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Performance of Cowpea and Horse Gram as Intercrops with Bt Cotton on Red Soils of Southern Transition Zone of Karnataka Plateau, India

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ABSTRACT

Background: Horizontal expansion of area under pulses at country level has very little possibilities. This necessitates exploring alternate ways to increase the area and production of pulses. Bt cotton is the major cash crop grown in large area in Southern transition zone of Karnataka on red soils. Bt cotton hybrids are sown at wide row spacing hence provide sufficient space for cultivation of short duration pulses like cowpea and horse gram.

Methods: On-farm trials were carried out in medium deep red soils of Basavanagiri village of Mysore district, Karnataka during 2014-15 and 2015-16. There were six treatments consists of Bt cotton with farmers practice (T1), Bt cotton with best management practice (T2), sole cowpea (T3), sole horse gram (T4), Bt cotton intercropped with cowpea (T5) and Bt cotton inter cropped with horse gram (T6). On-farm trials were laid out by using RCBD design in five farmer fields, which served as replications.

Result: On-farm investigation indicated that there was no much difference between cotton yield sole crop with BMP and inter cropped cotton yield. However, cotton yield was significantly lower in farmers practice over BMP. Intercropping of cowpea and horse gram with Bt cotton resulted in higher cotton equivalent yield, LER and production efficiency over the sole cotton cropping system. This was due to the wider spacing of the cotton and better resource use efficiency in intercropping system.

Key words: Bt cotton, Cowpea, Horse gram, Intercropping, Red soils.

INTRODUCTION

The pulses are unique crops as they have in-built mechanism to fix atmospheric nitrogen in their root nodules. They are also rich in protein, fit well in various cropping systems and have high water use efficiency as compared to other protein sources. India is a rare country which grows such a variety of pulse crops which none of the countries in the world grows. It is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20% of the area under food grains and contribute around 7-10% of the total food grains production in the country with the production of 23.40 mt in 2018-19 (DAC, 2019). If India want to become self-sufficient in pulses, it is very important that area under pulses is increased apart from increasing productivity. However, there is hardly any scope to increase acreage of pulses due to competition from cereals and cash crops. Thus, intercropping of the pulses with major crops can be explored. By this approach, the target of increasing area by 4-6 million ha can be easily achieved by intercropping various legume grains with major *kharif* and *rabi* season crops.

Pulses like field bean, cowpea, horse gram, green gram and black gram are grown extensively in Mysore district of Karnataka in rainfed conditions during monsoon season. Most of the farmers in this area are small to marginal farmers with land holding of 1-2 ha and preference is given to cash crops like cotton, maize and tobacco. Pulses as a pure crop is seldom grown in large area, however, it is grown as sole crop if main crop failed due to vagaries of climate. In seventies and eighties, pulses were used to grow in large area as compared to cotton, maize and tobacco. Now, most of the farmers purchase pulses from outside rather than producing in their own fields, thereby pulses in their nutritional security is very less. During participatory appraisal farmers showed keen interest in intercropping of pulses rather than allocating exclusive area for growing pulses. Cotton being a cash crop, long duration and widely spaced crop, the vacant interspaces between the rows during initial growth period can be utilized in better way by growing suitable short duration intercrops (Blaise *et al*., 2005). Even in the irrigated regions of North India, inter-cropping cotton with legumes was found more profitable than sole-cropping

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system. There are various pulse crops that can be intercropped with cotton like chickpea green gram, black gram, cowpea, horse gram *etc*.

