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Biological Indices Influenced by Sesame Based Intercropping System with Different Levels of Nitrogen

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during summer seasons of the years 2021 and 2022. An experiment was laid out in Randomized Block Design with Factorial concept and replicated three times. Fourteen treatment combinations comprising of seven intercropping treatments of sesame viz., I_1 - sole sesame, I_2 - sole cowpea, I_3 - sole green gram, I_4 - sesame + cowpea (paired 2:1), I_5 - sesame + green gram (paired 2:1), I_6 - sesame + cowpea (paired 3:2) and I_7 - sesame + green gram (paired 3:2) and two nitrogen levels viz., 75% RDN (N_1) and 100% RDN (N_2) were evaluated in the study. The experiment was conducted for two consecutive years with same randomization. Significantly higher seed, stover and biological yields, sesame equivalent yield and land equivalent ratio of sesame were found superior with 100 % RDN (N_2) on pooled basis.

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1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the most ancient oilseed crops grown for over 5000 years. Sesame, popularly known as sesamum, til, simsim, benised, gingelim, *etc*., is generally cultivated throughout the year, *i.e*., during *kharif*, semi *rabi* and summer as a sole as well as mixed/inter crop. Sesame is a rich source of oil (46-52%) and protein (18-20%). In India during 2020-2021 sesame is cultivated in an area of 17.22 lakh ha with a production of 8.16 lakh tonnes and productivity of 474 kg/ha [1]. In India, it is mainly grown in Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, West Bengal and Andhra Pradesh. In Gujarat, major sesame growing district are Surendranagar, Kutch, Rajkot, Junagadh, Jamnagar, Bhavnagar, Banaskantha and Amreli. It occupied about 2 lakh hectare area and production of 0.4 million tonnes of sesame during 2020-2021 [2].

Any scheme or plan to increase food and oil production cannot be a total success unless and until an appropriate production oriented cropping system and production technology are developed and implemented properly. The practice of multi-cropping in the form of intercropping has been a unique asset of tropical and sub-tropical areas and is becoming popular day by day among small farmers. Advantages of intercropping may be especially important because they are achieved not by means of costly inputs, but by the simple expedient of growing crops together. Spatial arrangement in intercropping is one of the most important factors for higher yield. In sesame + legume intercropping system, sesame is an oilseed crop. The suggested benefits of legumes are better root stratification, utilization of soil nutrients and nitrogen fixation by legume which allows an independent of soil nitrogen and making some nitrogen available to non-legume.

Among plant nutrients, nitrogen is the most important and expensive nutrient and it has marked effect on growth and yield of sesame crop. Inclusion of pulses in intercropping system has many ramifications. They are less demanding on soil resources, many of them can tolerate some amount of shading; they can fix atmospheric nitrogen (N) in root nodules, contributing part of fixed nitrogen (N) to associated crop and enriching the soil. Residues and root nodules release nitrogen during decomposition. There are reports to show that inclusion of pulses in cropping systems had indeed benefited the associated as well as succeeding crops [3,4]. Inclusion of pulses as intercrop helped to save up to 25 % of recommended level of nitrogen application to associated cereal [5] and improved soil nitrogen status and thus, reduced nitrogen application to the succeeding crop [6].

2. MATERIALS AND MATHODS

A field experiment was taken up at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during summer seasons of the years 2021 and 2022. Soil of experimental site was dark grayish brown type with flat topography. Soil is characterized by medium to poor drainage capacity and good water holding capacity. Because of predominance of montmorillonite clay mineral, soil cracks heavily on drying.

An experiment was laid out in Randomized Block Design with Factorial concept and replicated three times. Fourteen treatment combinations comprising of seven intercropping treatments of sesame viz., I_1 - sole sesame, I_2 - sole cowpea, I_3 - sole green gram, I_4 - sesame + cowpea (paired 2:1), I_5 - sesame + green gram (paired 2:1), I_6 - sesame + cowpea (paired 3:2) and I_7 - sesame + green gram (paired 3:2) and two nitrogen levels viz., 75% RDN (N_1) and 100% RDN (N_2) were evaluated in the study. An experiment was conducted for two consecutive years with same randomization.

