Journal of Crop and Weed, 10(1):19-24(2014)

Growth, yield and advantages of green gram – sesame intercropping under different moisture regimes in new alluvial zone of West Bengal

A. M. PUSTE, T. K. MANDAL, S. K. GUNRI, T. S. DEVI[1] AND B. R. PRAMANIK[2]

Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya Mohanpur - 741 252, West Bengal
[1]AICRP on Soybean (ICAR), CAU, Imphal 795 004, Manipur
[2]Department of Agriculture, Government of West Bengal

Received: 14-10-2012, Revised:21-10-2013, Accepted:25-10-2013

ABSTRACT

A field experiment was conducted at the university research farm during two consecutive summer seasons on the growth, yield and intercropping advantages of green gram (Vigna radiata Wilczek.) - sesame (Sesamum indicum L.) under different moisture regimes in new alluvial zone of West Bengal. Experiment was laid out in split-plot design, viz. three levels of irrigation [I_0 - no irrigation, I_1 - one irrigation at 30 DAS (days after sowing) and I_2 - two irrigations at 30 and 50 DAS] as main plot and seven cropping systems, comprised of sole and intercropping of inoculated (with Rhizobium) and uninoculated green gram with sesame sown in lines at 25 cm apart maintained at 2:2 and 3:3 row ratio [C_1 - C_7], considered as sub-plot treatments. Result reveals that growth, yield attributes and yield of both the crops were influenced significantly by the levels of irrigation in most cases, and maximum seed yield of both green gram (0.836 t ha^{-1}) and sesame (0.536 t ha^{-1}) was exhibited with two irrigations applied at 30 and 50 DAS. Among the sole and intercropping systems, highest seed yield of sesame (0.673 t ha^{-1}) and green gram (1.094 t ha^{-1}) was obtained when these were sown as sole with Rhizobium inoculation of green gram. Moreover, highest and lowest grain yield was obtained from the combination of 3:3 row ratio of inoculated green gram (0.708 t ha^{-1}) + sesame (0.478 t ha^{-1}) and 2:2 uninoculated green gram (0.567 t ha^{-1}) + sesame (0.411 t ha^{-1}), respectively. Among the different intercropping systems, green gram with Rhizobium inoculation + sesame maintained in row arrangement of 3:3 ratio exhibited greater advantages of competitive functions of intercropping like aggresivity, ± 0.12; relative crowding coefficient, 5.22; land equivalent ratio, 1.36 and monetary advantages, INR 9,982 ha^{-1}, respectively than those of other cropping systems.

***Key words*:** Competitive functions, cropping systems, green gram, irrigation, sesame

India is facing tremendous new challenges due to continued population growth, stagnation in farm level productivity in intensive farming areas and globalization. By 2050, India's population is expected to grow to 1.6 billion and will stand as the most populous country of the world. This rapid and continued increase in population implies a greater demand for food, shelter and cloth on a sustainable basis. To feed such a great population, our motto should be to produce maximum per unit from comprehensive and intensive agriculture through more rational management practices including efficient use of inputs particularly irrigation and nutrient. It is estimated that by 2020, India would need to produce 294 million tons of food grains from the same and even shrinking land resources (Grover *et al.*, 2003).

Growing of different crops together is an ancient technique of cultivation since the dawn of human civilization. Multiple cropping in the form of intercropping being a unique asset is becoming popular day by day as it offers yield stability and improved yield. Now-a-days the interest in growing food legumes in an intercropping system is increasing with time amongst the farmers (Khan *et al*., 2001 and 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. More precisely, it is productive and more advantageous than mono cropping, particularly of sesame when practiced with green gram (Bhatti *et al.*, 2006 and 2008). In addition, competitive behavior of component crops in different sesame-based intercropping systems in terms of aggressivity, relative crowding coefficient and competitive ratio have been reported by Sarkar and Chakraborty (2000), Sarkar and Sanyal (2000) and Sarkar *et al*. (2001). Irrigation maintains the soil moisture at about the levels that crops may need it. But excess or shortage of water affects the plant growth, crop yield and quality as well. More particularly, water stress during certain growth stages of the crop may have detrimental effects on yield as well as quality also. It is wise to supply irrigation water appropriately for its production and economics (Sarkar and Chakraborty, 1995). Though Chakraborty, 2013 demonstrated increase in no of branches vis-à-vis yield in sesame with the pplication of 40kg Nha^{-1}.The role of *Rhizobium* to provide atmospheric nitrogen through fixation is well known. Keeping this in view, a field experiment was carried out at the university research farm during two consecutive summer seasons on the growth, yield and intercropping advantages of

E-mail: ampuste_bckv@yahoo.co.in

green gram (*Vigna radiata* Wilczek.) - sesame (*Sesamum indicum* L.) using different moisture regimes under new alluvial zone of West Bengal.