Cowpea when intercropped with cotton had a production efficiency of 21.2 kg/ha/day compared to 19.3 kg/ha/day for sole cotton (Rajpoot *et al*., 2014). Short-duration pulses such as green gram, black gram and cowpea can be intercropped with cotton (Praharaj *et al*., 2009; Sankarnarayana *et al*., 2012). Even if half the area planted to cotton in central and south India is put to inter-cropping with grain legumes, nearly 3 million ha additional area can be created assuming a 50% pulse area as an intercrop. Legume is an essential component in sustainable agriculture because it contributes towards the soil stabilization, nutrient recycling and stability in production and profit. The component intercrops *viz.,* horse gram and cowpea can be harvested before the main crop. Compact, short duration and quick growing legume crops like black gram, green gram, soybean and cowpea are found to be more compatible for cotton inter-cropping in different regions (Giri and Upadhyay, 1980). Due to wider row spacing of cotton (90 × 20 cm) and different intercrops, none of the short duration pulse crops competed with the main crop of cotton during the growth and development. Thus, cropping system through intercrop was successful as a components in the system have different nutrient and moisture requirement, varied feeding zones in the soil profile, differential growth duration for enabling the utilization of natural resources optimally (Sankaranarayanan *et al*., 2011). Hence, present on-farm study was carried to know the performance of cowpea and horse gram as intercrops with Bt. cotton in red medium deep soils.

MATERIALS AND METHODS

Field studies were carried out during the *kharif* season (monsoon) for two consecutive years (2014-15 and 2015-16) at Basavangiri (12°10′65″ to 12°11′36″N Latitude and 76°26′83″ to 76°27′29″E Longitude) of H.D. Kote, Mysore district, Karnataka, India. The annual rainfall of H.D. Kote ranges from 611.7 to 1053.9 mm with an average of 832 mm received in 55 rainy days and the length of growing period is 150-180 days.

Prior to the field trials, profile has been opened near field trials plot and studied for its characteristics. The profile consisted of Medium deep soil profile (Depth upto 102 cm), consisting of four horizons with clay loam upper layers (0-38 cm) and clay texture (38-102 cm) in subsurface layers. On medium deep red soils the clay content was relatively increased with the depth (approximately >36 cm) (Table 1). Further, to study nutrient status, surface soil samples (0-20 cm) were taken from each experimental site.

Both surface and profile soil samples collected were dried in shade, ground and passed through 2 mm sieve for fine earth fraction. The fine earth fraction was analyzed for pH (1:2.5) and electrical conductivity (EC) in soil water suspension, Cation Exchange Capacity (CEC), Organic carbon (Walkley and Black, 1934), available N (Subbiah and

Table 1: Description of profile characteristics of Basavanagiri, H D Kote, Mysore, Karnataka.

Soils	Soil depth	Texture	pH	EC	OC	Available				Exchangeable			DTPA extractable				CEC
						N	P_2O_5	K_2O	S	Ca	Mg	Cu	Fe	Mn	Zn	
	cm			dsm^{-1}	%	kg ha^{-1}			mg kg^{-1}	meq 100 g^{-1}			mg kg^{-1}			cmol kg^{-1}
Medium deep soils	0-19	Clay loam	8.33	0.14	1.04	125	16.1	308.4	3271.1	594	16.4	3.5	17	26.2	0.1	37
	19-38	Clay loam	7.93	0.13	0.48	62.7	1.1	244.2	2295.4	680.9	13.6	3.7	22	28.3	0.1	22
	38-72	Clay	7.84	0.16	0.44	78	8.2	291.5	2800.8	725.7	18.6	3.9	20.8	28.4	0.5	28
	72-102	Clay	8.43	0.19	0.22	62.7	2.5	382.1	3343.7	567	7.1	4	16.5	32.3	0.4	28
Mean	-	-	8.13	0.16	0.55	82.2	6.9	306.6	2927.8	641.9	13.9	3.8	19.1	28.8	0.3	28.8

Asija, 1956), P_2O_5 (Brays and olsens extraction methods, depending on soil pH), K_2O (1N Ammonium Acetate extraction method), S (0.15% $CaCl_2$ method), exchangeable Ca and Mg as prescribed by Jackson (1973). Micronutrients *viz.*, Fe, Mn, Cu and Zn were estimated using DTPA extracting solution at pH 7.3 (Lindsay and Norvell, 1978). Particle size analysis was determined by International Pipette method (Piper, 1966).