2.1 Sesame Equivalent Yield

Seed yield of the intercrops was converted to sesame seed equivalent on the basis of price of grain of different crops involved in the treatments.

SEY= Gross profit of system / Price of sesame seed

2.2 Land Equivalent Ratio

Relative area of sole crop that would be required to produce the yield achieved by intercropping was calculated for each treatment.

LER= Yab / Yba + Yaa / Ybb

Where,

Yab = Yield of sesame in intercropping
Yaa = Yield of sesame as sole crop
Yba = Yield of intercrop in intercropping
Ybb = Yield of intercrop as sole crop

3. RESULTS AND DISCUSSION

3.1 Seed, Stover and Biological Yield (kg/ha)

3.1.1 Effect of intercropping

Data presented in Table 1 revealed that different intercropping systems significantly influenced seed, stover and biological yield of sesame during both the years as well as in pooled analysis. Among different intercropping systems examined, significantly higher seed yield of sesame was recorded with treatment I_1 (sole crop sesame) but it was statistically at par with treatments I_4 (sesame + cowpea (paired 2:1)) and I_5 (sesame + green gram (paired 2:1)) during the both years. However, it statistically at par only with treatment I_5 (sesame + green gram (paired 2:1)) in pooled analysis. Whereas, significantly the lowest seed yield was obtained due treatment I_6 (sesame + cowpea (paired 3:2)) during both the years and in pooled analysis. Similarly, significantly higher stover yield of sesame was gained with treatment (I_1) sole crop sesame during both the years and pooled analysis it was statistically comparable with I_5 (sesame + green gram (paired 2:1)) treatment during both individual years. Although, treatment I_1 produced significantly the highest stover yield of sesame in pooled results. Similar trend that of stover yield was also registered for biological yield of sesame crop. Seed, stover and biological yields of sesame were significantly reduced in intercropping system having 3:2 paired row ratio. On the contrary, the lowest seed, stover and biological yields of sesame was noted when it was intercropped with cowpea. Thus, reduction in seed, stover and biological yields of sesame under intercropping treatments could be assigned to lower values of almost all yield attributes viz., number of capsule per plant, capsule length, number of seeds per capsule and test weight under intercropping treatments resulting from poor plant growth due to competition effect between sesame and intercrops for resources like sun light, space, moisture and plant nutrients. Reduction in seed yield of sesame owing to legume intercropping was also remarked by Sarkar and Kundu [7] and Yadav *et al*. [8]. The maximum reduction in seed yield of sesame due to cowpea intercropping could be ascribed to its relatively luxuriant vegetative growth of cowpea as compared to green gram which might suppress the growth of sesame. Similar results are also in agreement with the findings of [9].

3.1.2 Effect of nitrogen levels

It is evident from Table 1 that seed, stover and biological yields of sesame were significantly affected by varying nitrogen levels during both the years and in pooled data. Among different nitrogen levels examined, significantly superior seed stover and biological yields of sesame were reported with an application of 100 % RDN (N_2) to sesame crop during both the years and pooled analysis. The minimum seed stover and biological yields of sesame due to lower level of nitrogen (N_1: 75% RDN) might be due to insufficient supply of nitrogen for achieving proper growth and development of sesame crop. This might be due to improvement in growth characters that favorably modified the yield attributes. Amount of nitrogen plays an important role in plant metabolism by virtue of being an essential constituent of diverse types of metabolically active compounds like amino acids, proteins, nucleic acid, enzymes, co-enzymes and alkaloids which are important for higher growth and yield. This increase in growth and yield attributes ultimately helped in realization of higher seed yield. The results obtained in this study are in agreement with those reported by Sarala and Jagannatham [10] Chakraborty [11] Patel *et al*. [12] Hasan [13] Gebremariam [14] Kithan *et al*. [15] Shamsuzzoha *et al*. [16] Adisu *et al*. [17] and Jose *et al*. [18].