MATERIALS AND METHODS

The field experiment was carried out at the university research farm (23.5ºN, 89ºE and 9.75 m above MSL), Bidhan Chandra Krishi Viswavidyalaya during two consecutive summer seasons of 2007 and 2008 on the yield characteristics, yield and intercropping advantages of sesame (*Sesamum indicum* L.) and green gram (*Vigna radiata* Wilczek.) with or without *Rhizobium* seed inoculation under new alluvial zone of West Bengal. The experimental site was an upland in the *Gangetic* alluvial plain and the soil was having pH 7.4, sandy-clayloam in texture (*Entisol soil - suborder udent and Fleuvudent*) with good drainage, with moderate nitrogen (0.068%), available P_2O_5 (17.01 kg ha^{-1}), available K_2O (84.7 kg ha^{-1}), respectively. Green gram var. B_{105} named as '*Panna*' and sesame var. improved selection no. 5, known as '*Rama*' were used in the experiment. The layout of the experiment was adopted in split-plot design with two factors *viz*. 3 levels of water management, I_0 - no irrigation, I_1 - one irrigation at 30 DAS (days after sowing) and I_2 - two irrigations at 30 and 50 DAS considered as main plot and seven cropping systems, combination of sole and intercropping of inoculated and uninoculated green gram with sesame, sown in lines maintained at a spacing of 25 cm row to row apart, *viz*., C_1 - sole crop of green gram without *Rhizobium* inoculation; C_2 - sole crop of green gram with *Rhizobium* inoculation; C_3 - sole crop of sesame; C_4 - combination of green gram without inoculation and sesame, maintained in 2:2 row ratio; C_5 - combination of green gram with *Rhizobium* inoculation and sesame, maintained in 2:2 row ratio; C_6 - combination of green gram without inoculation and sesame, maintained in 3:3 row ratio and C_7 - combination of green gram with *Rhizobium* inoculation and sesame, maintained in 3:3 row ratio), which were considered as sub-plot treatments of the experiments replicated thrice. Seeds of green gram were soaked overnight, stained and inoculated with respective *Rhizobium* bacterial culture (cowpea group of *Rhizobium*) and kept it under shade up to the completion of sowing operation. For both the years of experimentation, sowing was done between 15-17 February and harvesting was done between 25-30 April for green gram and 09-11 May for sesame. Green gram and sesame crops were fertilized with N: P_2O_5: K_2O @ 20:40:20 and 60:40:40 kg ha^{-1}, respectively, of which full dose of all the fertilizers applied at basal in case of green gram, where as, full dose of P_2O_5 and ½ of K_2O along with 1/3rd of N was applied at basal in case of sesame. Rest amount of K_2O along with 1/3rd of N at 30 DAS and rest amount of N was applied at 50 DAS, just prior to irrigation in the field. The same dose of fertilizer were followed in case of intercropping system also (as both the crops were shared 50% area each *i.e.* maintaining 2:2 and 3:3 row ratio), but care was taken to apply the split dose of fertilizer restricted to the base of row of sesame crop only. 4 cm at initial growth stages and subsequently 5 cm depth of irrigation water was applied at each irrigation to get proper moisture of field capacity. The observations of growth characteristics and yield thus recorded in the field (plant height, leaf area index, dry matter accumulation and number of pods $plant^{-1}$, number of grains/seeds $pod.seed^{-1}$, 1000-grain or test weight of seed and grain (/seed) yield of green gram and sesame) were statistically analyzed following the methods of Gomez and Gomez (1984). Pooled analysis of two years data is presented here for interpretation of results of the experiment.

RESULTS AND DISCUSSION

Crop performance

Effect of irrigation on growth characteristics

Maximum and minimum values of plant height, LAI and dry matter accumulation at 30, 60 DAS and at harvest for both crops were obtained in I_2 (two irrigation at 30 and 60 DAS) and I_0 (without irrigation) treatment, respectively (Table 1) However, in most cases significant difference were not observed between I_1 (one irrigation at 30 DAS) and I_2, but obviously it differentiated fromI_0 treatment.

