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B Arpita
Department of Agronomy, Palli-Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal, India

GC Malik
Department of Agronomy, Palli-Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal, India

Mahua Banerjee
Department of Agronomy, Palli-Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal, India

Jnana Bharati Palai
Department of Agronomy, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Odisha, India

Corresponding Author:
B Arpita
Department of Agronomy, Palli-Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal, India

Effect of sesame + pulses intercropping systems on growth, yield and quality parameters of sesame

B Arpita, GC Malik, Mahua Banerjee and Jnana Bharati Palai

Abstract
A field experiment was conducted to study the intercropping of sesame with black gram & green gram during *pre-kharif* season of 2015 at agricultural farm, Palli Siksha Bhavana, Visva-Bharati, Sriniketan, Birbhum, West Bengal in red and lateritic soil. The experiment was conducted by following Randomized Block Design (RBD) and 12 treatments were replicated thrice. The treatments were T1-sole sesame (30 cm spaced uniform row), T2-sole sesame (40 cm spaced uniform row), T3 - sole sesame (60 cm spaced paired row), T4 -sole sesame (100 cm spaced four row), T5 - sole black gram (15 cm spaced row), T6 - sole green gram (40 cm spaced row), T7-sesame + black gram (1:1 in 40 cm spaced row), T8 - sesame + green gram (1:1 in 40 cm spaced row), T9-sesame + blackgram (2:2 in 20/60 cm spaced row), T10-sesame + green gram (2:2 in 20/60 cm spaced row), T11-sesame + blackgram (4:4 in 20/100 cm spaced row), T12 -sesame + green gram (4:4 in 20/100 cm spaced row). Different growth parameters such as plant height and no. of branches plant^{-1} recorded higher than different intercropping systems. Whereas sesame + green gram (4:4) recorded highest dry matter accumulation (45.97 g m^{-2}). Intercropping of sesame with green gram and black gram also showed higher yield attributes such as no. of capsules plant^{-1}, no. of seeds capsule^{-1} and test weight. Highest grain yield, oil yield and protein content was obtained from sole sesame (30 cm spaced uniform row) followed by sesame + blackgram (2:2 in 20/60 cm spaced row) and also remained at par.

Keywords: Sesame, intercrop, growth, yield, oil, protein

Introduction
The diversified need of the society forces the agricultural land to shrink day by day. For achieving higher production potential level it is necessary to increase the land use both spatially and temporally. It is also true that increasing land area is not that easy in modern scenario. It's only possible to use waste lands, dry lands, arid zone lands or to intensify the land use pattern. So intercropping can be a solution to this. Intercropping is the practice of growing two or more crops in a same piece of land at same time with a definite row ratio. Mixed cropping is the practice of growing more than one crop in a field at a given time. Intercropping is the practice of growing more than one crop simultaneously in alternating rows of the same field (Beets 1990) [4]. Intercropping is therefore a type of mixed cropping. Biological efficiency of intercropping is higher due to exploration of large soil mass compared to monocropping (Francis, 1989) [8]. This advanced agro technique has been practiced in past decades and had achieved the goal of agriculture. There are some socio economic (Ofori and Stern, 1987) [10], biological and ecological advantages (Aggarwal *et al.*, 1992; Fininsa, 1996) [1, 7] in intercropping over monocropping. The intercropping help to reduce the risks at times of adversity and is regarded as safe insurance against total loss, (Jensen *et al.*,2005) [9]. Kumar and Prasad, (1999) revealed in their experiment that inclusion of pulses such as chickpea in the existing cropping system not only increases the overall productivity of the system but also improves physic-chemical properties of the soil. This is possible because chickpea can increase the productivity both in terms of N saving from fertilizer source and build up soil fertility through biological source of N. According to Li *et al.* (2006) and Choudhary *et al.*, (2008) [6], the reason behind are mainly that resources such as water, light and nutrients can be utilized more effectively than in the respective sole cropping systems. Ahamed *et al.* (2011) found that yield and contributing characters varied significantly due to variation in varieties and plant spacings. BARI Mung-2 and BARI Mung-6 produced the highest and lowest yield of 938.20 and 592.88 kg ha^{-1}. Intercropping decreased the yield of each crop but increased total productivity. The highest total yield, land equivalent ratio and financial return were given by 2 rows of sesame alternating with 2 rows of mung beans at a row spacing of 37.5 cm. (Sarkar and Pramanik 1989).

