136.9cm and collar diameter of 30.5mm, however as these parameters were not affected by tillage practices. Pooled data of 2014 and 2015 (*kharif season*) showed that growth parameters, yield attributes and yields of blackgram and greengram with minimum tillage were statistically at par with conventional tillage system. However, residue management practices through application of *leucaena* resulted in 14.17 and 11.89% higher seed yield of blackgram and greengram as compared to without crop residue, respectively during the both years. Increase in seed yield of blackgram and greengram with incorporation of crop residue was 11.52 and 11.33%, respectively over without crop residue.

***Key words**:* Agroforestry, Bundelkhand, conservation agriculture, crop residue, leucaena residue and minimum tillage

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1. INTRODUCTION

Agriculture is the predominant occupation in rural Bundelkhand, however it is rain dependent, diverse, complex, under-invested, risky and vulnerable. In addition, extreme weather events, like frequent droughts, short growing period and uneven distribution of rainfall add to the uncertainties in production and frequent crop failures and leads to seasonal migration. The scarcity of water in the semi-arid region, with poor soil and low productivity further aggravates the problem of food insecurity. On this account, more than 75% of 18.3 million population of Bundelkhand is living Below Poverty Line (BPL) (Gupta *et al*., 2014). Of late, the poverty situation in the region became extremely critical due to 15th consecutive crop failure because of droughts (13 times) and unseasonal rainfall (2 times) in last 15 years. This was not always the case in the past. During 18th and 19th century region faced drought once in 16 years, which reduced to once in five years between 1968 to 1992 (Jitendra, 2016). The risk in agriculture has increased with more and more complexities, hence, it is very difficult to sustain farm income. Furthermore, resource degradation due to overexploitation is emerging as a major threat in enhancing productivity. Thus, farmers of the Bundelkhand require multipronged approach to tackle the problems.

Agroforestry is one of such alternative approaches, which can tackle the problems arising due to resource degradation and climate change. It is also known to have the potential to mitigate the pace of climate change through micro-climate moderation and to provide employment to poor and deprived people of the semi arid region (NRCAF Vision 2050). Bundelkhand region represents upland plateaux characterized by shallow soil depth as Alfisols (56% area) and deep soil with swelling and cracking property in Vertisols (44% area). Inappropriate land preparation, monocropping, poor crop establishment, high oxidation of soil organic matter in extreme summer lead to deterioration in soil fertility and escalation in cost of cultivation (Simmons and Coleman, 2008; Helgason *et al*., 2009 and Shekhawat *et al*., 2016).

Adoption of conservation agriculture (CA) practices like minimum tillage, crop residue management and appropriate crop rotation could be the viable solution for the constraints of semi arid region (Lichter *et al*., 2008 and Fahong *et al*., 2004). CA practices have emerged over the past 2–3 decades as a means of achieving the sustainability in crop production (Sharma *et al*., 2012). These practices not only reduces the cost of cultivation but gives stable yields (Jat *et al*., 2011) and improves soil fertility through increased carbon accumulation and biological activity (Bhan and Behera 2014), and promote use of crop waste. However, in arid and semi arid region competing uses for crop residues for livestock production, which is major component of rural livelihood, inadequate biomass production by crops and increased labour demands for manual weeding (because herbicides are not much popular in Bundelkhand region) are the major constraints for adoption of CA by the small and marginal farmers.

Integration of trees with CA practices could overcome the constraints of CA in arid and semi arid region (Garrity *et al*., 2010) and can provide year round land cover. The region is home of dry deciduous thorny vegetation. Bael (*Aegle marmelos*) is becoming popular in Bundelkhand because of high tolerance to drought, long storability of fruits and increasing market demand. *Leucaena leucocephala* a fast growing tree with high biomass yield potential can be used as fodder, fuel, wood, shade, live fences, green manure and residue mulching (Chotchutima *et al*., 2013). In rainfed conditions, greengram and blackgram grows well under limited moisture availability. These crops fit in well within the ambit of CA as well (Shekhawat *et al*., 2016).

Considering all these alternatives and compulsions, a field experiment was designed with the objective of maximising the crop productivity of greengram and blackgram under bael based agroforestry system by using minimum tillage and crop residue management practices.

