Journal of Crop and Weed, 10(2):38-42(2014)

Sustainable system intensification of sesamum (*Sesamum indicum*) through legume intercropping in sandy loam tract of Kerala

J. S. BINDHU, S. K. RAJ AND L. GIRIJADEVI

Dept. of Agronomy,Kerala Agricultural University
College of Agriculture, Vellayani, Thiruvananthapuram-695522, Kerala

Received: 23-08-2014, Revised: 25-09-2014, Accepted: 01-10-2014

ABSTRACT

Onattukara sandy loam tract an important agro ecological zone spread over the Karunagapally taluk of Kollam and Karthikapally and Mavelikara taluks of Alappuzha districts of Kerala. The soils are highly permeable, acidic in reaction and are extremely deficient in all the major plant nutrients. Sesamum is mainly grown in Kerala as a sole crop in the summer rice fallows of Onattukara tract. The crop grows in this tract utilizing the residual moisture available in rice fields. The establishment of the crop is often poor resulting in low productivity. Hence an experiment was laid out to find out the suitability of raising pulses as an inter crop in Sesamum and to find out the nutrient status and residual effect of the intercropping. The experiment was laid out in Randomised Block Design with 9 treatments viz Sesamum sole (T_1), black gram sole (T_2), green gram sole (T_3), Sesamum + Blackgram (1:1) (T_4), Sesamum + black gram (2:1) (T_5), Sesamum + black gram (3:1) (T_6), Sesamum + green gram (1:1) (T_7), Sesamum + green gram (2:1) (T_8), Sesamum + green gram (3:1) (T_9) with 4 replication. Sesamum being a soil exhausting crop, the inclusion of leguminous crops like black gram and green gram may benefit the companion crop through current nitrogen transfer and to the rice crop through the residual effect. The soil test data after the experiment indicated a significant positive build up of nitrogen and phosphorus in all plots except in plots of sole crop of Sesamum. Among intercropping system, Sesamum + Blackgram in 1:1 ratio gave highest monetary returns and biological efficiencies. The results indicated that legume association with Sesamum could increase the total productivity in addition to the enrichment of soil fertility. Thus, in summer rice fallows instead of growing sole crop of Sesamum, intercropping of Sesamum with black gram in 1:1 proportion can be recommended as an economically viable, biologically suitable and sustainable intercropping system.

***Keywords*:** Intercropping, onattukara, pulses, sesamum, sustainable system

Onattukara sandy loam tract an important agro ecological zone spread over the Karunagapally taluk of Kollam and Karthikapally and Mavelikara taluks of Alappuzha districts of Kerala. The soils are highly permeable, acidic in reaction and are extremely deficient in all the major plant nutrients. Sesamum is mainly grown in Kerala as a sole crop in the summer rice fallows of Onattukara tract. The crop grows in this tract utilizing the residual moisture available in rice fields. The establishment of the crop is often poor resulting in low productivity.

Pulses have certain unique features which together make them an indispensable component in sustainable agriculture. They play an important role in the restoration and build up of soil fertility. The deep penetrating root system enables them to utilize the limited available moisture more efficiently. Recent evidence suggests that there are remarkable benefits of legumes intercropping which are achieved not only by means of costly inputs but by the simple expedient of growing crops together in an appropriate geometry (Bhatti *et al*., 2008). Besides, two crops differing in height, canopy, adaptation and growth habits grow simultaneously with least competition (Jabbar *et al*.,2009). When legumes are grown in association with non legumes, there is often advantage to the non legumes from nitrogen fixed by the legumes (Wahla *et al*., 2009).

Email: jsbindhu@gmail.com

Experiments have shown that growing pulses like Blackgram and Greengram intercropped with Sesamum is successful without any adverse effect on the latter crop. Suitable changes in the cropping system to accommodate both oilseeds and pulses will be a better proposition to bridge the gap between demand and supply of oilseeds and pulses in India. Hence an experiment was laid out to find out the suitability of raising pulses as an inter crop in Sesamum, to work out appropriate planting geometry and to find out the nutrient status and residual effect of the intercropping.