Materials and Methods

A field experiment was conducted to study the intercropping of sesame with black gram & green gram during *pre-kharif* season of 2015 at agricultural farm, Palli Siksha Bhavana, Visva-Bharati, Sriniketan, Birbhum, West Bengal in red and lateritic soil. The soil of the experimental plot was sandy loam in texture, acidic in soil reaction with low level of organic carbon and available nitrogen but medium level of available P_2O_5 and K_2O. The experiment was conducted in order to observe the performance and yield of Sesame intercropping with pulses like Black gram & Green gram. Studies on intercropping of Sesame with pulses in different row arrangements in *pre-kharif* season. The experiment was conducted by following Randomized Block Design (RBD) and 12 treatments were replicated thrice. The treatments were T1-sole sesame (30 cm spaced uniform row), T2-sole sesame (40 cm spaced uniform row), T3 - sole sesame (60 cm spaced paired row), T4 -sole sesame (100 cm spaced four row), T5 - sole black gram (15 cm spaced row), T6 -sole green gram (40 cm spaced row), T7-sesame + black gram (1:1 in 40 cm spaced row), T8 - sesame + green gram (1:1 in 40 cm spaced row), T9-sesame + blackgram (2:2 in 20/60 cm spaced row), T10-sesame + green gram (2:2 in 20/60 cm spaced row), T11-sesame + blackgram (4:4 in 20/100 cm spaced row), T12 - sesame + green gram (4:4 in 20/100 cm spaced row). Varieties used were Savitri (SWB-32-10-1) (sesame), WBU-108 (black gram) and PDM-84-139 (Samrat) (green gram). The sesame variety Savitri was sown with a seed rate of 7-8 kg/ha on 26th March 2015 with a spacing of 30 cm, 40 cm, 20/60 cm, 20/100 cm row to row spacing in a continuous row. The Black gram & Green gram are sown in 15 & 40 cm row apart respectively in sole crop treatment. In intercropping treatment, both Green gram and black gram were intercropped with sesame in 1:1, 2:2 &3:3 row ratios separately. Seeding depth was 2 – 3 cm (approx). The fertilizers (N, P_2O_5 & K_2O) were applied to sesame only in the dose of 80:80:40 kg/ha. During basal application, full dose of P_2O_5 & K_2O along with ½ dose of N was applied to each row of all the crops. But the remaining ½ dose of N which was for top dressing was only applied to sesame row only. The top dressing was done at 25DAS. In sole pulse plots fertilizers (N, P_2O_5 & K_2O) were applies at a dose of 25:45:25 kg/ha.

Result and Discussion

Growth parameters

Plant height

The plant heights of sesame observed at 30 DAS, 45 DAS, 60 DAS and 75 DAS of crop were statistically analyzed and presented in the Table -1. An increasing trend of plant height was observed in each treatment with the increase in age of the crop up to harvest. Highest plant heights were observed in case of sole sesame at 30 DAS and 45 DAS and in case of sole sesame paired row the same was observed at 15 DAS and 60 DAS and sole sesame at 40cm row spacing gave highest plant height at 75 DAS. The second highest value was found in sole sesame 40 cm row spacing, Sesame+ black gram (1:1), Sesame+ Green gram (2:2), sole sesame four row & sole sesame 30 cm row spacing at 15 DAS, 30 DAS, 45 DAS, 60 DAS & 75 DAS respectively. The lowest value was seen in Sesame + Black gram (2:2), Sesame + Green gram (2:2), Sesame+ black gram (4:4), Sesame+ black gram (2:2) & Sesame + Green gram (2:2) at 15 DAS, 30 DAS, 45 DAS, 60 DAS & 75 DAS respectively. This result may be due to better availability of space, solar energy, nutrients, moisture and less competition among the plants. Here the plant height is higher in sole crops than the intercrops and similar result was found by Thakur *et al.* (2005).