2. MATERIALS AND METHODS

Data presented in this research paper is part of long term ongoing project "Agroforestry based conservation agriculture for sustainable land use and improved productivity". A field experiment (Bael based CA system) was initiated during *kharif* season of 2014 at Central Research Farm (25°30'14.5" N, 78°32' 34" E and 271.0 m above mean sea level) of ICAR-CAFRI, Jhansi (U.P.), India. The total rainfall received during *kharif* crop season was 425 mm (2014) and 602 mm (2015) (Fig. 1). The soil (0-15cm) of the experimental field was a mixture of black and red soil (Alfisol). These soils were shallow, gravelly and light in texture. The initial soil pH (1:2.5 soil: solution ratio, Jackson, 1958), electrical conductivity (dS m^{-1}, Richards, 1954) and soil organic carbon (%, Walkley and Black, 1934) were 6.59, 0.09, 0.34, respectively. The experimental soil was poor in available N (118 kg ha^{-1}), 0.5N $NaHCO_3$ extractable P (6.4 kg ha^{-1}) and medium in 1.0 N NH_4OAc exchangeable K (112 kg ha^{-1}).

Improved variety of bael (CISH-B2-obtained from ICAR-Central Institute of Subtropical Horticulture, Lucknow) was planted in July 2014 at a spacing of 9m x 4m. The experiment comprising of 04 main plot treatments *viz.*, Conventional Tillage (CT)- Blackgram-Mustard; CT-Greengram-Barley; Minimum Tillage (MT)-Blackgram-Mustard and MT-Greengram-Barley and 03 subplot treatments (with crop residue; without crop residue and with leucaena residue). The experiment was laid out in split plot design with three replications. During *kharif* season greengram (PDM-139) and blackgram (Azad-2) were sown as a rainfed crops as per the treatment details. *Leucaena leucocephala* (K-636) was planted on boundary of experimental field at 1.0m distance. In case of 'with residue treatment' residue of the previous crop grown in cropping sequence has been added @ 1.0 t ha^{-1}, *leucaena* residue was also added at the same rate, and both were applied as soil cover at the time of crop sowing. In initial study boundary plantation of leucaena could not produce required amount of residue, so that leucaena for both *kharif* and *rabi* season and

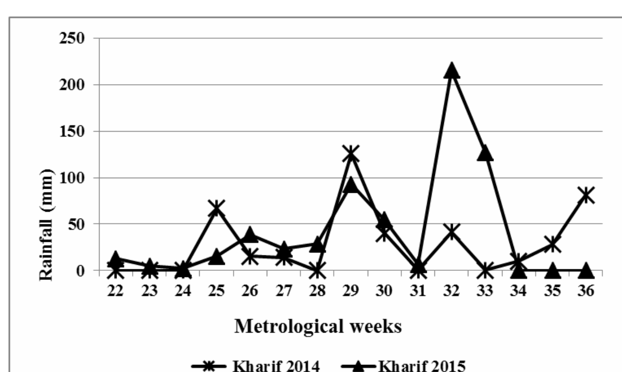

Fig. 1. Rainfall pattern during 2014 and 2015 *Kharif* season

crop residue for first kharif season were arranged from other fields of central research farm of ICAR-CAFRI, Jhansi.

The fields were ploughed as per tillage treatments (CT-one deep tillage + three harrowing/ploughing + one planking, MT-one harrowing/ploughing + one planking) and made ready for sowing. Recommended doses of N, P and K were applied and seeds were treated with fungicide, insecticide and rhizobium culture before sowing. The blackgram and greengram were grown as per recommended agronomic practices.

The height and collar diameter of bael were recorded at the time of transplanting, at 9 months after planting (MAP) and at 21 MAP using measuring tape and digital vernier caliper, respectively. No pruning has been done upto 21 MAP. Plant height of the blackgram and greengram was measured from the base of the plant at ground surface to the tip of the tallest leaf by using standard metre scale. Plant population was counted from the sampling unit. Dry matter accumulation in crop was taken by weighing the oven dried samples taken from the sampling unit.

Before harvesting of both the crops, all the yield attributing characters like pods plant^{-1}, pod length, seeds pod^{-1} and 1000-seed weight were recorded. 10 pods were sampled for observations on pod length and seeds plant^{-1}. After harvesting, threshing, cleaning and drying, the seed yield was recorded at 14% moisture. Stover yield was obtained by subtracting seed yield from the total biomass yield. Extreme weather aberrations caused damage to both the crops in kharif 2015 which resulted in lesser yields as compared to kharif 2014.

Analysis of variance (ANOVA) was performed with the PROC MIXED procedure of the SAS/STAT software (SAS Institute, 1999) to determine the effects of tillage and residue management practices on growth and productivity of blackgram and greengram under bael based agroforestry system for pooled data of two years. CD at 5% level of probability and P values were used to examine differences among treatment means.

