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Full Length Research Paper

Economic assessment and biological feasibility of summer sesamum based intercropping systems

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An experiment was conducted at College Farm, Navsari Agricultural University, Navsari (Gujarat) to study the production potential and economic assessment of various sesamum based intercropping systems during summer season of 2016. The total nine treatments were tested in randomized block design with four replications. Green gram and cowpea were intercropped in sesamum with 2:1 and 3:2 row ratios. Sole green gram gave highest net return (Rs. 56441/ha) and found to be most beneficial treatment among all of the nine treatments. Intercropping of green gram with sesamum was found more beneficial over sole sesamum. Among the intercropping treatments, sesamum + green gram (3:2) gave maximum sesamum equivalent yield (944 kg/ha), land equivalent ratio (1.18), area time equivalent ratio (1.13), income equivalent ratio (1.18), monetary advantages (Rs. 10515/ha), net return (Rs. 48118/ha) and benefit cost ratio (3.01).

Keywords: Intercropping, sesamum, green gram, cowpea, productivity, economics.

INTRODUCTION

Despite being largely self-sufficient in food production, Indian agriculture currently faces a plethora of problems like declining productivity, widening income gap between farmers and the rest of the workforce; and the perpetual conversion of agricultural lands into urban landscapes is threatening agricultural intensification. This rapid urbanization coupled with unpredictable climate changes will put added pressures on land and food.

India ranks second in area (18.94%) next to Sudan, first in production (14.83%) and highest in export (17.56%) of sesamum (Anon, 2016). India accounts for the production of 8.28 lakh tonnes from 17.46 lakh ha area with 474 kg/ha productivity of sesamum during 2014-15. The area and production of sesamum are higher in *Kharif* season while, productivity is higher in summer season.

Sesamum being a short duration crop, has the potential to enhance cropping systems intensification and diversification (Oyeogbe *et al*., 2015). It has unique attributes that can fit almost any cropping system. In recent days, the interest of growing food legumes in an intercropping system is increasing with time amongst the farmers (Khan and Khaliq, 2004) due to more advantages with the system as intercropping may play a pivotal role in increasing production and also providing assurance against total crop failure.

MATERIAL AND METHODS

Site description

A field experiment was carried out during summer season of 2015-16 at College Farm, Navsari Agricultural University, Navsari (Gujarat). The climate of this zone is typically tropical, characterized by humid and warm monsoon with heavy rains, cold winter and fairly hot summer. The summer season commences by the middle of February and the temperature reaches to its maximum