Number of branches/plant of sesame

Data recorded on number of primary branch /plant of sesamum at 25, 45, and 65 DAS were statistically analyzed and presented in Table-2. Number of primary branches per plant of sole sesame at 30 cm row spacing was found to be highest followed by sole sesame at 40 cm row spacing. The lower value was found in Sesame+ black gram (4:4). The highest value of no. of branches in sole crop may be due to the abundant resource and space available to plant.

Dry matter accumulation (g m^{-2})

Data observed on dry weight /plant at 15, 30, 45 and 60 DAS were statistically analyzed and recorded in Table-3. The highest value was found in Sesame + Green gram (4:4) at 15 DAS, 45 DAS, 60 DAS & 75 DAS. At 30 DAS paired row sesame gave highest result. The lowest value was found in sole Sesame 30 cm row spacing & Sesame + Black gram (1:1) at 15 DAS, 60 DAS & 75 DAS. Sesame + Black gram (2:2) gave lowest result in 30 DAS & 45 DAS. Here we can find more dry matter in intercrops. A similar result was also found by Patra *et al.* (1994). The association of higher values with sole Sesame treatments might be due to more number of functional leaves, more nutrient uptake, more vegetative growth of sole Sesame plants in absence of greater competition. The lowest value was found in Sesame+ black gram (2:2) at 30 DAS, 45 DAS & 60 DAS. Treatment sole sesame 30 cm row spacing Sesame+ black gram (1:1) gave lowest result at 15 DAS & 75 DAS respectively. As we can see here that intercropping is good in case of dry matter accumulation & similar result was found by Arya & Jain (2003).

Crop growth rate (CGR)

Table-4 indicates that the highest CGR during 60-75 DAS was recorded in Sesame+ Black gram (2:2) treatment. The CGR is highest in sole sesame (paired row) in 15-30 DAS. Then the highest CGR were seen in Sesame+ Green gram (4:4), Sesame+ Black gram (4:4) & Sesame+ Black gram (2:2) in 30-45 DAS, 45-60 DAS & 60-75 DAS respectively. This may be due to less competition experienced by Sesame as compared to the Sesame grown under paired row system. At 15 DAS treatment Sesame+ black gram (2:2) gave lowest result. At later stages treatment Sesame+ black gram (1:1) gave lowest result.

Chlorophyll estimation

The data on total chlorophyll was statistically analyzed & represented in table-5.The highest chlorophyll a, b and total chlorophyll were recorded in Sesame+ Green gram (1:1) followed by sole sesame (paired row) treatment. The lowest value was given by treatment sole Sesame (30 cm row spacing). We can see more chlorophyll in intercropping. A similar result was found by Chaniyara *et al.* (2008) [5].

Yield attributes.

Test weight

Data recorded on the test weight of Sesame seed was statistically analyzed and presented in Table -6. The effects of different treatments were found to be significant in case of test weight of Sesame. The highest test weight of Sesame

grain was observed on the Sesame+ Green gram (1:1) treatment followed by sole Sesame (40 cm row spacing. The lowest value was got on Sesame+ Black gram (4:4).

Number of seeds/capsule

Data recorded on the number of grains/cob was statistically analyzed and presented in Table-6. The highest test weight of Sesame grain was observed on the Sesame+ Black gram (2:2) treatment followed by sole Sesame (40 cm row spacing). The lowest value was got on Sesame+ Green gram (1:1). Highest seeds per pod in 2:2 row ratio was also found by Sachan *et al.* (1992) [12].