Effect of cropping systems on growth characteristics

Results of the experiment revealed that cropping system either as sole and/or intercropping system of green gram - sesame including the effect of seed *Rhizobium* inoculation (green gram) had influence significantly on the growth characteristics of both the crops (plant height, leaf area index, dry matter accumulation) observed at 60 DAS and at harvest except the values obtained at 30 DAS (Table 1). Unlikely, the values of dry matter accumulation was significant differentiated among the treatments even at 30 DAS.

Maximum values of all the growth characters of both the crops were obtained when green gram (inoculated) and sesame were intercropped maintaining 3:3 row ratio, while, minimum values were observed when both were grown as pure crop (green gram as uninoculated), may be due to competitive function in respect to space, light, energy etc. Among the two intercropping systems, comparatively lesser values were obtained in green gram (without inoculation) - sesame maintained in 2:2 row ratio in the experiment. In most cases either as sole or intercropping system, there were no significant difference was observed particularly in consecutive treatments of both the crops.

Effect of irrigation on yield attributes and yield

Application of irrigation water had a favourable effect on the yield attributes and yield of both the crops practiced either as sole or intercropping system of the experiment (Table 2). Irrigation water given twice at 30 and 50 DAS (I_2) achieved higher no. of pods plant^{-1} (36.58), no. of grains pod^{-1} (8.72) and highest 1000-grain or test weight (37.50 g) of green gram and was

Table 1: Growth attributes of green gram and sesame as influenced by levels of irrigation and cropping systems (Pooled)

Treatment	Green gram									Sesame								
	Plant height (cm)			LAI			DMA (g m^{-2})			Plant height (cm)			LAI			DMA (g m^{-2})		
	DAS																	
	30	60	H	30	60	H	30	60	H	30	60	H	30	60	H	30	60	H
Levels of irrigation (I)																		
I_0	16.52	27.35	30.02	2.02	2.43	1.86	67.12	126.25	148.23	20.86	53.29	74.06	1.16	2.18	1.42	85.23	241.56	408.12
I_1	17.58	33.68	34.82	2.26	2.65	2.06	70.06	142.76	176.23	22.45	71.45	91.08	1.21	3.15	1.65	91.08	291.45	542.23
I_2	19.03	36.08	36.46	2.38	3.07	2.61	75.62	156.34	246.82	25.12	85.45	96.25	1.38	4.26	1.96	103.12	312.07	592.48
SEm (±)	**0.842**	**0.986**	**0.941**	**0.125**	**0.149**	**0.194**	**1.851**	**4.125**	**18.481**	**0.910**	**4.441**	**1.802**	**0.076**	**0.351**	**0.097**	**3.276**	**6.194**	**14.041**
LSD (0.05)	**N.S.**	**3.012**	**2.861**	**N.S.**	**0.451**	**0.591**	**5.620**	**12.541**	**56.170**	**2.761**	**13.420**	**5.482**	**N.S.**	**1.081**	**0.296**	**9.962**	**18.831**	**42.682**
Cropping systems (C)																		
C_1	16.81	29.04	29.49	1.98	2.28	1.92	62.16	125.96	142.66	—	—	—	—	—	—	—	—	—
C_2	17.16	30.83	31.06	2.11	2.36	2.02	67.23	138.05	168.21	—	—	—	—	—	—	—	—	—
C_3	—	—	—	—	—	—	—	—	—	20.62	58.96	73.06	1.17	2.87	1.421	76.28	253.17	406.12
C_4	17.02	30.56	30.98	2.16	2.41	1.98	66.71	134.22	156.07	21.18	64.78	78.52	1.22	2.98	1.483	81.04	268.06	452.08
C_5	18.39	34.68	38.16	2.32	3.06	2.37	77.14	150.18	224.32	23.42	75.46	92.04	1.29	3.41	1.721	98.74	291.53	581.19
C_6	17.92	32.85	34.07	2.28	2.88	2.16	72.03	142.71	178.53	22.46	71.18	89.55	1.26	3.06	1.566	88.56	279.55	496.31
C_7	18.96	36.26	38.86	2.47	3.33	2.63	80.31	159.56	272.79	26.37	79.92	102.48	1.31	3.66	2.194	121.08	316.14	635.70
SEm (±)	**0.716**	**1.115**	**1.562**	**0.168**	**0.145**	**0.152**	**2.717**	**5.467**	**29.031**	**1.279**	**2.717**	**4.053**	**0.047**	**0.191**	**0.204**	**10.138**	**11.799**	**43.605**
LSD (0.05)	**N.S.**	**3.392**	**4.751**	**N.S.**	**0.441**	**0.461**	**8.260**	**16.623**	**88.262**	**3.890**	**8.261**	**12.321**	**N.S.**	**0.581**	**0.621**	**30.821**	**35.872**	**132.562**

