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Effect of Intercropping Greengram and Blackgram in Sesame for Augmenting the Productivity and Rain Water Use Efficiency Under Rainfed Upland Condition

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ABSTRACT: A field experiment was conducted during the *kharif* seasons of 2010, 2011 and 2012 at the research farm of All India Coordinated Research Project for Dryland Agriculture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali with the objectives to find out the feasibility of intercropping green gram and black gram in sesame. The experiment was conducted with 11 treatments (T_1 - Sesame Sole, T_2 -Green gram Sole, T_3 -Black gram Sole, T_4 - Sesame + Greengram (1:1),T_5 - Sesame + Greengram (2:1), T_6 Sesame + Greengram (2:2), T_7 -Sesame + Greengram (3:1), T_8 - Sesame + Blackgram (1:1), T_9 - Sesame + Blackgram (2:1),T_{10}- Sesame + Blackgram (2:2), T_{11} -Sesame + Blackgram (3:1).) in a Randomized Block Design with three replications. Considering the sesame as base crop, sesame, greengram and blackgram were sown simultaneously as per treatment during post *kharif* seasons (Mid August- Mid September). It was observed that intercropping of sesame in green gram and blackgram had significantly superior value in respect of the Sesame Equivalent Yield (SEY), Land Equivalent Ratio (LER), Rain Water Use Efficiency (RWUE) net return and B : C ratio. From the pooled data of three years, the highest SEY (13.85q/ha) was recorded by T_8- Sesame + blackgram (1:1) followed by Sesame + Greengram (2:2) and Sesame + blackgram (2:1). The highest LER (1.42), RWUE (7.42kg/ha/mm), Net return (₹ 39,374/ha) and B: C ratio(4.40) was also recorded in Sesame + Blackgram (1:1).

Key words: Intercropping, sesame equivalent yield (SEY), rain water use efficiency, crop diversification, net return, land equivalent ratio

Introduction

Crop diversification through intercropping has long been recognized as a kind of biological insurance against risks and aberrant rainfall behaviour in dry environment (Dutta and Bandyopadhyay, 2006). Sesame (*Sesamum indicum* L.) is an oilseed crop popularly grown in Assam and it occupies an important place in oilseed scenario of the country next to rapeseed and mustard. However, the productivity of sesame is very unstable in the state as it is cultivated mainly in rainfed upland situation which is highly susceptible due to vagaries of monsoon. It is hardly disputed that productivity and cropping intensity of upland ecosystem cannot be raised to a desired level unless the existing production system is diversified through low duty high value crop. Pulses are considered to be an ideal crop for their suitability in different intercropping systems. In India, 78% of sesame production goes for oil extraction, 20% for domestic use (culinary purpose) and two per cent for the next sowing (Singh *et al*., 2007). India's major gains in oilseeds export have come from sesame apart from groundnut and gained 90% of European and 50% of US market in oilseed export (Vittal *et al.,* 2004). Multiple cropping in the form of intercropping being a unique asset of tropical and subtropical areas is becoming popular day by day among small farmers as it offers the possibility of yield advantage relative to sole cropping through yield stability and improved yield. Furthermore, two crops differing in height, canopy, adaptation and growth habits grow simultaneously with least competition (Keerio & Aslam, 1986). Presently, interest in intercropping is increasing among the small growers because of their diversified needs and low farm income from the mono cropping system. In the past mono cropping of grain legumes (pulses) was a usual practice among the growers, but now-a-days the interest in growing food legumes in an intercropping system is increasing (Khan *et al*., 2001). When legumes are grown in association with non-legumes, there is often advantage to the non legumes from nitrogen fixed by the legumes (Mandal and Pramanick, 2014). Intercropping in sesame with pulses in various parts of the country showed encouraging results not only in increasing productivity but also improving soil health. Legumes like green gram/black gram being short duration crops may constitute potential intercrop for sesame in rain fed upland condition. Therefore, keeping these in view an experiment was carried out at the experimental field of All India Coordinated Research Project for Dryland Agriculture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali to find out the feasibility of intercropping in sesame with green gram and black gram for increasing the productivity and profitability of the system and also to determine the Rain Water Use Efficiency by sole and intercropping system under rain fed upland situation.