MATERIALS AND METHODS

The experiment was conducted in the summer rice fallows of Onattukara Regional Agricultural Research Station, Kayamkulam under Kerala Agricultural University. The experimental field is located at 9^0 80' N latitude and 76^0 20' E longitude at an altitude of 3.05 m above mean sea level. After that a bulk crop of paddy was raised during the *kharif* season without disturbing the lay out to assess the residual effect of treatments on the succeeding crop of paddy. The soil of

the experimental site is loamy sand and acidic in nature. The soil is low in available N (194.3 Kg ha $^{-1}$), organic carbon(0.45%) ,exchangeable K_2O (43.2 kg ha $^{-1}$) and medium in available P_2O_5 (34.2 Kg ha $^{-1}$). The experiment was laid out in Randomised block design with 9 treatments *viz* Sesamum sole (T_1), Black gram sole (T_2), Green gram sole (T_3), Sesamum + Blackgram (1:1) (T_4), Sesamum + Black gram (2:1) (T_5), Sesamum + Black gram (3:1) (T_6), Sesamum + Green gram (1:1) (T_7), Sesamum + Green gram (2:1) (T_8), Sesamum + Green gram (3:1) (T_9) with 4 replication. The varieties used were Kayamkulam 1 for Sesamum, Syama for Black gram and PUSA 8973 for Green gram.

Biometric observations, yield and yield attributing characters were recorded for both main crop and intercrops. Soil analysis was done before and after the experiment for finding out the available nutrient status. Plant uptake of major nutrients were done for Sesamum, Green gram and Black gram. Bio suitability of the intercropping system was analyzed using parameters like Land Equivalent Ratio (LER) (Mead and Willey (1980)), Land Equivalent Coefficient (LEC) (Adetiloye *et al* (1983)), Relative Crowding Coefficient (RCC),(de Wit (1960)), Aggressivity (Mc Gilchrist (1965)). Economic efficiency of the intercropping systems was analyzed by calculating Gross returns, Net returns, Benefit Cost Ratio (BCR) and Net returns per rupee invested. Bio-economic efficiency was analyzed by monetary advantage based on LER and Sesamum Equivalent Yield (SEY) which was calculated by converting the yield of intercrop into yield of base crop considering the market rates. Data relating to each character is analysed by applying the Analysis of Variance technique.

RESULTS AND DISCUSSION

Growth characters and yield attributes

The results revealed that the different intercropping treatments did not significantly influence the growth characters of Sesamum (Table 1). Sesamum in general, having an erect growing habit was least affected by shade when put under intercropping systems with different planting ratios. Thus the results indicated that Sesamum can be successfully intercropped with Greengram and Blackgram without much competition. Intercropping treatments significantly influenced the plant height of green gram (Table 3). The sole crop recorded the maximum height at all stages of crop growth.

Among the yield characters the sole crop of Sesamum recorded the maximum seed yield (539 kg ha^{-1}) and was significantly superior to all other treatments (Table 5). This might be attributed to improvements of yield components like more number of capsules per plant and higher 1000 grain weight in sole crop over intercrop. The seed yield of inter crops were also recorded (Table 5). Rathode *et al.* (2004) reported the seed yield of different intercrops showed significant differences due to row proportions and intercropping systems. The 1000 seed weight of Sesamum was found to be significantly influenced by intercropping treatments(Table 1). Plant competition due to higher population observed in treatments when Sesamum with Black gram and Green gram were grown in 1:1 proportion can be attributed as the reason for the lowest values.

The nutrient uptake was significantly higher in sole crop when compared to intercropping treatments. In all intercropped treatments, there was reduction in Sesamum yield below the expected level on the basis of planted area. The increased nitrogen uptake noticed was due to the increased dry matter production of the sole crop. As in the case of nitrogen, uptake of phosphrous and potassium were maximum under the sole crop situation. Among the intercropping treatments, Sesamum + Greengram and Sesamum + Blackgram in 1:1 ratio recorded the highest uptake values.

Biological efficiency of the intercropping system

Galil and Ghany (2014) reported the interaction between cropping system and mineral nutrients (nitrogen) is an important factor affecting yield and its attributes of legumes. To achieve higher productivity from intercropping, the component crops are to be evaluated and selected for better compatibility. Therefore a basic knowledge of techniques of evaluations of competitive relation of component crops and their yield advantages in intercropping situation would be helpful in future for selecting suitable intercropping system for any specific agro-ecological situation.