Experimental details

On-farm trials were conducted in medium deep red soils with six treatments *viz.*, T1 - Bt cotton with farmers practice (FP), T2 - Bt cotton with best management practice (BMP), T3 - sole cowpea, T4 - sole horse gram, T5 - Bt cotton + cowpea and T6 - Bt cotton + horse gram. Each treatment area consisted of 600 m^2. There were 5 farmers, which served as replications. Design used for layout of experiment was randomized complete block design (RCBD). Cotton seeds were sown in the last week of April after sufficient rains received in both the years (both sole crop and inter crop fields). Cowpea and horse gram seeds were sown in the last week of May both as sole crop and intercrop plots. Cowpea and horse gram seeds were sown after one crisscross harrowing in the cotton in cotton inter-crop plots. The experimental sites were invariably rain fed, no additional irrigation was given during cropping season.

The best management practice (BMP) consisted of sowing of high yielding good quality Bt cotton hybrids (Bahubali) with 90 × 60 cm spacing, 3-4 times intercultivation (crisscross harrowing) and at final harrowing dead furrows were opened perpendicular to slope, application of soil test based NPK. As per recommendations 150 kg N, 75 kg P_2O_5, 75 kg K_2O ha^{-1} was applied. To protect crop from pest plant protection measures were adopted. Whereas, farmers practice (FP) comprises of planting of locally available Bt cotton hybrids sowing at a spacing 90 × 90 cm, 3-4 times harrowing as inter cultivation and application of 100 kg of DAP or urea per ha. Cowpea and horse gram were introduced as inter crops in BMP cotton plots. At harvest, 10 plants were randomly selected for recording number of bolls $plant^{-1}$ and boll wt. Seed cotton yield per ha was estimated. The various inter-cropping indices were worked out as given by Banik *et al.* (2006).

$$\text{Cotton equivalent yield} = \frac{Ycp}{Pco} \times Pcp + Yco$$

Ycp=Yield of cowpea as intercrop.
Yco=Yield of cotton as intercrop.
Pco=Price of cotton.
Pcp=Price of cowpea.

$$\text{Land equivalent area} = \frac{Yab}{Yaa} \times \frac{Yba}{Ybb}$$

Yab= Yield of cotton as intercrop with cowpea.
Yba = Yield of cowpea as intercrop with cotton.
Yaa= Yield of sole cotton.
Ybb= Yield of sole cowpea.

$$\text{Production efficiency (kg/day)} = \frac{\text{Equivalent yield (kg)}}{\text{Duration (days)}}$$

Statistical analysis

The data on various parameters were analyzed statistically using the Ag Res statistical software (Pascal Intel Software Solutions).

RESULTS AND DISCUSSION

Soil nutrient status

The medium deep red soils of the experimental sites were varying in their profile characteristics in different depth of the soil. Soil textural characteristic of the soil was varying from clay loam to clay. Whereas, the mean pH of the soil was 8.13. EC of the soil was ranged from 0.13-0.19 (dsm^{-1}). Organic carbon content varies from 0.11-1.04 (%). Mean value of the available macro nutrients of the soil was 82.2, 6.9 and 306.6 (kg ha^{-1}) N, P and K respectively and nutrient status falls under low category except potassium. Sulphur content was ranged from 2295.4 to 3343.7 (mg kg^{-1}) as the depth of the soil increases sulphur content also increases. However, the mean exchangeable Ca and Mg content of the soil were found 641.9 and 13.9 (meq 100 g^{-1}) respectively. DTPA extractable micro nutrient *viz.*, Cu, Fe, Mn and Zn status of the soil was sufficient (Table 1).

Productivity of sole and inter crops

There was no much difference in productivity of cotton, cowpea and horse gram yield either in sole crop or in intercrop. However, cotton equivalent yield varied significantly both in 2014 and 2015 and also pooled data. Intercropping of horse gram with cotton recorded significantly higher cotton equivalent yield than other treatments but on par with cotton intercropped with cowpea (Table 2). This might be due to the wider row spacing of the cotton and the both pulse crop with less cropping duration, none of the two crops compete with the growth and development of the cotton. Similar results were also reported by Vaghasia and Dobariya (2019); Ravindra Kumar *et al.* (2017); Sankaranarayanan *et al.* (2012) and Rusinamhodzi *et al.* (2006). Among the sole crops, cotton equivalent yield was highest in sole horse gram as compared to others both in individual years and pooled data, whereas, cotton sole crop with FP recorded significantly lowest cotton equivalent yield.