Materials and Methods

The present study was conducted at the Experimental farm of All India Coordinated Research Project for Dryland Agriculture at Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali during post rainy seasons (Mid

August-Mid September) of 2010, 2011 and 2012. The soil was sandy loam with organic carbon 0.53%, p^H 5.05. The available N, P and K_2O were 385.73, 40.01 and 259 kg/ha, respectively. The experiment consisted of 11 treatments viz. T_1 - Sesame Sole,T_2 - Green gram Sole, T_3 - Black gram Sole, T_4 - Sesame + Greengram (1:1), T_5 - Sesame + Greengram (2:1), T_6 Sesame + Greengram (2:2), T_7 Sesame + Greengram (3:1), T_8 - Sesame + Blackgram (1:1), T_9 Sesame + Blackgram (2:1),T_{10} Sesame + Blackgram (2:2), T_{11} Sesame + Blackgram (3:1).The experiment was laid out in randomized block design with 3 replications. The main crop sesame (ST-1683), intercrops greengram (Pratap) and blackgram (T-9) were sown simultaneously in replacement series at a row spacing of 30cm during the post rainy season (mid August-mid September). A fertilizer dose of 30-20-20 kg N-P-K/ha recommended for sesame was applied to sole sesame and other intercropping treatments, whereas, sole greengram and sole blackgram were fertilized @15-35-0Kg N-P- K/ha. The cultural operations were carried out as and when required as per State's Package of Practices. Observations on growth and yield attributes (plant height, number of capsules/pods per plant, branches/plant and test weight), grain yields, Sesame Equivalent Yield and Land Equivalent Ratios were recorded and analysed statistically. The Rain Water Use Efficiency (RWUE) was calculated by dividing the grain yield (Kg/ha) to cumulative rainfall (mm) from sowing to harvest. Since there is no irrigation to the crop other than rain water, RWUE would also indicate the water productivity or water use, the efficiency of a treatment under rainfed condition (Sharma *et al*., 2013). The soil properties *viz*, N, P_2O_5 and K_2O. The total rainfall received during the cropping periods in 2010, 2011 and 2012 were 270.6 mm, 398.2 mm and 478.4 mm, respectively, and its distribution pattern are presented in Figure 1.

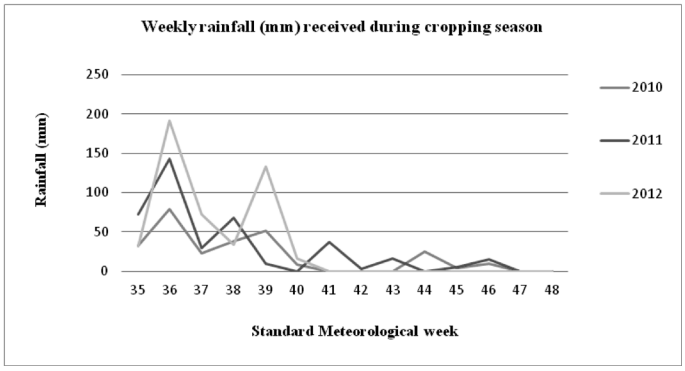

Fig. 1 : Rainfall distribution pattern during the cropping periods of 2010, 2011 and 2012

Results and Discussion

Growth and yield attributing characters and grain yields of sesame, greengram and blackgram

Pooled data of growth and yield attributing characters recorded significant variations in plant height, number of capsules/ plant of sesame due to intercropping (Table 1).The highest plant height was recorded in sole sesame and was found to be significantly superior over all the intercropping treatments with blackgram irrespective of treatments. Similarly, the number of capsules/plant was statistically higher in case of sole sesame irrespective of intercropping with greengram or blackgram. The higher number of capsules/plant in sole sesame might be due to lack of competition for growth resources than those of intercropping. Similar results were also recorded by Bhatti *et al* 2005. However, number of branches/plant and test weights of sesame due to treatments were not significant. All the intercropping treatments in sesame with blackgram registered significantly higher number of brances/plant than in sesame with greengram. The T8 i.e. Sesame + blackgram (1: 1) recorded the highest number of branches/plant and was significantly superior over intercropping with all the treatments of greengram and both the sole crops. The plant height, number of pods/plant and test weights of intercrop greengram and blackgram under sole cropping and intercropping were statistically similar.

The grain yields of sesame, greengram and blackgram for 2010, 2011, 2012 and pooled data are presented in Table 1. Among the treatments, sole sesame (T_1) recorded significantly higher grain yield of 5.60 and 6.41 and 6.48q/ha during 2010 and 2011 and 2012 respectively. However, in 2012, though grain yield of sesame was highest in sole sesame but it was statistically at par withT_4, T_5, T_6, T_9 and T_{11}. The pooled data of three years recorded the highest sesame yield of 6.16q/ha in sole sesame (T_1) which was statistically superior over the rest of the intercropping treatments. The significantly higher number of capsules/plant of sesame in sole crop might have resulted in higher grain yields over all the intercropping treatments. Within the rest of the intercropping system the grain yields were at par. The reduction in sesame yield under intercropping than in sole crop might be attributed to competition with greengram and blackgram along with a reduced plant population under various sowing ratios. Reduction in grain yield of sesame due to legume intercropping was also reported by Patra and Bhal (1994) and Mohiuddin and Ghosh (1997).