N.S- Not significant; I_0 - no irrigation, I_1 - one irrigation at 30 DAS (days after sowing) and I_2 - two irrigations at 30 and 50 DAS, respectively and C_1 - sole crop of green gram without Rhizobium inoculation; C_2 - sole crop of green gram with Rhizobium inoculation; C_3 - sole crop of sesame; C_4 - combination of green gram without inoculation and sesame, maintained in 2:2 row ratio; C_5 - combination of green gram with Rhizobium inoculation and sesame, maintained in 2:2 row ratio; C_6 - combination of green gram without inoculation and sesame, maintained in 3:3 row ratio and C_7 - combination of green gram with Rhizobium inoculation and sesame, maintained in 3:3 row ratio.

significantly differed with I_0 treatment (without irrigation),However, the difference between I_2 and I_1 (one irrigation at 30 DAS) were statistically at par in most of the characters, except no. of pods plant^{-1} in sesame. Likewise, greater no. of capsules plant^{-1} (72.68), no. of seeds capsule^{-1} (57.01) and test weight of seeds (3.54 g) were observed at two levels of irrigation given at 30 and 50 DAS (I_2) that were significantly superior to control (I_0) and the treatment I_1 (with one irrigation applied at 30 DAS), respectively.

Two levels of irrigation applied at 30 and 50 DAS (I_2) produced significantly highest grain yield of green gram (0.836 t ha^{-1}), whereas, least performance (0.664 t ha^{-1}) was shown with the treatment I_0, where the crop raised without irrigation (Table 2)The effect of single irrigation applied at 30 DAS (I_1) and double irrigation (I_2) on the yield of the crop was statistically at par. This result corroborated the findings of Yoshida (1992). The yield increment of green gram at this level (I_2) was 25.90% over without irrigation and 8.01% over single irrigation (I_1), respectively. Like green gram, maximum seed yield of sesame (0.536 t ha^{-1}) was obtained with two levels of irrigation (I_2), though this level was quite at par with single irrigation (I_1). Least performance of sesame was exhibited at I_0 level of irrigation (0.437 t ha^{-1}). The extent of yield increment at I_2 level was 22.65 and 7.85%, respectively over I_0 and I_1 level of irrigation.

Effect of cropping systems on yield attributes and yield

From the experimental data (Table 2) it revealed that yield attributing characteristics of green gram (with and without *Rhizobium* culture) was significantly influenced, when it was grown as sole and intercropping along with sesame maintaining different row ratios. Significant differences were observed among the various treatments related with the combination of 2:2 and 3:3 row ratios of green gram + sesame imposed in this experiment. Highest no. of pods plant^{-1} (38.73), no. of grains pod^{-1} (8.99) and 1000-grain weight (38.20 g) were obtained in 3:3 row arrangement of inoculated green gram + sesame, whereas lowest value of these characters were obtained in sole crop of uninoculated green gram as well as intercropping system of 2:2 row arrangement of uninoculated green gram accompanied by sesame crop. However, among the sole and intercropping systems, in most cases the treatments C_1, C_2 and C_4; C_5 and C_7 were statistically at par in respect to all the characters studied relating to the seed yield. The entire yield attributing characteristics of sesame was significantly varied among the sole and intercropping system.

Significant differences were observed among the various treatments related with the combination of 2:2 and 3:3 row ratios of green gram + sesame including sole crop of sesame imposed in this experiment, except no. of capsules plant^{-1}, where no significant difference was observed among the treatments. Like green gram, highest no. of capsules plant^{-1} (69.20), no. of seeds capsule^{-1} (56.67) and 1000-seed weight (3.73 g) were obtained when sesame grown along with inoculated green gram in 3:3 row arrangements. However, among the sole and intercropping systems, treatments C_3, C_4, C_5 and C_6 were statistically at par in respect to their no. of capsules plant^{-1} and no. of seeds capsule^{-1}.