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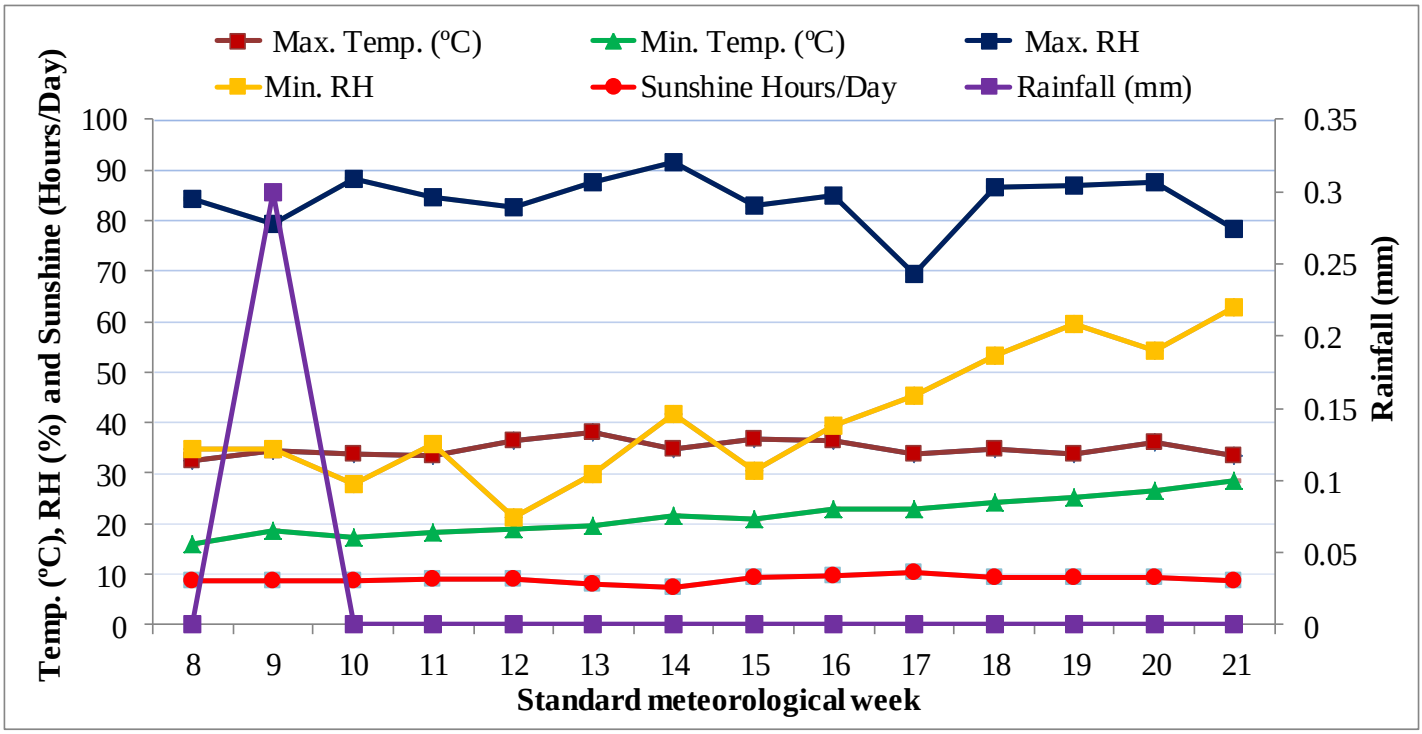
Figure 1. Mean weekly meteorological data during crop season of the year 2016.



in April or May. The overall meteorological data (Figure 1) revealed that the weather and climate conditions were normal and favorable for the growth and development of sesamum and pulse crops.

The soil of the experimental site was clayey in texture with slightly alkaline (pH 7.6) and normal electric conductivity (0.32 dS/m). The available nitrogen, phosphorous and potassium content of this soil was 197.26, 30.93 and 369.80 kg/ha, respectively (Jackson, 1967).

Experimental design and treatments

Total nine treatments *viz.*, T_1 – sole sesamum, T_2 – sole sesamum (Paired rows at 30-60 cm), T_3 – sole sesamum (Paired rows at 30-30-75 cm), T_4 – sole green gram, T_5 – sole cowpea, T_6 – sesamum + green gram (Paired 2:1), T_7 – sesamum + green gram (Paired 3:2), T_8 – sesamum + cowpea (Paired 2:1) and T_9 – sesamum + cowpea (Paired 3:2) were tried in randomized block design with four replications.

Crop management

The sesamum cv. GT-3, green gran cv. Meha and cowpea cv. GC-4 were used for conducting the experiment. The recommended dose of NPK as 50-25-00 kg/ha for sesamum and 20-40-00 kg/ha for intercrops was applied. Sesamum as well as intercrops were sown on 22nd February, 2017. Seed were covered properly with soil and irrigation was applied carefully in each plot immediately after sowing. Sesamum was sown as sole (Normal sowing as well as paired rows) and intercropping treatments. In all the treatments, 100 per cent plant population of sesamum was maintained (Additive series). For weed control, one intercultural operation at 20 DAS followed by two hand weeding at 25 and 40 days after sowing were carried out. Intercrops were harvested on 15th May, 2017 prior to sesamum which was harvested on 24th May, 2017. In general, sesamum, green gram and cowpea were harvested 92, 81 and 81 days after sowing, respectively. The produce of each of net plot was threshed, cleaned, weighted separately and recorded for each net plot. The grain weight per net plot was, then converted into kg/ha and presented accordingly. Finally, seeds of sesamum as well as intercrops (Green gram and cowpea) were sold. The sale price of seed of sesamum, green gram and cowpea were 73, 80 and 50 Rs./kg, respectively, while, sale price for intercrops stover is 4 Rs./kg.