Yield attribute of cotton such as no of bolls per plant was highest in sole cotton with BMP (46) treatment and it was on par with treatment Cotton + Cowpea (45) followed by Cotton + Horse gram (38) and (T1) Cotton (FP) (30) in 2014 (Fig 1). However boll weight was significant in both the years and treatment (T3) Cotton + horse gram recorded highest boll weight over the other treatments (Fig 2). Though number of bolls was highest in BMP and cotton + cowpea treatment but due to higher boll weight in cotton+ horse gram, pooled cotton yield was highest in BMP and cotton + horse gram (Table 2).

Pulses such as cowpea and horse gram were grown as intercrop in cotton. Yield of cowpea as intercrop in cotton recorded 5 q/ha in both 2014 and 2015 and in horse gram 5 and 6 q/ha in 2014 and 2015 respectively. However the yield

Table 2: Effect of different treatments on yield of crops.

Treatment	Cotton yield (q/ha)			Yield of pulse crops (q/ha)			Cotton equivalent yield (qha)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T1 - Cotton (FP)	5.70	6.00	5.85	-	-	-	5.70	6.00	5.85
T2 - Cotton (BMP)	8.00	8.00	8.00	-	-	-	8.00	8.00	8.00
T3 - Sole cowpea	-	-	-	6.00	5.60	5.80	9.99	10.00	9.99
T4 - Sole horse gram	-	-	-	6.66	6.40	6.53	10.46	10.57	10.51
T5 - Cotton + Cowpea	7.80	8.00	7.90	5.00	5.00	5.00	11.37	11.57	11.47
T6 - Cotton + Horse gram	8.00	8.00	8.00	5.00	6.00	5.50	11.57	12.29	11.93
Mean	7.38	7.50	7.44	5.67	5.75	5.71	9.52	9.75	9.63
CD (P=0.05)	-	-	-	-	-	-	0.49	0.52	0.46

Table 3: Effect of different treatments on different intercropping indices and B: C ratio.

Treatment	Land equivalent ratio (LER)			Production efficiency (kg/ha/day)			Net returns (Rs ha^{-1})			B:C ratio		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T1 - Cotton (FP)	1.00	1.00	1.00	4.38	4.62	4.50	9950	11570	10760	1.0	1.2	1.1
T2 - Cotton (BMP)	1.00	1.00	1.00	6.15	6.15	6.15	16000	16000	16000	1.3	1.3	1.3
T3 - Sole cowpea	1.00	1.00	1.00	9.51	9.52	9.52	16964	17000	16982	2.1	2.1	2.1
T4 - Sole horse gram	1.00	1.00	1.00	11.01	11.13	11.07	18143	18429	18286	2.3	2.3	2.3
T5 - Cotton + Cowpea	2.24	2.21	2.22	8.75	8.90	8.82	24800	25500	25150	1.7	1.7	1.7
T6 - Cotton + Horse gram	2.28	2.16	2.22	8.90	9.45	9.18	25500	28000	26750	1.7	1.9	1.8
Mean	1.26	1.28	1.41	10.38	10.57	8.21	18560	19417	18988	1.7	1.8	1.7
CD (P=0.05)	0.09	0.08	0.07	0.42	0.46	0.40	1540.46	1828.93	1588.92	0.14	0.17	0.14

of sole cowpea (T3) and sole horse gram (T4) was higher than the same crops in intercropping system in both the years and also showed the similar trend in pooled data analysis. This is because of intercrops occupied only 60% of the area as compared to sole crop. Per cent reduction in yield due to inter cropping in cowpea was 13% and 16% in horse gram.