It was also observed that both the sole crop yielded higher than that of intercrops of the component crops and the difference were statistically significant. It was evident from the Table 2 that greater the crop competition poorer would be their performance, hence, pure stands of both inoculated and uninoculated green gram produced better yield than in its mixed crop stands. The extent of yield increment by the sole inoculated green gram over the uninoculated

Table 2: Yield attributes and yields of green gram and sesame as influenced by levels of irrigation and cropping systems (Pooled)

Treatments	Green gram				Sesame			
	No. of pods plant^{-1}	No. of grains pod^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	No. of capsules plant^{-1}	No. of seeds capsule^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})
Levels of irrigation (I)								
I_0	30.18	7.39	33.26	0.664	54.92	50.10	3.24	0.437
I_1	35.00	8.43	36.55	0.774	69.34	55.62	3.41	0.497
I_2	36.58	8.72	37.50	0.836	72.68	57.01	3.54	0.536
SEm (±)	**0.312**	**0.171**	**0.340**	**0.0204**	**1.406**	**0.711**	**0.035**	**0.014**
LSD (0.05)	**1.212**	**0.670**	**1.351**	**0.081**	**5.518**	**2.816**	**0.136**	**0.056**
Cropping systems (C)								
C_1	30.77	7.45	33.47	0.892	—	—	—	—
C_2	32.63	8.10	35.64	1.094	—	—	—	—
C_3	—	—	—	—	62.50	52.20	3.15	0.673
C_4	31.67	7.72	34.79	0.567	64.33	52.60	3.24	0.411
C_5	36.40	8.90	36.91	0.673	67.30	55.30	3.52	0.453
C_6	33.33	7.92	35.62	0.624	65.00	54.50	3.68	0.435
C_7	38.73	8.99	38.20	0.708	69.20	56.67	3.73	0.478
SEm (±)	**0.880**	**0.112**	**0.880**	**0.033**	**2.001**	**1.532**	**0.065**	**0.039**
LSD (0.05)	**2.251**	**0.321**	**2.551**	**0.056**	**5.776**	**NS**	**0.189**	**0.114**

I_0 - no irrigation, I_1 - one irrigation at 30 DAS (days after sowing) and I_2 - two irrigations at 30 and 50 DAS, respectively and C_1 - sole crop of green gram without Rhizobium inoculation; C_2 - sole crop of green gram with Rhizobium inoculation; C_3 - sole crop of sesame; C_4 - combination of green gram without inoculation and sesame, maintained in 2:2 row ratio; C_5 - combination of green gram with Rhizobium inoculation and sesame, maintained in 2:2 row ratio; C_6 - combination of green gram without inoculation and sesame, maintained in 3:3 row ratio and C_7 - combination of green gram with Rhizobium inoculation and sesame, maintained in 3:3 row ratio.

Table 3: Assessment of intercropping advantages (mean)

Treatments	Aggressively values(AV)		Relative Crowding Co-efficient (RCC)			Land Equivalent Ratio (LER)			Monetary Advantages (INR ha^{-1})
	Ams	Asm	Km	Ksm	K	LER	Yield advantage (%)	RNR	
C_4 (M_u + S) in 2: 2	0.05	-0.65	1.75	1.59	2.78	1.25	25	0.98	6,146.00
C_5 (M_i + S) in 2: 2	0.06	-0.06	1.60	2.06	3.29	1.28	28	0.99	8,056.00
C_6 (M_u + S) in 3: 3	0.10	-0.10	2.32	1.83	4.25	1.34	34	1.02	8,680.00
C_7 (M_i + S) in 3: 3	0.12	-0.12	1.83	2.85	5.22	1.36	36	1.40	9,982.00

Ams - Aggressivity value of moong over sesame, Asm - Aggressivity value of sesame over moong, RNR - relative net return.

was 22.64 per cent. Among the intercropping systems, lowest grain yield of green gram (0.567 t ha^{-1}) was obtained when uninoculated green gram intercropped with sesame in 2:2 row arrangement (C_4) and this treatment was comparable with T_6 treatment (0.624 t ha^{-1}), where, uninoculated green gram were sown consecutively with sesame maintained in 3:3 row ratio 25 cm apart. It was observed that higher grain yield of green gram (0.708 t ha^{-1}) produced only when green gram inoculated with *Rhizobium* culture intercropped with sesame in 3:3 row arrangements (C_7) and this was significantly differed from T_5 treatment (0.673 t ha^{-1}). This result was corroborated with the findings of Ghosh *et al*. (1996). Seed yield increment was to the tune of 24.87 and 13.46%, respectively in C_7 treatment than that of C_4 and C_6.