Statistical analysis

The statistical analysis of data recorded for different characters was carried out through the Randomized Block Design of the experiment as described by Panse and Sukhatme, (1967). The significance of difference was tested by 'F' test. Five per cent level of significance was

used to test the significance of results. The critical differences were calculated when the differences among treatments were found significant in 'F' test. In the remaining cases, only standard error of means was worked out. The co-efficient of variance (C.V. %) was also worked out.

Economic Productivity

Sesamum equivalent yield (kg/ha) (SEY) was worked out for all the experiment units by following formula and statistical analysis.

$$\text{SEY (kg/ha)} = \text{Yield of sesamum} + \frac{\text{Yield of intercrop} \times \text{Price of intercrop}}{\text{Price of sesamum}}$$

Economic Assessment

Economic analysis has preponderant importance as it gives the clear picture about cost involved, income and their ratio which is most important for farmers. Farmers are mostly concerned with the total profit and the marginal B: C ratio from investment in labour and inputs (Ghosh, 2004).

Gross Return (Rs./ha): The gross return in term of rupees per hectare was calculated on the basis of the yield of sesamum for each treatment using the prevailing market prices of produce.

Cost of cultivation (Rs./ha): It was calculated by considering the cost of all the inputs used and operations followed starting from the preparatory tillage to harvesting.

Net Return (Rs./ha): Net return (kg/ha) was calculated by using following formula.

$$\text{Net Return (Rs./ha)} = \text{Gross return} - \text{Cost of cultivation}$$

Benefit Cost Ratio (B: C ratio): The benefit cost ratio was calculated for each treatment using following formula.

$$\text{B: C ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

Income Equivalent Ratio (IER): IER is the relative land area needed under sole cropping to produce the same gross income as is obtained from 1 ha of intercropping at the same management level. The IER is the conversion of the LER into economic terms. It was calculated by using the following formula. The value of IER >1 denotes advantages of intercropping system.

$$\text{IER} = \frac{GI_{ab}}{GI_{aa}} + \frac{GI_{ba}}{GI_{bb}}$$

Monetary Advantages (Rs./ha): Monetary advantage as suggested by Willey (1979) was calculated as follows

$$\text{Monetary Advantages (Rs./ha)} = \frac{\text{LER} - 1}{\text{LER}} \times \text{value of combined intercrop}$$

$$\text{Value of combined intercrop} = (Y_{ab} \times P_a) + (Y_{ba} \times P_b)$$

Biological Feasibility

Land Equivalent Ratio (LER): LER is the relative land area needed under sole cropping to produce the same yield as is obtained from one ha of intercropping at the same management level. It was worked out for all the experiment units by using following formula as suggested by Mead and Willey (1980).

$$\text{LER} = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

The value of LER >1, <1 and =1 denotes advantages, disadvantageous and neither advantages nor disadvantages of intercropping system, respectively.

Area Time Equivalent Ratio (ATER): ATER is the evaluation of crop yield per day basis. LER can only consider the profitability of intercropping in terms of land area but not the time. So, unlikely of LER, the measure of ATER can consider both land area as well as the time for which the crops were on the land. It was calculated by using the following formula as proposed by Hiebsch (1978).

$$\text{ATER} = \frac{(RY_a \times D_a) + (RY_b \times D_b)}{T}$$

$$RY_a = \frac{\text{Yield of sesamum in intercropping treatment}}{\text{Yield of sesamum as sole treatment}}$$

$$RY_b = \frac{\text{Yield of intercrop in intercropping treatment}}{\text{Yield of intercrop as sole treatment}}$$

The value of ATER >1, <1 and =1 denotes advantages, disadvantageous and neither advantages nor disadvantages of intercropping system, respectively.