3. RESULTS AND DISCUSSION

Growth of bael

Data on growth parameters of bael has been presented in table 1. No-significant differences among different tillage practices and residue management were observed in bael *w.r.t.* collar diameter and height. It was observed that bael recorded with 7.86, 15.56, 30.5mm collar diameter (CD) at the time of transplanting, 9 MAP and 21 MAP, respectively. Similarly height attained by bael was recorded as 47.7, 70.7 and 136.9cm at the time of transplanting, 9 MAP and 21 MAP, respectively. No significant influence on the tree growth parameters may be due wider spacing and lesser competition for belowground resources between the trees and crops and within tree species. Among the residue management practices, it was observed that addition of *leucaena* residue had more positive effect on seedling collar diameter and height of bael as compared to addition of crop (barley/mustard) residues. *Leucaena* residue decomposes fast and supplies more N than the equal

Table 1. Growth parameters of bael influenced by tillage and residue management practices

Treatments	Collar diameter (mm)			Height (cm)		
	Initial	9 MAP	21 MAP	Initial	9 MAP	21 MAP
Main						
CT-Blackgram-Mustard	7.96	15.57	30.25	47.67	70.67	135.52
CT-Greengram- Barley	7.99	15.99	30.63	47.00	70.22	139.37
MT- Blackgram-Mustard	7.72	15.08	30.29	48.17	64.28	134.72
MT- Greengram- Barley	7.77	15.62	30.65	48.00	77.39	137.93
SEm±	0.20	1.33	0.42	1.38	4.13	1.22
CD (0.05)	NS	NS	NS	NS	NS	NS
Sub						
Without crop residue	7.76	15.49	29.96	47.83	67.67	135.23
With crop residue	7.90	15.41	30.58	47.33	67.25	136.33
With leucaena residue	7.92	15.79	30.82	47.96	77.00	139.09
SEm±	0.12	1.13	0.46	0.63	3.45	1.20
CD (0.05)	NS	NS	NS	NS	NS	NS

* MAP-Month after planting

amount of crop residue. Nutrient recycling in *leucaena* is faster than the crop residue. On farm research shows that the inclusion of short term rotational leguminous tree species such as *Gliricidia sepium* in crop lands of semi-arid regions has the potential to improve soil fertility, water infiltration and retention (Kalinda *et al.*, 2015).

Growth, yield attributes and yields of blackgram

Minimum tillage (MT) and conventional tillage (CT) did not influence significantly the plant population and height of blackgram. However, all the growth parameters *i.e.*, plant population, plant height, dry matter accumulation at harvest, pod length, seeds pod^{-1} and 1000-seed weight were observed marginally higher with conventional tillage (Table 2). Similarly, tillage effects were found to be non-significant, but there was marked increase in seed yield from 452.5 (MT) to 465.2 kg ha^{-1} (CT). Similarly, stover yield varied from 971.1 (MT) to 990.4 kg ha^{-1} (CT). This might be due to formation of compact layer in plough zone, low soil organic carbon (SOC), stratification of P and K fertilizers in top soil during initial years of experimentation and ultimately might have affected the growth and yield performance (Shekhawat *et al.*, 2016). Marginally higher yields of crops with CT than MT during initial years (upto 3 years) have also been reported by Sharma *et al.* (1999) and Sangakkara (2007). Residue management significantly increased most of the growth parameters, yield attributes and yields. Perusal of the data on residue management revealed the fact that, almost all the growth parameters improved under *leucaena* residue incorporation followed by crop residue than without crop residue. It is apparent that, incorporation of residues under tillage management system leads to better crop yield. Significantly higher dry matter accumulation at harvest (186.5 g m^{-2}) with the application of *leucaena* residue over without residue management (170 g m^{-2}). Averaged over two years, application of leucaena and crop residue resulted in 14.17 and 11.52% higher seed yield over without residue added plots, respectively and the corresponding increase in stover yields were 10.56 and 9.23%, respectively. However, the growth parameters, yield attributes and yields showed non-significant difference between crop residue and *leucaena* residue, however were significantly higher over without residue treatment. Residue addition as soil cover leads to lowering of soil bulk density, improved infiltration, reduce weed population and thereby better soil aggregation (Mondal *et al.*, 2013). The interaction between tillage and residue practices were observed non significant.