Seed yield of sesame in sole system (0.763 t ha^{-1}) was higher than that any intercropped system, practiced in both the row ratios (0.411 - 0.478 t ha^{-1}), it was higher to the tune of 40.79 - 63.75 per cent. However, seed yield of sesame was also significantly influenced by the intercropping systems with green gram maintaining different row ratios (2:2 and 3:3). Among the intercropping systems, sesame produced higher seed yield (0.478 t ha^{-1}) when it was sown in 3:3 arrangement with green gram (C_7), whereas, least performance (0.411 t ha^{-1}) was exhibited when sesame was grown along with uninoculated green gram maintained in 2:2 row arrangement (C_4). However, the treatments C_4 & C_5; C_6 & C_7 and C_3 & C_7, respectively were statistically at par in respect to their seed yield. The yield increment of sesame at C_7 was 16.30 and 9.88%, respectively over C_4 and C_6treatment.

Competitive functions of the system

The values of all the measuring parameters of competitive functions of the green gram, sesame intercropping system (aggressivity value, relative crowding co-efficient, land equivalent ratio and ultimately monetary advantages) is presented in table 3.

Aggressively values

The competitive ability of the component crop in an intercropping system is determined by its aggressivity values obtained through calculation. From the experiment it was assumed that the mixture formed a replacement series and gave a simple measure of how much relative yield increase in one species was greater than that of the other one, indicating zero value that component species were equally competitive. Here, the species were not equally competitive. Aggressivity values were found to be '+ve' in green gram, while, sesame had '-ve' values. However, from the calculated results the aggressively values shows that green gram was dominant species, whereas associated crop sesame was appeared to be the dominated among the intercropping system practiced in the experiment. Thus, sesame was proved to be less competitive than green gram. The numerical values in inoculated green gram + sesame (3:3) was greater compared with treatments giving rise to more difference between the actual and expected yield in that treatment combinations.

Relative crowding co-efficient

It formed a replacement series and gave indication whether there was any yield advantage due to intercropping situation. Green gram + sesame with different row ratios were advantageous because the product of co-efficient i.e. relative crowding co-efficient were greater than unity. Regarding the value of relative crowding coefficient, it may be found that coefficient value of each of the crop was greater than one, markedly indicating the yield was more than the expected. The component crop with higher co-efficient value indicated the dominant one i.e. green gram was dominant one. As the product of the co-efficient was greater than unity, there was yield advantage in green gram + sesame in 3:3 row ratio with *Rhizobium* seed inoculation during both year of experimentation.

Land equivalent ratio

LER is a measure of relative advantage of intercropping over monocropping at a given degree of management and it is perhaps the most appropriate measure in intercropping in getting the total productivity $unit^{-1}$ area based on the yield of intercropping over monoculture for a given level of management. The yield advantages extrapolated from LER values (>1) were due to the development of complementary relationship between the component crops. Maximum yield advantages had gone in favour of inoculated green gram intercropped with sesame in 3:3 row ratio, whereas, least of these value were obtained in uninoculated green gram + sesame in 2:2 row arrangement. According to Mandal *et al.* (1991a and 1991b) mustard + lentil and niger + lentil intercropping systems increased the LER values. Data showed that there was a yield advantage in the intercropping system and that was more in the 3:3 ratio of green gram (seed inoculated with *Rhizobium* culture) and sesame.

Monetary advantages

Monetary advantage is the right way to judge the profitability and acceptability of intercropping system in region or farming communities in any areas. Thus, the highest monetary value was estimated with green gram (with *Rhizobium* culture) + sesame in 3:3 ratio followed by the similar row arrangement of uninoculated green gram with sesame, which corroborating with the observation of Das (1982). These advantages were possible due to better utilization of growth resources. The physical resources were better utilized due to spatial as well as temporal complementarities under intercropping situations. Spatial complementarity may be due to better spatial use of light, nutrient and/or water by combined root system. Better temporal use may be due to differences in growth pattern of component crops, so that the crops might take their major demand on resources at different times (Chakraborty, 1991).