Number of capsule/plant

Data recorded on the number of grains/cob was statistically analyzed and presented in Table-6. The highest test weight of Sesame grain was observed on the Sesame+ Green gram (2:2) treatment followed by Sesame+ Green gram (4:4). The lowest value was got on sole Sesame paired row.

Yield

The data of yield of Sesame were collected & compiled in table-7. Higher yield of intercrops were also reported by Willey & Robert (1976).

Seed yield

Data recorded on the seed yield of Sesame was statistically analyzed and presented in Table -7. Among the treatments sole sesame (30 cm row spacing) gave highest seed Yield which was followed by Sesame + Black gram (4:4). The sole treatment gave highest yield because of the higher plant population. The presence of Black gram in the paired row system probably has more synergistic effect as compared to antagonistic effect. The lowed grain yield was found in Sesame+ Green gram (1:1). Highest grain yield was found in 30 cm row spacing which is similar to report of Ali *et al.* (2001) [3].

Stick yield

Data recorded on the stick yield of Sesame was statistically analyzed and presented in Table-7. Among the treatments Sesame+ Green gram (2:2) gave highest seed yield which was followed by Sole Sesame (40 cm row spacing). The intercrop treatment gave highest yield because of the higher compatibility. The presence of Green gram in the paired row system probably has more synergistic effect as compared to antagonistic effect. The lowed stick yield was found in Sesame+ Green gram (1:1).

Biological yield

Data recorded on the biological yield of Sesame was statistically analyzed and presented in Table-7. The highest stick yield was found in Sesame+ Sesame gram (2:2) which was followed by sole Sesame (40 cm row spacing). The lowed biological yield was found in Sesame+ Green gram (1:1).

Harvest index

Data recorded on the harvest index of Sesame was statistically analyzed and presented in table-7. The highest harvest index was found in Sesame+ Black gram (2:2) which was followed by sole Sesame (paired row).the highest HI was found in Sesame+ Black gram (2:2) because the it has the higher seed yield and low stick yield. The lowed HI was found in Sesame+ Green gram (2:2).

Quality parameters

Oil percentage

The oil percentage was calculated & presented in table-8. The oil percentage is highest in sesame + Black gram (4:4) (48.31%) followed by sesame + Black gram (4:4). The lowest percentage was found in sole sesame four row.

Oil yield (kg/ha)

The oil yield were calculated & presented in table-8. The oil yield was highest (600.48 kg ha^{-1}) in sole Sesame 30 cm row spacing followed by sesame + Black gram (2:2) (593.28 kg ha^{-1}). The highest value was found in sole treatment as it has best growth. The lowest percentage was found in sesame + Black gram (4:4).

Protein content (%)

The protein content were calculated & presented in table-8. The protein content was highest (12.90%) in sole Sesame 30 cm row spacing followed by sesame + Black gram (2:2) (12.50%). The highest value was found in sole treatment as it has best growth. The lowest percentage was found in sesame + Black gram (4:4).

Table 1: Effect of intercropping systems on plant height of sesame

Treatment of sesame	Plant height				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Sole sesame 30 cm row spacing	1.87	27.75	85.63	88.00	104.22
Sole sesame 40 cm row spacing	2.40	24.75	80.83	94.67	**104.49**
Sole sesame paired row	2.48	26.00	82.29	98.33	100.32
Sole sesame four row	2.03	25.50	81.46	96.00	**103.01**
SM:BG::1:1	1.70	27.67	76.67	82.67	101.99
SM:GG::1:1	1.95	26.75	80.63	83.67	98.35
SM:BG::2:2	1.33	24.50	75.83	80.33	98.69
SM:GG::2:2	1.57	21.83	83.13	86.00	97.25
SM:BG::4:4	1.98	21.83	74.38	85.33	100.67
SM:GG::4:4	1.83	23.42	77.71	82.33	98.78
S.Em(±)	0.20	2.14	3.55	1.37	1.34
CD 5%	0.59	6.35	10.55	4.07	3.97
CV%	17.83	14.81	7.70	2.72	2.30

