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Pest Incidence and Yield as Influenced by Intercropping Unconventional Greenmanures in Cotton

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Field experiments were conducted at Agricultural Research Station, Bhavanisagar, Tamil Nadu, India to find out the effect of Intercropping unconventional greenmanures on pest incidence and yield of cotton during the year 2004 -2005 in well drained sandy clay loam soil. Four cropping systems viz, sole cotton, cotton + marigold (*Tagetus erecta* L.), cotton + sesamum (*Sesamum indicum* L.) and cotton + sunnhemp (*Crotalaria juncea* L.) were tested (Factor A) in single and double rows (Factor B) incorporating them on 30 and 40 DAS (Factor C). The results revealed that intercropping with marigold in two rows in between cotton rows and incorporating it on 30 DAS had contributed ultimately to less incidence of pests and more kapas and lint yield of cotton securing higher yield advantage in both summer and winter crops Sunnhemp and sesamum had moderate and low effects, respectively on pest incidence.

Key words: Cotton, unconventional green manure, pest incidence, yield

Cotton (*Gossypium spp*.), considered as "white gold", is one of the most important commercial crops which is cultivated in our country over an area of 9.1 m. ha with a production of 270 lakh bales. The productivity is 503 kg ha^{-1}which is low as compared to the world average of 733 kg ha^{1} (AICCIP, 2007). In view of low productivity in our country, the yield enhancing practices in cotton have to be strengthened. Hybrid cotton in general has more potential than varieties. It is mostly grown under irrigation with high level of management to exploit the hybrid vigour.

Despite the largest area in the world, cotton yield is abysmally low in India. The labour cost in cotton cultivation is 70 per cent and the balance 30 per cent is towards material cost. In spite of a whopping sum of Rs.1600 crores spent on pesticides to save cotton, pests cause considerable damage. It is the American bollworm that caused a loss of Rs 380 crores in Punjab in 2001-02 and the major outbreak in Tamil Nadu during 2002-03 had been stem weevil. Poor rains and substandard pesticides are the other causes for low yield (Singhal, 2003). While agriculture overall has reached stagnation as an aftermath of green revolution, cotton has been the worst hit. Cotton is grown on 5 per cent of the land in India but it consumes about 54 per cent of the pesticides in the country (Menon, 2003). Thus, the emphasis is on newer measures preferably by non-chemical, agronomic approaches for managing the pests. They have to buildup beneficial insects or as an attractant of cotton pests or both.

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Green manuring is an age-old practice and the maiden experiment on green manuring was first commenced as early as 1882 at Kanpur in India (Krishnamurthy, 1978). Though it continues to be researched, the practice of green manuring is, in fact, getting phased out as it is not appealing to the farmers who do not want to sacrifice a time slot in their cropping programme to raise a green manure. Further, fertilizers come handy to them.

Green manures are neither cash crops nor food crops and this is yet another reason for green manures not becoming popular in the present day agriculture. Unlike in the past, the 'bulkiness' of green manures or for that matter of any other organic manure is a constraint in the present day agriculture. The opportunity cost of raising green manures is also less. Yet it has to be promoted due to several unfavourable effects caused by chemical agriculture widely prevalent now.

In order to promote greenmanuring, innovations should stretch even beyond intercropping green manures and optimizing their rows. Cotton and plant protection are inseparable. Cotton is cultivated in 5 per cent of arable area but consuming as much as 50-55 per cent of pesticides used in our country. Therefore it would be significant if a greenmanure for cotton serves as a plant protectant too. Marigold is noted for the control of nematodes. Sesamum is known for root exudation. An attempt has been made in the present study to find out their pest suppression effect in cotton in comparison with sunnhemp as standard. To find out their optimal row ratio and ideal time of incorporation, they were

raised in single and double rows allowing them for 30 and 40 DAS for incorporation

Materials and Methods

Field experiments were conducted at Agricultural Research Station, Bhavanisagar, Tamil Nadu, India to find out the effect of intercropping Unconventional Greenmanures pest incidence and yield of Cotton during the year 2004 to 2005. The soil of the experimental fields was well drained sandy clay loam. The fertility status of the soil in both the fields was low, medium and high in available N, P and K respectively. Four cropping systems viz, sole cotton, cotton + marigold (*Tagetus erecta* L.), cotton + sesamum (*Sesamum indicum* L.) and cotton + sunnhemp (*Crotalaria juncea* L.) were tested (Factor A) in single and double rows (Factor B) incorporating them on 30 and 40 DAS (Factor C). The trials were laid out in a factorial randomized block design replicated thrice.