3.1.3 Interaction effect

The findings are indicated significant interaction between intercropping and different nitrogen levels to sesame crop during both the years and in pooled results (Table 2). During both years, treatment combination I_1N_2 (100% RDN applied to sole sesame) registered significantly higher seed yield, but it was at par with treatment

Table 1. Seed yield and stover yields of sesame as influenced by intercropping and nitrogen levels

Treatments	Seed yield (kg/ha)			Stover yield (kg/ha)			Biological yield (kg/ha)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
A. Intercropping									
I_1: Sole crop sesame	783	813	798	1172	1218	1195	1955	2030	1993
I_2: Sole crop cowpea	-	-	-	-	-	-	-	-	-
I_3: Sole crop green gram	-	-	-	-	-	-	-	-	-
I_4: Sesame + cowpea (paired 2:1)	727	750	738	1083	1127	1105	1810	1876	1843
I_5: Sesame + green gram (paired 2:1)	752	769	761	1104	1133	1119	1857	1902	1879
I_6: Sesame + cowpea (paired 3:2)	604	622	613	905	928	916	1509	1550	1529
I_7: Sesame + green gram (paired 3:2)	622	635	628	942	961	951	1563	1596	1579
SEm$\pm$	20.01	21.44	14.66	29.96	31.33	21.68	44.96	46.19	32.33
CD (P=0.05)	59	64	42	89	93	62	134	137	92
B. Nitrogen levels									
N_1: 75 % RDN	614	629	622	917	937	927	1531	1566	1548
N_2: 100 % RDN	781	806	794	1166	1209	1187	1947	2016	1981
SEm$\pm$	12.66	13.54	9.27	18.95	19.82	13.71	28.44	29.21	20.38
CD (P=0.05)	38	40	27	56	59	39	85	87	58
Interaction effect (I × N)									
SEm$\pm$	28.30	30.32	20.74	42.37	44.31	30.65	63.59	65.33	45.58
CD (P=0.05)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Sig. int. with Y	-	-	NS	-	-	NS	-	-	NS
CV (%)	7.03	7.32	7.18	7.05	7.15	7.10	6.33	6.32	6.33

Table 2. Seed, Stover and Biological yield of sesame stover as influenced by I x N interaction

Treatment	Seed yield (kg/ha)		Stover yield (kg/ha)		Biological yield (kg/ha)	
	B. Nitrogen levels		B. Nitrogen levels		B. Nitrogen levels	
	2021		2021		2021	
A. Intercropping	**N_1. 75% RDN**	**N_2. 100% RDN**	**N_1. 75% RDN**	**N_2. 100% RDN**	**N_1. 75% RDN**	**N_2. 100% RDN**
I_1: Sole crop sesame	720	846	1069	1275	1789	2121
I_4: Sesame + cowpea (paired 2:1)	670	783	1009	1158	1680	1940
I_5: Sesame + green gram (paired 2:1)	696	808	1019	1190	1715	1998
I_6: Sesame + cowpea (paired 3:2)	481	727	721	1089	1202	1816
I_7: Sesame + green gram (paired 3:2)	502	741	767	1116	1269	1857
S.Em.±	28.30		42.37		63.59	
CD (P=0.05)	84		126		189	
CV (%)	7.03		7.05		6.33	
	2022		**2022**		**2022**	
I_1: Sole crop sesame	746	879	1109	1327	1855	2206
I_4: Sesame + cowpea (paired 2:1)	690	810	1039	1216	1726	2025
I_5: Sesame + green gram (paired 2:1)	710	828	1038	1228	1748	2056
I_6: Sesame + cowpea (paired 3:2)	491	753	726	1129	1217	1883
I_7: Sesame + green gram (paired 3:2)	509	761	775	1147	1284	1908
S.Em.±	30.32		44.31		65.33	
CD (P=0.05)	90		132		194	
CV (%)	7.25		7.15		6.32	
	Pooled		**Pooled**		**Pooled**	
I_1: Sole crop sesame	733	863	1089	1301	1822	2164
I_4: Sesame + cowpea (paired 2:1)	680	796	1024	1187	1703	1983
I_5: Sesame + green gram (paired 2:1)	703	818	1028	1209	1731	2027
I_6: Sesame + cowpea (paired 3:2)	486	740	723	1109	1209	1849
I_7: Sesame + green gram (paired 3:2)	505	751	771	1131	1277	1882
S.Em.±	20.74		30.65		45.38	
CD (P=0.05)	60		88		131	
CV (%)	7.15		7.10		6.33	