Table 2: Effect of intercropping systems on no of branches /plant of Sesame

Treatment of sesame	No. of branches/plant		
	25 DAS	45 DAS	65 DAS
Sole sesame 30 cm row spacing	3.50	6.43	**9.30**
Sole sesame 40 cm row spacing	3.43	6.33	9.03
Sole sesame paired row	3.13	5.27	8.20
Sole sesame four row	3.30	5.73	8.80
SM:BG::1:1	2.93	4.83	6.53
SM:GG::1:1	2.70	4.67	5.83
SM:BG::2:2	2.87	5.23	5.23
SM:GG::2:2	3.03	5.37	**7.67**
SM:BG::4:4	2.37	4.53	5.13
SM:GG::4:4	3.17	5.00	7.00
S.Em(±)	0.05	0.09	0.12
CD 5%	0.15	0.26	0.36
CV %	2.86	2.81	2.88

Table 3: Effect of intercropping systems on dry mater accumulation (g m^{-2})

Treatment of sesame	Dry mater accumulation (g m^{-2})				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Sole sesame 30 cm row spacing	0.02	12.33	18.29	24.50	28.86
Sole sesame 40 cm row spacing	0.29	7.85	11.45	15.34	21.93
Sole sesame paired row	0.55	18.06	22.00	29.52	43.75
Sole sesame four row	0.42	12.53	20.55	29.05	45.50
SM:BG::1:1	0.51	11.40	12.92	16.68	20.71
SM:GG::1:1	0.55	6.60	11.38	17.03	22.28
SM:BG::2:2	0.40	5.39	9.40	16.10	41.88
SM:GG::2:2	0.27	16.01	21.39	28.23	41.53
SM:BG::4:4	0.39	13.78	19.92	29.17	41.65
SM:GG::4:4	0.84	12.08	21.81	32.90	45.97
S.Em(±)	0.02	0.72	1.53	0.51	1.65
CD 5%	0.05	2.14	4.53	1.52	4.89
CV %	6.85	10.78	15.63	3.72	8.05

Table 4: Effect of Sesame based intercropping systems on Crop growth rate (CGR) of sesame plants

Treatment of sesame	Crop growth rate(g/m^2/day)			
	15-30 DAS	30-45 DAS	45-60 DAS	60-75 DAS
Sole sesame 30 cm row spacing	12.30	8.28	3.89	5.41
Sole sesame 40 cm row spacing	7.56	5.33	2.16	6.59
Sole sesame paired row	17.51	5.97	5.48	13.15
Sole sesame four row	12.11	11.74	4.78	14.56
SM:BG::1:1	10.89	2.60	2.02	4.03
SM:GG::1:1	6.05	7.57	2.19	5.25
SM:BG::2:2	4.99	6.04	4.67	23.49
SM:GG::2:2	15.74	8.49	5.07	16.15
SM:BG::4:4	13.39	8.86	6.53	12.48
SM:GG::4:4	11.24	16.16	4.67	13.07
S.Em(±)	0.72	0.77	0.18	0.88
CD 5%	2.13	2.28	0.55	2.62
CV%	11.09	16.40	7.71	13.40