Evaluation of Sesamum-Pulse intercropping system for their biological efficiency were analyzed. In all intercropping systems except Sesamum and Blackgram in 2:1 ratio, LER excelled unity, indicating greater biological efficiency of intercropping. The results on LEC showed that LEC was more than 0.25 in Sesamum and Blackgram in 1:1 ratio and Sesamum with Greengram in 1:1 row proportion and they were on par. In all other situations LEC was less than 0.25

which indicated that due to competition between the components crops ,the yield would be less than the expected yield. The aggressivity values were found to be positive in pulses and negative in Sesamum. Similar results were also reported by Puste *et al*. (2014). The maximum value of aggressivity (0.12) was recorded by Blackgram when it was intercropped with Sesamum in 1:1 ratio. Here the intercrops Blackgram and Greengram have its coefficient greater than one in all treatments. The product of RCC was greater than one except in Sesamum+ Blackgram in 2:1 ratio indicating a definite yield advantage due to intercropping.

The results on mean energy values showed that the highest energy values were obtained from the sole crop of Blackgram due to the highest seed yield and lowest value was obtained from sole crop of Sesamum. Among the intercropping systems Sesamum and Blackgram grown in 1:1 row arrangements gave the highest energy values in intercropping system.

Table 1: Growth and yield attributes of sesamum at harvest

Treatments	Plant height (cm)	Number of leaves	Number of branches	Leaf area index	Number of pods per plant	1000 seed weight (g)
T_1	99.48	68.7	3.4	1.818	30.25	2.818
T_4	93.13	66.58	3.35	1.778	28.18	2.595
T_5	94.6	61.45	3.25	1.793	28.63	2.773
T_6	95.98	69.83	3.2	1.808	29.78	2.82
T_7	93.75	66.95	3.48	1.829	28.28	2.588
T_8	92	66.85	2.9	1.838	29.9	2.74
T_9	93.25	67.95	3.23	1.833	28.7	2.825
SEm(±)	**2.478**	**3.0**	**0.8**	**0.012**	**0.72**	**0.03**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**0.09**

Table 2: Growth and yield attributes of black gram at harvest

Treatments	Plant height (cm)	Number of leaves	Number of branches	Leaf area index	Number of pods per plant	100 seed weight(g)
T_2	51.3	36.65	2.73	2.51	27.3	4.485
T_4	47.43	30.58	2.65	2.43	24.55	4.512
T_5	44.13	35.05	2.95	2.5	24.53	4.508
T_6	44.9	29.5	2.68	2.37	24.7	4.513
SEm(±)	**2.12**	**1.94**	**0.277**	**0.039**	**0.535**	**0.013**
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**1.71**	**NS**

Table 3: Growth and yield attributes of green gram at harvest

Treatments	Plant height (cm)	Number of leaves	Number of branches	Leaf area index	Number of pods per plant	100 seed weight(g)
T_3	45.98	28.03	2.6	2.51	25.15	4.178
T_7	42.8	28.77	2.75	2.46	24.9	4.083
T_8	43.28	26.8	2.55	2.5	24.8	4.1
T_9	40.05	28.78	2.53	2.48	23.75	4.113
SEm(±)	**1.17**	**1.15**	**0.213**	**0.025**	**0.325**	**0.028**
LSD(0.05)	**3.74**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4: Sesamum Equivalent Yield (kg ha^{-1})

Treatments	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	SEm (±)	LSD(0.05)
Sesamum equivalent yield	539.53	1006.9	720	812.46	689.03	662.81	643.01	624.32	604.07	**12.3**	**2.39**

Economic efficiency of the intercropping system

The results indicated that Sesamum equivalent yield from all intercropping systems were significantly more than sole Sesamum yield and highest equivalent yield was obtained in Sesamum + Blackgram in 1:1 row proportion (Table 4). Highest monetary advantage based on LER was also obtained from the intercropping of Sesamum and Blackgram in 1:1 row arrangement. Economic efficiency of intercropping system was analyzed. Significant differences were observed for gross returns, net returns, BCR and net return per rupee invested. The most profitable intercropping treatment was Sesamum and Blackgram in 1:1 ratio which gave a BCR of 1.73 which was significantly superior to other intercropping treatments. This was in conformity with findings of Kumar and Thakur (2006) who reported that among intercropping systems, Sesamum + Blackgram (1:1) gave the maximum land equivalent ratio (1.17), sesame equivalent yield (0.605 t ha^{-1}) and net return (Rs 13 510).