RESULTS AND DISCUSSION

Economic Productivity

Seed Yield of Sesamum (kg/ha)

The results pertaining to the influence of various treatments on seed yield of sesamum (Table 1) indicated the significant influence of different treatments on seed yield of sesamum. Sole sesamum *viz.*, normal sowing (T_1), paired rows at 30-60 cm (T_2) and paired rows at 30-30-75 cm (T_3) with 702, 691 and 682 kg/ha seed yield were statistically at par and recorded significantly higher seed yield as compared to all sesamum + green gram and sesamum + cowpea intercropping treatments.

Comparison of intercropping treatments showed that treatment T_7 – sesamum + green gram (Paired 3:2) recorded the maximum seed yield of sesamum followed by T_6 – sesamum + green gram (Paired 2:1), but the differences were statistically non-significant. The maximum reduction in seed yield of sesamum due to

Table 1. Seed yield, sesamum equivalent yield (SEY) and economics of summer sesamum based intercropping systems.

Treatment		Seed yield (kg/ha)		Stover yield (kg/ha)	SEY (kg/ha)	Gross return (Rs./ha)	Cost of cultivation (Rs./ha)	Net return (Rs./ha)	B: C ratio
		Sesamum	Intercrop						
T_1	Sole sesamum	702	–	–	702	51246	19676	31570	2.60
T_2	Sole sesamum (Paired rows at 30-60 cm)	691	–	–	691	50443	19676	30767	2.56
T_3	Sole sesamum (Paired rows at 30-30-75 cm)	682	–	–	682	49786	19676	30110	2.53
T_4	Sole green gram	–	923	1725	1012	80776	24335	56441	3.32
T_5	Sole cowpea	–	1015	1910	695	58375	23335	35040	2.50
T_6	Sesamum + green gram (Paired 2:1)	518	292	635	838	63714	23443	40271	2.72
T_7	Sesamum + green gram (Paired 3:2)	530	378	795	944	72092	23974	48118	3.01
T_8	Sesamum + cowpea (Paired 2:1)	472	325	725	695	53635	23110	30525	2.32
T_9	Sesamum + cowpea (Paired 3:2)	505	435	925	803	62319	23530	38789	2.65
	S.Em.±	29	–	–	45	–	–	–	–
	C.D. (0.05)	87	–	–	133	–	–	–	–

Note: Sole sesamum yield were considered as average of T_1, T_2 and T_3 for SEY.

cowpea intercropping can be ascribed to its relatively luxuriant vegetative growth of cowpea as compared to green gram which suppress the growth of sesamum. These results were also supported by Bhatti *et al.* (2005).

Sesamum Equivalent Yield (kg/ha)

The results (Table 1) revealed that SEY was influenced significantly due to various intercropping treatments. Inclusion green gram or cowpea intercrop in sesamum at different row ratios exhibited rise in sesamum equivalent yield to varying extent except sesamum + cowpea in 2:1 ratio (T_8). Among the intercropping treatments, T_7 – sesamum + green gram (Paired 3:2) recorded the highest SEY (944 kg/ha) which was statistically at par with T_6 – sesamum + green gram (Paired 2:1). Conversion of green gram and cowpea yield under sole stand (T_4 and T_5, respectively) into SEY revealed that former was significantly higher over sole sesamum yield recorded in T_1, T_2 and T_3. The higher SEY due to introducing of legumes in sesamum was also reported by Mandal and Pramanick (2014) in sesame + green gram (2:2).

Biological Feasibility

Land Equivalent Ratio

The data with respect to land equivalent ratio (Table 2) showed that all intercropping treatments increased the LER compared with sole crops except treatment T_8 – sesamum + cowpea (Paired 2:1) with being 1.0 value of LER. The highest LER was recorded in treatment T_7 – sesamum + green gram (Paired 3:2) followed by T_9 – sesamum + cowpea (Paired 3:2) and T_6 – sesamum + green gram (Paired 2:1), the values of LER being 1.18, 1.16 and 1.07, respectively. The results are in conformity with the findings of Sarkar and Chakraborty (2000).