combinations I_4N_2 and I_5N_2 during both years and at par with treatment combination I_5N_2 only in pool analysis. Even though, Treatment combination I_1N_2 (100% RDN applied to sole sesame) produced the highest stover and biological yields on pooled basis. With respect to lower yields (seed, stover and biological) of sesame crop were obtained due to combination I_6N_1 (sesame + cowpea paired 3:2) which was statistically comparable with I_7N_1 (sesame + green gram paired 3:2) treatment combination only. Lower yields obtained under treatment combination I_6N_1 might be due to lower nitrogen level. The results corroborate with the findings of [19,20,21,22] in pearl millet.

3.2 Sesame Equivalent Yield (kg/ha)

3.2.1 Effect of intercropping

Results illustrated in Table 3 revealed that sesame equivalent yield was significantly influenced by sole crop sesame and intercropping systems during both the years and in pooled analysis. Significantly higher SEY was produced due to treatment I_5 - sesame + green gram (paired 2:1) which statistically at par with treatment I_4- sesame + cowpea (paired 2:1) only during first year. The lowest SEY was reported with sole crop cowpea (I_2) during second year and in pooled data. This might be attributed due to additional seed yield of intercrops viz., cowpea and green gram. Higher sesame equivalent yield in these intercropping treatments indicated yield advantages over sole sesame. Higher sesame equivalent yield due to introducing of legumes in sesame were also reported by Mandal and Pramanick [23] in sesame + green gram (2:2) and Sarma *et al*. [24] sesame + black gram (1:1).

3.2.2 Effect of nitrogen levels

It is evident from Table 3 that sesame equivalent yield was significantly affected by varying nitrogen levels to sesame crop in both the years and in pooled analysis. Among different nitrogen levels tested, significantly superior sesame equivalent yield was noted with an application of 100 % RDN (N_2) to sesame crop during both the years and pooled analysis. These finding are in conformity with those reported by Sharda *et al*. [25] in pearl millet + mung beans (2:1).

3.2.3 Interaction effect

The data showed in Table 4 indicated significant interaction between intercropping and different nitrogen levels to sesame crop during both the years and in pooled analysis. Treatment combination between sesame + green gram (I_5) and 100% RDN to sesame (I_5N_2) applied to sesame registered significantly higher sesame

Table 3. Sesame equivalent yield of sesame as influenced by intercropping and nitrogen levels

Treatments	Sesame equivalent yield (kg/ha)		
	2021	**2022**	**Pooled**
A. Intercropping			
I_1: Sole crop sesame	797	828	812
I_2: Sole crop cowpea	751	762	757
I_3: Sole crop green gram	895	922	909
I_4: Sesame + cowpea (paired 2:1)	1004	1004	1004
I_5: Sesame + green gram (paired 2:1)	1045	1075	1060
I_6: Sesame + cowpea (paired 3:2)	896	911	904
I_7: Sesame + green gram (paired 3:2)	930	932	931
SEm±	23.18	21.03	15.65
CD (P=0.05)	67.39	61.12	44.41
B. Nitrogen levels			
N_1: 75 % RDN	805	833	817
N_2: 100 % RDN	1000	1009	1005
SEm±	12.39	11.24	8.36
CD (P=0.05)	36	33	24
Interaction effect (I × N)			
SEm±	32.79	29.73	22.13
CD (P=0.05)	Sig.	Sig.	Sig.
Sig. int. with Y	-	-	-
CV (%)	6.32	5.61	5.95