The grain yields of intercrop greengram and blackgram differed significantly due to treatments. Highest grain yields of 11.23, 13.43 and 9.80 q/ha was recorded by sole blackgram during 2010, 2011 and 2012 respectively, which were statistically superior over other treatments. Among the sowing ratios T_8 i.e, S + BG (1:1) registered higher grain yield throughout the years of experimentation. From the pooled data, it was found that the highest grain yield 11.50q/ha was registered under of sole blackgram. Among the intercropping treatments highest grain yield of blackgram was noticed under T_8 i.e, S + BG (1:1) which was statistically superior over other intercropping treatments. The comparative higher mean test weight of blackgram (40.38g) than the mean test weight of greengram (38.90g) might have the positive effect leading to increased grain yields under all the treatments with blackgram. The variation in seed yield of sesame intercropped with different legumes might be attributed to their variable competitive behaviour and allelopathic effects on the associated sesame crop. Significant variation in grain yield of sesame among different planting patterns was also reported by Sarkar and Pramanik (1992) and Osman (1993).

Sesame Equivalent Yield (SEY), Land Equivalent Ration (LER) and Rain Water Use Efficiency (RWUE)

It was found from Table 2 that sesame equivalent yields differed significantly due to treatments. Intercropping of sesame either

Table 1 : Growth and yield attributes, grain yield (q/ha) of sesame, greengram and blackgram as influenced by intercropping treatments

Treatments	Plant height (cm)		No. of capsule / pod per plant		No. of branches / plant of		Test weight (gm)		Sesame yield (q/ha)				Intercrop yield (q/ha)			
	Sesame	Intercrops	Sesame	Intercrops	Sesame	Intercrops	Sesame	Intercrops	2010	2011	2012	Pooled	2010	2011	2012	Pooled
T1 - Sesame (Sole)	120	--	43.0	--	5.70	--	3.05	--	5.60	6.41	6.48	6.16	------	------	---	---
T2 - Green Gram (Sole)	--	63.0	--	17.7	--	4.67	--	385.57	------	---	--	-	7.00	8.74	8.82	8.19
T3 - Black Gram (Sole)	--	48.0	---	22.3	--	4.00	--	40.21	----	---	--	-	11.23	13.43	9.80	11.50
T4 - S + GG (1:1)	117	62.0	29.3	18.3	6.00	3.67	3.00	38.95	3.50	4.28	5.42	4.40	3.22	5.91	6.67	5.27
T5 - S + GG (2:1)	111	57.6	29.0	16.0	5.60	4.67	3.02	39.03	4.20	3.82	5.32	4.45	1.75	4.23	5.54	3.84
T6 - S + GG (2:2)	98.3	57.3	30.3	19.3	5.70	4.67	3.07	39.85	3.91	4.19	5.53	4.54	4.70	6.83	5.25	5.59
T7 - S + GG (3:1)	110	54.3	30.0	17.3	6.00	3.67	3.02	38.12	4.60	4.89	4.73	4.74	2.14	4.08	4.34	3.52
T8 - S + BG (1:1)	79	38.0	28.3	13.0	6.00	6.67	3.10	40.85	3.47	3.91	5.18	4.19	6.01	11.21	8.25	8.59
T9 - S + BG (2:1)	86	37.3	28.7	13.0	5.60	6.33	3.08	40.20	4.38	4.10	5.70	4.73	5.17	10.14	5.67	6.99
T10 - S + BG (2:2)	96	40.3	32.7	12.0	5.30	5.67	3.07	40.39	4.20	4.26	4.39	4.28	4.51	8.43	8.96	7.30
T11 - S + BG (3:1)	100	36.0	25.0	11.0	5.50	6.33	3.03	40.26	4.93	4.08	5.32	4.78	3.86	5.36	4.72	4.66
CD (P = 0.05)	11.55	NS	5.74	NS	NS	1.19	NS	NS	1.09	1.20	1.18	0.98	1.78	2.38	1.53	2.11

S = Sesame, GG= Green Gram, BG= Black Gram

with greengram or blackgram in any ratio recorded higher SEY over sole sesame during all the years of experimentation and also in pooled data. The highest SEY of 13.85 q/ha was registered under T_8 i.e, S + BG (1:1) which was statistically at par with T_2, T_3, T_4, T_6, T_9 and T_{10}. The pooled data recorded an increase of 125% in SEY by T_8 over T_1 (sole sesame) indicating greater benefits of intercropping. Sarkar *et al*. (2003) registered significant and appreciable increase in total productivity due to intercropping in terms of sesame-equivalent yield over sole sesame. Higher equivalent yields due to legume intercropping were also reported by Sarma *et al.* (1994), Reddy *et al.* (2015) and Osman *et al.* (2015).