Table 5: Effect of intercropping systems on chlorophyll estimation Sesame crops

Treatment of sesame	Chlorophyll content(mg/g)		
	Chlorophyll a	Chlorophyll b	Total chlorophyll
Sole sesame 30 cm row spacing	0.88	0.0032	0.89
Sole sesame 40 cm row spacing	1.74	0.0022	1.74
Sole sesame paired row	1.87	0.0022	1.87
Sole sesame four row	1.06	0.0034	1.06
SM:BG::1:1	1.70	0.0044	1.70
SM:GG::1:1	1.89	0.0066	1.90
SM:BG::2:2	1.58	0.0055	1.59
SM:GG::2:2	1.86	0.0019	1.86
SM:BG::4:4	1.47	0.0035	1.47
SM:GG::4:4	1.54	0.0030	1.55
SEM(±)	0.14	0.0004	0.14
CD 5%	0.42	0.0013	0.42
CV %	15.85	21.4495	15.83

Table 6: Effect of Sesame based intercropping systems on yield attributes of Sesame crop

Treatment of sesame	Yield attributes of sesame		
	No. of capsules/ plant	No. of seed / capsule	test wt.(g)
Sole sesame 30 cm row spacing	**25.67**	30.33	2.65
Sole sesame 40 cm row spacing	24.73	**32.33**	2.78
Sole sesame paired row	21.37	29.33	2.70
Sole sesame four row	23.40	28.33	2.65
SM:BG::1:1	28.80	23.33	2.49
SM:GG::1:1	27.60	18.67	2.91
SM:BG::2:2	24.43	38.00	2.68
SM:GG::2:2	36.17	22.67	2.74
SM:BG::4:4	24.37	22.67	2.45
SM:GG::4:4	35.27	20.33	2.61
S.Em(±)	0.26	0.33	0.11
CD 5%	0.78	0.97	0.32
CV%	1.67	2.13	6.96

Table 7: Effect of sesame based intercropping systems on yield (kg/ha) of sesame crop

Treatment of sesame	Yield			
	Grain yield (Kg/ha)	Stick yield (Kg/ha)	Biological (Kg/ha)	HI
Sole sesame 30 cm row spacing	1342.15	5806.67	7148.81	0.19
Sole sesame 40 cm row spacing	1113.70	6100.00	7213.70	0.16
Sole sesame paired row	1097.57	3336.67	4434.24	0.25
Sole sesame four row	1054.23	5320.00	6374.23	0.17
SM:BG::1:1	837.79	3033.33	3871.13	0.23
SM:GG::1:1	750.36	2066.67	2817.03	0.27
SM:BG::2:2	1242.45	2400.00	3642.45	0.34
SM:GG::2:2	1123.10	6233.33	7356.43	0.15
SM:BG::4:4	677.24	2166.67	2843.91	0.25
SM:GG::4:4	934.96	3800.00	4734.96	0.20
S.Em(±)	48.52	526.26	529.89	0.02
CD 5%	144.15	1563.61	1574.40	0.07
CV%	8.26	22.64	18.20	18.47

Table 8: Effect of intercropping system on oil percentage & oil yield of Sesame

Treatment of sesame	Oil content (%)	Oil yield (kg/ha)	Protein content (%)
Sole sesame 30 cm row spacing	44.77	**600.48**	**12.90**
Sole sesame 40 cm row spacing	44.40	494.81	12.56
Sole sesame paired row	45.44	498.03	12.27
Sole sesame four row	44.05	464.21	11.56
SM:BG::1:1	46.09	386.01	10.21
SM:GG::1:1	47.25	354.60	9.21
SM:BG::2:2	47.74	593.28	12.50
SM:GG::2:2	47.97	538.93	11.92
SM:BG::4:4	48.31	327.16	8.56
SM:GG::4:4	48.26	451.50	11.65
S.Em(±)	0.46	22.05	0.11
CD 5%	1.38	65.50	0.34
CV %	1.73	8.11	1.73

Conclusion

From the experiment, it was found that maximum experimental parameters were higher in case of intercropping and less no. of parameters were found higher in sole cropping. Thus, under the red and lateritic soil condition where cultivation is practiced with limited water, legume crops like black gram & green gram can be grown as intercrops with sesame to get higher seed and oil seed, which will be profitable for the farmers.

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