Table 1. Effect of unconventional green manure intercrops on the biomass and dry matter production, N content and contribution during summer 2003 and winter 2003-04

Treatment	Biomass production (t ha^{-1})		Dry matter production (kg ha^{-1})		N content (%)		N contribution (kg ha^{-1})	
	Summer 2003	Winter 2003-04	Summer 2003	Winter 2003-04	Summer 2003	Winter 2003-04	Summer 2003	Winter 2003-04
Inter crop								
I_1 – Marigold	9.20	9.76	1897	1957	1.93	1.84	36.65	36.13
I_2 – Sesamum	8.55	9.41	1743	1806	1.75	1.65	30.57	29.82
I_3 – Sunnhemp	10.10	10.63	2003	2000	2.43	2.46	48.69	49.10
Sed	0.33	0.45	50.91	60.21	0.02	0.04	0.64	2.1
CD (P=0.05)	0.69	0.95	105.6	125.0	0.05	0.09	1.33	4.4
Row ratio								
R_1 – Single row	8.95	9.49	1777	1806	2.02	1.97	36.29	35.80
R_2 – Double row	9.62	10.38	1985	2036	2.05	1.99	40.98	40.90
SEd	0.27	0.37	41.6	49.2	0.02	0.04	0.53	1.8
CD (P=0.05)	0.57	0.77	86.2	102.0	NS	NS	1.09	3.6
Days of incorporation								
D_1 – 30 DAS	9.17	9.70	1880	1943	2.05	2.01	38.96	39.39
D_2 – 40 DAS	9.39	10.18	1882	1899	2.03	1.95	38.31	37.31
SEd	0.27	0.37	41.6	49.2	0.02	0.04	0.53	1.75
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Cotton seeds were sown at a spacing of 120 x 60 cm. Sesamum and sunnhemp were sown in solid rows in the interspace i.e., 60 cm in between two cotton rows for single row spacing. For two rows, they were sown at 40cm interval in the interspace. In a similar way, marigold seedlings were planted keeping 10 cm intra row spacing, cotton was earthed up simultaneously at the respective incorporation timings. Fertilizers were applied at the rate of 120: 60: 60 kg N, P_2O_5 and K_2O ha^{-1} respectively. Full dose of P & K and ½ N were applied as basal. Remaining N was applied in equal splits at the time of incorporation of green manure and at 60 DAS. Fertilizers were applied to cotton rows alone. The seed cotton was harvested in five pickings. The population of sucking pests *viz.,* leaf hopper (*Amrasca biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius), aphid (*Aphis gossypii* Glover) and Thrips (*Thrips tabaci* Lind.) was recorded on top, middle and bottom leaves at 30, 60 and 75 DAS and expressed as number / 15 leaves. The values were subjected to square root transformation and presented. Five plants each of marigold, sesame and sunnhemp were pulled out at random on 30 and 40 DAS, cleaned, weighed and expressed as biomass in kg ha^{-1}. The dry weight was then recorded and expressed as dry matter production in kg ha^{-1}. Nitrogen content of the green manures at the time of incorporation was estimated by microkjeldahl method (Yoshida *et al*., 1971).

Galls of stem weevil were recorded in 15 plants on 60 and 90 DAS and finally at harvest (120 DAS) and the respective mean values were worked out. The values were subjected to arc sine transformation and presented. For boll worm infestation (%), total bolls and boll worm infested bolls were counted in 15 plants and expressed as per cent boll worm infestation. The values were subjected to arc sine transformation and presented.

$$\text{Boll worm damage (\%)} = \frac{\text{No. of bolls affected}}{\text{Total no. of bolls}} \times 100$$

Table 2. Effect of unconventional green manure intercrops on the incidence of natural enemies, thrips in the associate cotton during summer 2004 and winter 2004-05 (No. per 15 leaves)