The Land Equivalent Ratio (LER) was always higher over sole cropping of Sesame, Greengram and Blackgram during 2010, 2011, 2012 and also on pooled (Table 2) except in greengram + sesame (2:1) during 2010. The highest LER of 1.64 was noticed during 2012 in T8 followed by T4 (1.60). However, pooled data recorded highest LER in T8 (1.42) followed by T6 (1.41) indicating 42% and 41% yield advantage respectively over sole cropping. Kumar and Thakur (2006) also registered highest LER value with intercropping of sesame + blackgram (1:1), sesame equivalent yield and net return.

The Rain water Use Efficiency (RWUE) was statistically higher in all the intercropping systems over sole sesame (Table 3) during 2010, 2011, 2012 and when polled. The pooled data recorded the highest RWUE of 7.42 Kg/ha/mm in T_8 i.e. Sesame + Blackgram (1:1), which was 189% more over T_1 (sole sesame). This indicated the benefits of intercropping over sole cropping for better use of rain water.

Economics of Intercropping

The computation of economics for different treatments indicated that intercropping of sesame either with greengram or blackgram in any ratio under study recorded always better in terms of net return, and B:C ratio (Table 3). Among the years, highest net return (₹ 46,254) was achieved in T_8 i.e. Sesame + Blackgram (1:1) during 2012 with the B:C ratio of 4.99. The pooled data for three years recorded highest net return of ₹ 39,374 by Sesame + Blackgram (1:1) followed by Sole Greengram (Figure 2). The lowest net return was obtained in T_1 (Sole sesame). Similarly the highest B:C ratio was recorded in Sesame + Blackgram (1:1) with the value of 4.40 followed by Sesame + Blackgram (2:1). It can be inferred that though the cost of cultivation is high in intercropping than sole cropping of sesame it was

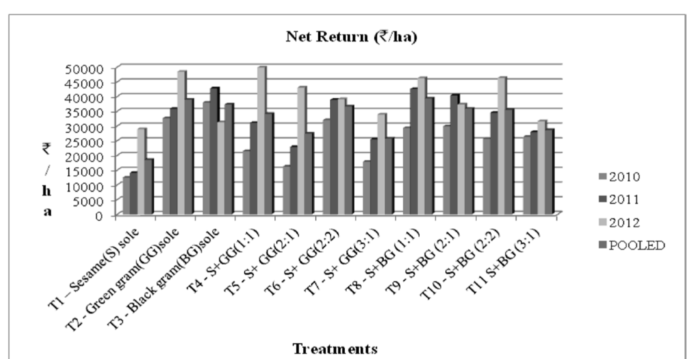

Fig. 2 : Net return (₹/ha) as affected by treatments during 2010, 2011 and 2012 and its pooled value

always beneficial in terms of overall return. Bhatti *et al.*, 2005 reported higher net return due to intercropping of sesame with greengram and blackgram. Jain *et al.* (2001) reported that at Jalgaon, sesame + pigeonpea (3:1) intercropping system proved significantly better with higher net return and benefit cost ratio (₹ 2,331/ha) and Sharma *et al.* (1998) obtained significantly higher B:C ratio of 4.05 and net return (₹ 33,035/ha) when pigeon pea and sesame was grown together in 2:2 row proportion over sole crop of pigeon pea and different cropping systems. Thus, in all the three evaluating criteria viz. sesame equivalent yield, land equivalent ratio and Benefit: Cost ratio, intercropping system of sesame + black gram (1:1) followed by sesame + green gram (2:2) proved superiority over mono cropping and other intercropping treatments. Hence, it can be concluded that sowing of 1 rows of sesame with 1 row of green gram var. T_9 is biologically and economically sustainable intercropping system for rainfed conditions of Assam.