Land equivalent ratio (LER)

Land equivalent ratio (LER) is useful single index for expressing the yield advantage (Willey, 1979). LER of T5 and T6 indicated that Bt cotton intercropping with cowpea or horse gram didn't show any difference in utilization of space and resources (Table 3). This may be due to the better resource use and resource complementarily in intercrop than the sole crops. This attributed to the better cotton and pulse yield in the intercropping system compare to sole crop yield. These results were in line with the findings of Gajendra singh *et al.* (2017); Ravindra Kumar *et al.* (2017); Rajpoot *et al.* (2014); Singh *et al.* (2014) and Rusinamhodzi *et al.* (2006). Calculation of LER clearly indicates that which combinations are genuinely more productive, and also examine, where appropriate, the benefit of intercropping as compared with growing crop as a sole crop (Mead and Willey, 1980).

Production efficiency (PE)

Production efficiency indices represents the per unit production in the cropping period. Production efficiency (PE) significantly differed among the treatments. Sole horse gram recorded highest PE of 11 kg/ha/day as compared to other treatments (Table 3) in both individual years and also in pooled data. This may be due to lower crop duration and higher economic value of horse gram and higher economic value of legume. Rajpoot *et al.* (2014) and Remesa *et al.* (2016) also reported the similar result.

Economics

Average net returns of treatments were 18560, 19417, and 18988 Rs ha^{-1} in 2014, 2015 and in pooled respectively. Bt cotton intercropped with horse gram recorded significantly highest net returns as compared to T1, T2, T3 and T4 but it was on par with T5 (Table 3). This was due to the higher seed cotton equivalent yield of the intercropping treatments

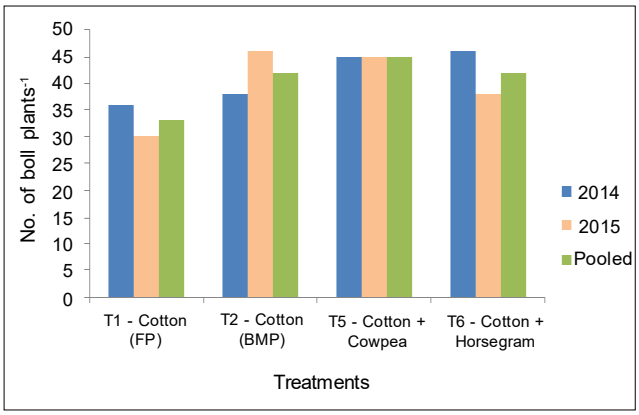

Fig 1: Number of bolls per plant of cotton in different cropping system.

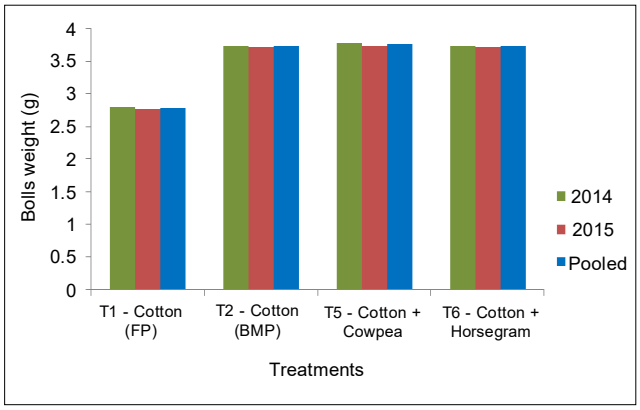

Fig 2: Boll weight of cotton in different cropping system.

and also remunerative price of the pulses. Similar results were reported by Gajendra *et al.* (2017); Singh *et al.* (2014) and Khargkharate *et al.* (2014).

Significantly highest B:C ratios were recorded in sole cowpea and horse gram treatments than other treatments. However, B: C ratio of T5 and T6 were on par with each other, the significantly lowest ratio was recorded in sole cotton with farmer practice (T1) (Table 3).

CONCLUSION

The results and discussion of the above study concluded that intercropping of pulses like cowpea and horse gram with cotton resulted in higher cotton equivalent yield, LER and production efficiency over the sole cotton cropping system. This was due to the wider spacing of the cotton and better resource use efficiency in intercropping system. Intercropping of pulses with the cotton increases the pulse growing area of the country in a significant way and leads to meet the low production of the pulses.

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