Growth, yield attributes and yields of greengram

Among the tillage practices, the CT performed better than MT in terms of growth, yield attributing characters and yields, although the effects were non-significant (Table 3). This might be due to the initial stage of experimentation. Especially the seed yield was better (687 kg ha^{-1}) under CT over MT (645.8 kg ha^{-1}) and similarly, stover yield was 1358 kg ha^{-1} under CT over

Table 2. Growth, yields and yield attributes of blackgram influenced by tillage and residue management practices (Pooled data of two years)

Treatments	Plant population (m^{-2})	Plant height (cm)	Dry matter accumulation at harvest (g m^{-2})	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed weight	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Main										
CT-Blackgram-Mustard	27.4	34.1	181.5	13.35	3.39	5.26	33.2	465.2	990.4	32.35
MT- Blackgram-Mustard	26	33.4	177.0	13.35	3.29	5.14	33.1	452.5	971.1	32.15
SEm±	0.25	0.4	2.0	0.05	0.05	0.04	0.35	4.9	7.6	0.35
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub										
Without crop residue	25.3	33.7	170.0	12.50	3.20	4.99	32.7	422.5	920.2	32.00
With crop residue	27.4	33.7	182.0	13.70	3.40	5.29	33.5	471.2	1005.2	32.35
With leucaena residue	27.5	33.9	186.5	13.90	3.42	5.33	33.5	482.8	1017.4	32.45
SEm±	0.4	0.5	3.0	0.20	0.07	0.08	0.6	10.1	10.3	0.30
CD (0.05)	NS	NS	9.0	0.55	NS	0.26	NS	28.9	32.7	NS

CT-Conventional tillage; MT-Minimum tillage

Table 3. Growth, yields and yield attributes of greengram influenced by tillage and residue management practices (Pooled data of two years)

Treatments	Plant population (m^{-2})	Plant height (cm)	Dry matter accumulation at harvest (g m^{-2})	Pods $plant^{-1}$	Pod length (cm)	Seed pod^{-1}	1000-seed weight	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Main										
CT-Greengram- Barley	29.55	54.25	246.5	13.85	6.25	10.06	33.75	687.0	1358.0	33.8
MT- Greengram- Barley	28.45	53.75	240.0	13.75	6.24	9.84	34.00	645.8	1317.7	33.1
SEm±	0.45	0.65	2.50	0.10	0.015	0.095	0.40	6.50	10.3	0.35
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub										
Without crop residue	27.9	53.0	231.0	13.00	6.17	9.48	33.7	618.6	1239.8	33.3
With crop residue	29.5	54.4	246.5	14.20	6.24	10.16	34.0	688.7	1379.1	33.3
With leucaena residue	29.6	54.8	252.5	14.20	6.32	10.22	34.2	692.2	1394.3	33.2
SEm±	0.4	0.8	2.5	0.20	0.07	0.17	0.40	17.6	28.8	0.5
CD (0.05)	NS	NS	6.7	0.65	NS	NS	NS	35.3	66.5	NS

CT-Conventional tillage; MT-Minimum tillage

1317.7 kg ha^{-1} in MT. As far as residue management is concerned, normally all the yield attributes and yields (seed and stover) were better under residue management over no residue. Particularly, dry matter accumulation at harvest, pods $plant^{-1}$, seed and stover yield showed significant difference over no residue. Pooled data of two years showed that significantly higher seed yield was recorded under *leucaena* residue added plots (692.2 kg ha^{-1}) followed by crop residue added plots (688.7 kg ha^{-1}) over no residue added plots (618.6 kg ha^{-1}). Likewise *leucaena* and crop (barley) residue resulted in 12.46 and 11.23% higher stover yield over the control (without residue), respectively. The organic supplements from the *leucaena* and crop residue improves the SOC, plant growth, soil health, and widened the sink base through optimum biomass partitioning resulting in higher yield attributes and yield (Pasricha *et al.*, 1988; Bandyopadhyay *et al.*, 2010; Kumari *et al.*, 2011; Mondal *et al.*, 2013 and Das *et al.*, 2014). No significant interactions between tillage and residue practices were observed during both the years of experimentation.

4. CONCLUSION

During initial years tillage practices did not influence substantially the crop growth and yield as well as bael growth. However energy inputs (less no. of tillage operations) were less in minimum tillage as compared to conventional tillage at almost same level of yields. Application of *leucaena* and crop residue (barley/ mustard) significantly increased crop growth and yields. Among the residue management practices, addition of *leucaena* residue performed better than the addition of crop residue. Based upon two year of study it can be concluded that residue management practices in conjunction with tillage practices offers the great potential to enhance the production of these marginal areas with less cost and higher environmental security.

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