The lowest RWUE of 2.57 was registered under sole sesame. Highest grain yields of 11.23, 13.43 and 9.80 q/ha was recorded by sole blackgram during 2010, 2011 and 2012, respectively which were statistically superior over other treatments. Pandita *et al*. (2000) also recorded the LER values greater than unity when maize was intercropped with legumes. Similarly rain water use efficiency (RWUE) was maximum when sesame intercropped with Black gram in 1:1 ratio (7.42 kg/ha/mm) and recorded the lowest in Sesame sole (2.57 kg/ha/mm).

Table 2 : Sesame equivalent yield, land equivalent ratio and RWUE as influenced by treatments

Treatments	SEY (q/ha)				LER				RWUE (kg/ha/mm)			
	2010	2011	2012	Pooled	2010	2011	2012	Pooled	2010	2011	2012	Pooled
T1 - Sesame (Sole)	5.6	6.41	6.48	6.16	1.00	1.00	1.00	1.00	3.8	2.34	1.56	2.57
T2 - Green gram (Sole)	11.5	13.11	15.45	13.35	1.00	1.00	1.00	1.00	8.14	5.18	3.72	5.68
T3 - Black gram (Sole)	12.69	15.11	11.02	12.92	1.00	1.00	1.00	1.00	8.71	5.97	2.65	5.78
T4 - S + GG (1:1)	8.33	13.14	15.43	12.30	1.09	1.35	1.60	1.35	9.92	5.19	3.72	6.28
T5 - S + GG (2:1)	6.83	10.16	13.53	10.17	1.00	1.08	1.45	1.28	8.14	4.01	3.26	5.14
T6 - S + GG (2:2)	10.96	14.43	12.47	12.62	1.37	1.43	1.45	1.41	13.05	5.70	3.00	7.25
T7 - S + GG (3:1)	7.21	11.01	11.23	9.82	1.02	1.23	1.22	1.16	8.58	4.35	2.71	5.21
T8 - S + BG (1:1)	10.22	16.86	14.46	13.85	1.16	1.47	1.64	1.42	12.17	6.66	3.48	7.42
T9 - S + BG (2:1)	10.22	15.51	12.08	12.60	1.24	1.40	1.44	1.36	12.17	6.13	2.91	7.07
T10 - S + BG (2:2)	9.3	13.74	14.48	12.50	1.15	1.29	1.59	1.34	11.07	5.43	3.49	6.66
T11 - S + BG (3:1)	9.29	10.11	10.62	10.00	1.22	1.04	1.30	1.19	11.06	3.99	2.56	5.87
CD (P=0.05)	4.28	2.64	2.53	2.83				0.20	5.09	1.04	0.60	2.18

Price of sesame : ₹ 4000/- per q, Price of green gram : ₹ 6000/- per q, Price of black gram : ₹ 4500/- per q, SEY: Sesame equivalent yield, LER: Land equivalent ratio

Table 3 : Cost of cultivation (₹/ha), net return (₹/ha) and benefit:cost ratio as influenced by treatments

Treatment	Cost of cultivation (₹/ha)	Net returns (₹/ha)				B:C			
		2010	2011	2012	Pooled	2010	2011	2012	Pooled
T1 - Sesame Sole (S)	9935	12465	15705	15985	14718	2.25	2.58	2.61	2.48
T2 - Green gram Sole (GG)	13384	32616	39056	48416	38956	3.43	3.91	4.62	3.91
T3 - Black gram Sole (BG)	12837	37923	47603	31243	37309	3.95	4.70	3.43	3.90
T4 - S + GG (1:1)	11859	21461	40701	49861	34134	2.81	4.43	5.20	3.88
T5 - S + GG (2:1)	11085	16235	29555	43035	27388	2.46	3.66	4.88	3.47
T6 - S + GG (2:2)	11859	31981	45861	39101	36667	3.7	4.86	4.30	4.09
T7 - S + GG (3:1)	10997	17843	33043	33923	25736	2.62	4.00	4.08	3.34
T8 - S + BG (1:1)	11586	29294	55854	46254	39374	3.53	5.82	4.99	4.40
T9 - S + BG (2:1)	10992	29888	51048	37328	35861	3.72	5.64	4.39	4.26
T10 - S + BG (2:2)	11586	25614	43374	46334	35480	3.21	4.74	4.99	4.06
T11 - S + BG (3:1)	10860	26300	29580	31620	28620	3.42	3.72	3.91	3.63

S = Sesame, GG = Green gram , BG = Black gram

Conclusion

It can be concluded that intercropping system of greengram and blackgram in sesame is beneficial in terms of sesame equivalent yield, LER, net return, B:C ratio, rain water use among the treatments, intercropping of blackgram in sesame at 1:1 row ratio was the best combination under rainfed upland situation of Assam for increasing equivalent yield, economic return and RWUE.

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