Area Time Equivalent Ratio

The results (Table 2) revealed that all the intercropping treatments except sesamum + cowpea (Paired 2:1) were found to be advantageous in respect of ATER (value being more than one), the extent of which varied in the different systems. Sesamum + green gram (Paired 3:2) recorded maximum ATER (1.13) followed by sesamum + cowpea (Paired 3:2) and sesamum + green gram (Paired 2:1). The higher value of ATER was also reported by Ghosh *et al.* (1995) in sesamum + black gram (1:2) and Mandal and Pramanick (2014) in sesamum + green gram (2:2).

Economic Feasibility

The data pertaining to economics of sole and intercropping treatments furnished Table 1 revealed that sole green gram (T_4) recorded comparatively higher net return of Rs. 56441/ha with 3.32 B: C ratio followed by sesamum + green gram (Paired 3:2) (T_7) (Rs. 48118/ha and 3.01, respectively), sesamum + green gram (Paired 2:1) (T_6) (Rs. 40271/ha and 2.72, respectively) and sesamum + cowpea (Paired 3:2) (T_9) (Rs.

Table 2. Biological and economic feasibility of summer sesamum based intercropping systems.

Treatment		LER	ATER	IER	Monetary advantages (Rs./ha)
T_6	Sesamum + green gram (Paired 2:1)	1.07	1.03	1.07	4002
T_7	Sesamum + green gram (Paired 3:2)	1.18	1.13	1.18	10515
T_8	Sesamum + cowpea (Paired 2:1)	1.00	0.96	1.01	0.00
T_9	Sesamum + cowpea (Paired 3:2)	1.16	1.11	1.17	8085

Note:- Sole sesamum yield as well as gross income were considered as average of T_1, T_2 and T_3.

38789/ha and 2.65, respectively). Similar results are also in agreement with the findings of Sarkar and Chakraborty (2000), Sharma and Singh (2008) and Bindhu *et al*. (2014).

Income Equivalent Ratio

With the values of IER higher than 1 (Table 2), we could infer that all the intercropping system provided higher economic returns and were advantageous. The maximum IER (1.18) was obtained from sesamum + green gram (Paired 3:2) closely followed by sesamum + cowpea (Paired 3:2) (1.17). Sarkar and Chakraborty (2000) also found the maximum IER in sesamum + green gram (1:1).

Monetary Advantages (Rs./ha)

Inclusion of green gram in sesamum with 3:2 row ratio gave maximum monetary advantage of 10515 Rs./ha. Sesamum + cowpea (Paired 2:1) intercropping system could not be able to give monetary advantages. Mandal and Pramanick (2014) also obtained the highest monetary advantages from sesamum + green gram (2:2).

CONCLUSION

Based on one year experimentation, we conclude that sesamum + green gram intercropping in 3:2 row ratio (Paired) proved to be more productive, remunerative and utilized land more efficiently as indicated by higher values of land equivalent ratio, area time equivalent ratio, income equivalent ratio, monetary advantages and net income.

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Abbreviations table

Anon.	Anonymous	IER	Income equivalent ratio
ATER	Area time equivalent ratio	LER	Land equivalent ratio
B: C	Benefit cost ratio	P_a	Price of sesamum (Rs./kg)
C.V.	Co-efficient of variance	P_b	Price of intercrop (Rs./kg)
D_a	Duration of sesamum (Days)	pH	Potential of hydrogen ion
D_b	Duration of intercrop (Days)	RY_a	Relative yield of sesamum (kg/ha)
dS/m	Decisiemens per meter	RY_b	Relative yield of intercrop (kg/ha)
et al.	And others	SEY	Sesamum equivalent yield
GC - 4	Gujarat cowpea – 4	T	Duration of intercropping system
GI_{aa}	Gross income of sesamum as sole crop	*viz.*	Namely
GI_{ab}	Gross income of sesamum in intercropping treatment	Y_{aa}	Yield of sesamum as sole crop (kg/ha)
GI_{ba}	Gross income of intercrop in intercropping treatment	Y_{ab}	Yield of sesamum in intercropping treatment (kg/ha)
GI_{bb}	Gross income of intercrop as sole crop	Y_{ba}	Yield of intercrop in intercropping treatment (kg/ha)
GT-3	Gujarat Til – 3	Y_{bb}	Yield of intercrop as sole crop (kg/ha)