Table 5: Seed yield (kg ha^{-1}) of sesamum, black gram and green gram

Treatment	Sesamum	Black gram	Green gram
T_1	539.53	-	-
T_2	-	1401.25	-
T_3	-	-	1200
T_4	262.92	763.25	-
T_5	356.21	462.25	-
T_6	406.85	355.5	-
T_7	262.76	-	633.75
T_8	363.02	-	435.5
T_9	407.72	-	327.25
SEm(±)	**6.024**	**11.776**	**247.05**
LSD(0.05)	**17.898**	**37.67**	**79.03**

Table 6: Soil nutrient status after the experiment

	Soil nutrient (kg ha^{-1})		
Treatments	**Nitrogen**	**Phosphorous**	**Potassium**
T_1	193.03	35.68	41.17
T_2	205.58	37.98	43.59
T_3	206.58	38.33	44.2
T_4	198.35	37.93	41.32
T_5	198.2	37.3	40.45
T_6	195.73	38.18	39.06
T_7	197.23	38.73	39.85
T_8	198.03	38.08	40.03
T_9	197.1	36.98	39.48
SEm (±)	**0.82**	**0.51**	**0.45**
LSD (0.05)	**2.39**	**1.47**	**1.32**

Soil nutrient status as influenced by intercropping

The results on the nutrient status before the experiments indicated that there was not much variations in the fertility status of the soil of the experimental field. The soil test data after the experiment indicated a significant positive build up of nitrogen and phosphorus in all plots except in plots of sole crop of Sesamum where a slight reduction in the soil nitrogen status was observed (Table 6). But in case of potassium the exchangeable potassium was slightly reduced after the experiment. The results showed that there was a gain in nitrogen in which legume crop where included and maximum gain was noticed in the plots of sole crop of black gram and green gram. The plot of sole crop of Sesamum was recorded the lowest nitrogen content (193 kg ha^{-1}).

Available phosphorus content of the soil also had been significantly increased after the experimentation. The maximum gain was observed in the inter cropped plot of Sesamum and green gram in 1:1 ratio (38.73kg ha^{-1}). The plot of sole Sesamum recorded the lowest value of P (35.68 kg ha^{-1}).

The exchangeable potassium status of the soil was also significantly influenced by the treatments. In general, the K content of the soil was found to be decreased after the experiment. The decrease was maximum in the intercropped plot of Sesamum and green gram in 3:1 ratio (39.48 kg ha^{-1}). This may be due to the fact that the total potassium uptake of the system exceeded the total addition. Further, the soil of the experimental sight was sandy loam in texture which might have contributed to the leaching loss of potassium.

Effect of inter cropping in summer rice fallows on succeeding first crop of rice

A major advantage of using legumes as component crops in an intercropping system was that they can bring about an increase in nitrogen content of soil and this nitrogen in turn may be available to crops grown either in the same season or in succeeding season. In this experiment, rice fallows were cultivated by growing Sesamum and pulses as summer crops. A bulk crop of rice was raised during the succeeding *kharif* season, to assess the residual fertility. In this experiment the sole and intercropped Blackgram and Greengram proved more efficient in increasing the grain yield of paddy compared to sole crop of Sesamum. The highest grain and straw yields were obtained from plots when the preceding crop combination was Sesamum and Blackgram in 2:1 row arrangement. The results indicated that legume association with Sesamum could increase the total productivity in addition to enrichment of soil fertility.

It may be concluded that in summer rice fallows of Onattukara tract, intercropping of Sesamum with Blackgram in 1:1 proportion can be recommended as an economically viable, biologically suitable and a sustainable intercropping system instead of growing sole crop of Sesamum.

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