Table 4. Sesame equivalent yield of sesame as influenced by I x N interaction

Treatment	**Sesame equivalent yield**	
	B. Nitrogen levels	
		2021
A. Intercropping	**N_1. 75% RDN**	**N_2. 100% RDN**
I_1: Sole crop sesame	733	862
I_2: Sole cowpea	686	816
I_3: Sole green gram	827	963
I_4: Sesame + cowpea (paired 2:1)	891	1117
I_5: Sesame + green gram (paired 2:1)	964	1126
I_6: Sesame + cowpea (paired 3:2)	750	1041
I_7: Sesame + green gram (paired 3:2)	784	1076
SEm$\pm$	32.79	
CD (P=0.05)	95	
CV (%)	6.32	
	2022	
A. Intercropping	**N_1. 75% RDN**	**N_2. 100% RDN**
I_1: Sole crop sesame	760	896
I_2: Sole cowpea	698	826
I_3: Sole green gram	868	976
I_4: Sesame + cowpea (paired 2:1)	930	1078
I_5: Sesame + green gram (paired 2:1)	990	1159
I_6: Sesame + cowpea (paired 3:2)	766	1057
I_7: Sesame + green gram (paired 3:2)	789	1075
SEm$\pm$	29.73	
CD (P=0.05)	86	
CV (%)	5.61	
	Pooled	
A. Intercropping	**N_1. 75% RDN**	**N_2. 100% RDN**
I_1: Sole crop sesame	746	879
I_2: Sole cowpea	692	821
I_3: Sole green gram	848	970
I_4: Sesame + cowpea (paired 2:1)	910	1097
I_5: Sesame + green gram (paired 2:1)	977	1143
I_6: Sesame + cowpea (paired 3:2)	758	1049
I_7: Sesame + green gram (paired 3:2)	786	1075
SEm$\pm$	22.13	
CD (P=0.05)	63	
CV (%)	5.95	

Table 5. Land equivalent ratio of sesame as influenced by intercropping and nitrogenlevels

Treatments	**Land equivalent ratio**		
	2021	**2022**	**Pooled**
A. Intercropping			
I_1: Sole crop sesame	1.000	1.000	1.000
I_2: Sole crop cowpea	1.000	1.000	1.000
I_3: Sole crop green gram	1.000	1.000	1.000
I_4: Sesame + cowpea (paired 2:1)	1.244	1.242	1.243
I_5: Sesame + green gram (paired 2:1)	1.276	1.261	1.268
I_6: Sesame + cowpea (paired 3:2)	1.129	1.097	1.113
I_7: Sesame + green gram (paired 3:2)	1.118	1.081	1.099
B. Nitrogen levels			
N_1: 75 % RDN	1.083	1.072	1.077
N_2: 100 % RDN	1.136	1.123	1.129

equivalent yield during both years and in pooled analysis. However. It was at par with treatment combinations I_4N_2 and I_6N_2 during first year and treatment combination I_4N_2 during second year as well as in pooled analysis. This was also due to additional advantage of intercrop yield and higher yield of green gram with sesame due to better complementary relationship resulted in to the highest sesame equivalent yield. These results are in accordance with the results of [26] in pearl millet, Ghosh *et al*. [20] and Kumar *et al*. [22] in pearl millet.

3.2.4 Land equivalent ratio

The data with respect to land equivalent ratio (LER) depicted in Table 5 revealed that all intercropping treatments increased LER as compared to sole crops. Here, sole sesame, sole green gram and cowpea recorded LER (1.00). The minimum value of LER was reported in treatment I_5 (sesame + green gram (paired 2:1)) followed by I_4 sesame+ cowpea (paired 2:1) during both year and in pool analysis. The results are in conformity with the findings of Mandal and Pramanick [23] in sesame + green gram (4:2) and Sarma *et al*. [24] in sesame + black gram (1:1).

3.2.5 Effect of nitrogen levels

The data showed in Table 5 revealed that maximum land equivalent ratio of sesame was obtained in N_2 (application of 100 % RDN) during both year and pool data. These results corroborate with the findings of Sharda *et al*. [25] pearl millet + mung bean (1:2).

4. CONCLUSION

Based on the findings of two years experimental results, it can be concluded that application of 100 % recommended dose of nitrogen to sesame and green gram crop (50 kg N/ha and 20 kg N/ha, respectively) to sesame + green gram (paired 2:1) in intercropping system recorded higher yield, Sesame Equivalent Yield and Land Equivalent Ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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