From the present investigation it is concluded that the maintenance of optimum soil moisture status in the root zone depth during the critical growth stages of the crops, may be possible by providing two irrigations at 30 and 50 DAS on green gram along with *Rhizobium* inoculation + sesame intercropping, maintaining 3:3 row ratio 25 cm apart, exhibited maximum outcome of the produce. The results further concluded that the intercropping system of pulse-oilseeds has been found to be more beneficial over monocrooping in this sub-zone of the country.

ACKNOWLEDGEMENT

The authors are thankful to Indian Council of Agricultural Research and Department of Land Resources, Government of India, New Delhi for providing partial financial assistance and university research farm for providing incessant facilities in conducting the field study.

REFERENCES

Bhatti, I.H., Riaz, A., Jabbar, A., Nazir, M.S. and Mahmood, T. 2006. Competitive behaviour of component crops in different sesame-legume intercropping systems. *Int. J. Agri. Biol.*, **8**:165-67.

Bhatti, I.H., Riaz, A., Jabbar, A., Virk, J.A. and Aslam, A. 2008. Agro-economic performance of mungbean intercropped in sesame under different planting patterns. *Pak. J. Agri. Sci.*, **45**: 25-28.

Chakraborty A. 1991. Studies in inter-cropping of oilseed at two levels of nitrogen with legumes under rainfed condition. *M. Sc. (Ag.) Thesis* BCKV, Nadia, West Bengal.

Chakraborty A (2013) Performance of summer sesame (*Sesamum indicum* L) and estimation of economic and optimum doses of nitrogen and phosphorus in red and laterite soils of West Benfal. *J. Crop Weed* **9**: 75-78.

Das, N.R 1982. Why not more pulses and oilseeds in Bengal? *Intensive Agric.* **20**: 11-14.

Ghosh, A; Mandal, B.K. and Mondal B.B. 1996. Feasibility of maize and moong bean, groundnut and sesame as sequential crops in rice based cropping pattern under irrigated upland ecosystem. *Oryza*, **33**: 14-18.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research* John Willey & Sons, New York: 97-107.

Grover, A., Aggarwal, P.K., Kapoor, A., Katiyar-Agarwal, S., Agarwal. M. and Chandramouli, A. 2003. Addressing Abiotic stresses in agriculture through transgenic technology. *Curr. Sci.*, **84**: 355-67.

Khan, M.B. and Khaliq. A. 2004. Studies on intercropping summer fodders in cotton. *J. Res. (Sci.),* **15**: 325-31.

Khan, M.B., Akhtar, M. and Khaliq, A. 2001. Effect of planting and different intercropping systems on the productivity of cotton (*Gossypium hirsutum* L.) under irrigated conditions of Faisalabad. *Int. J. Agri. Biol.*, **3**: 432-35.

Mandal, B.K., Rajak, S., Mondal, B.B.; Bhunia, S.R., Patra, B.C. and Dandapat, A. 1991c. Yield of mustard, chickpea and lentil grown as sole and intercrops with mulch. *Indian. Agriculturist*, **35**: 247-53.

Mandal, B.K., Singh, Y.V., Mondal, B.B., Bhunia, S.R. 1991b. Yield of lentil and niger grown as sole and intercrops as influenced by irrigation and mulch. *Indian J. Agro.* **36** : 133-37.

Sarkar, R.K. and A. Chakraborty, 2000. Biological feasibility and economic viability of intercropping pulse and oilseed crops with sesame (*Sesamum indicum*) under different planting patterns in rice-fallow Gangetic alluvial land. *Indian. J. Agric. Sci.*, **70**: 211-14.

Sarkar, R.K. and Chakraborty, A. 1995. Yield components and yield of sunflower (*He1ianthus annuus*), sesame (*Sesamum indicum*) and green gram (*Phaseolus radiatus*) as influenced by irrigation and intercropping. *Indian. J Agron.* **40**: 499-01.

Sarkar, R.K. and Sanyal, S.R. 2000. Production potential and economic feasibility of sesame (*Sesamum indicum* L.) based intercropping system with pulse and oilseed crops on rice fallow land. *Indian. J. Agron*., **45**: 545-50.

Sarkar, R.K., Saity, Kundu and Kundu, C. 2001. Sustainable intercropping system of sesame (*Sesamum indicum* L.) with pulse and oilseed crops on rice fallow land. *Indian. J. Agric. Sci.*, **71**: 90-93.

Yoshida, S. 1992. *Physiological Aspects of Grain Yield.* Annual Review of Plant Physiology, Int. Rice Res. Institute, **23**: 437-64.