Treatment	Natural enemies						Thrips					
	Summer			Winter			Summer			Winter		
Stages	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS
Inter crop												
I_1 – Marigold	3.93	4.75	3.17	3.42	4.97	3.41	3.57	3.94	3.06	3.15	3.64	1.87
	(15.47)	(22.58)	(10.09)	(11.78)	(22.79)	(11.72)	(12.91)	(13.64)	(9.23)	(10.25)	(13.50)	(3.58)
I_2 – Sesamum	3.67	4.59	2.85	3.35	4.70	3.28	3.84	4.49	3.10	3.56	4.20	1.94
	(13.58)	(21.13)	(8.17)	(11.26)	(22.13)	(10.30)	(14.91)	(20.30)	(10.27)	(12.81)	(16.50)	(3.74)
I_3 – Sunnhemp	3.89	4.49	2.83	3.39	4.76	3.36	3.69	4.05	3.29	3.28	4.13	1.83
	(15.17)	(20.25)	(8.31)	(11.52)	(22.68)	(11.35)	(13.71)	(17.95)	(9.71)	(11.04)	(15.61)	(3.36)
SEd	0.15	0.06	0.20	0.08	0.07	0.22	0.10	0.27	0.16	0.10	0.24	0.09
CD (P=0.05)	NS	0.11	NS	NS	0.15	NS	0.21	NS	NS	0.20	NS	NS
Row ratio												
R_1 – Single row	3.73	4.47	2.81	3.35	4.76	3.25	3.85	4.41	3.15	3.67	4.21	1.89
	(14.09)	(20.05)	(8.00)	(11.28)	(22.73)	(10.26)	(14.89)	(19.60)	(9.87)	(13.57)	(16.71)	(3.64)
R_2 – Double row	3.93	4.75	3.09	3.42	4.86	3.45	3.56	3.91	3.15	2.99	3.77	1.86
	(15.39)	(22.58)	(9.71)	(11.80)	(23.67)	(11.99)	(12.80)	(16.33)	(9.60)	(19.16)	(13.69)	(3.49)
SEd	0.12	0.05	0.16	0.07	0.06	0.18	0.08	0.22	0.13	0.08	0.20	0.08
CD (P=0.05)	NS	0.09	NS	NS	NS	NS	0.17	0.46	NS	0.16	0.41	NS
Days of incorporation												
D_1 – 30 DAS	3.74	4.66	2.95	3.38	4.85	3.37	3.63	4.20	3.20	3.30	3.82	1.92
	(13.49)	(21.75)	(6.03)	(11.49)	(23.62)	(11.40)	(13.30)	(17.83)	(9.57)	(11.13)	(14.60)	(3.74)
D_2 – 40 DAS	3.92	4.56	2.95	3.39	4.77	3.34	3.77	4.12	3.11	3.36	4.15	1.84
	(14.74)	(20.88)	(8.86)	(11.58)	(22.72)	(10.86)	(14.39)	(18.00)	(9.89)	(11.61)	(15.80)	(3.38)
SEd	0.12	0.05	0.16	0.07	0.06	0.18	0.08	0.22	0.13	0.08	0.20	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cropping system												
Without GM (S_1)	3.34	4.24	2.45	2.83	4.47	3.03	4.49	5.09	4.08	4.06	4.91	3.40
	(13.47)	(18.00)	(6.03)	(11.58)	(20.00)	(9.22)	(20.25)	(26.00)	(13.43)	(16.52)	(21.05)	(11.79)
Overall mean of GM (S_2)	3.83	4.61	2.95	3.39	4.81	3.35	3.70	4.16	3.15	3.33	3.99	1.88
	(14.74)	(21.32)	(8.86)	(8.11)	(23.20)	(11.13)	(13.84)	(17.96)	(9.73)	(11.37)	(16.12)	(3.56)
SEd	0.22	0.08	0.29	0.12	0.11	0.32	0.15	0.40	0.24	0.14	0.36	0.14
CD (P=0.05)	0.46	0.17	NS	0.25	0.22	NS	0.31	0.83	0.49	0.29	0.74	0.28

(Figures in parenthesis are original values**)**

Results and Discussion

Contribution of green manures

Marigold and sesame (unconventional) and sunnhemp (standard) were raised in single and double rows as intercrops in cotton and incorporated *in situ* on 30 and 40 DAS. While sunnhemp is known for its fast growth, the growth of marigold and sesame for greenmanurial purpose has not been previously studied and in the present study the planted marigold contributed on an average 9.48 t ha^{-1} of biomass and sesame 8.98 t ha^{-1}, while sunnhemp gave 10.37 t ha^{-1} (Table1). Though sunnhemp gave higher biomass, biomass from marigold is more than sufficient and satisfies more than what is recommended for important field crops such as rice where the recommendation is 6.25 t ha^{-1} (CPG, 1999). The study indicates that the biomass production from all the three green manures as intercrops is ample lending scope for *in situ* greenmanuring.

Cotton is slow growing and the spacing is wider (Praveen Rao, 1991). Further hybrid (TCHB 213) has been raised with more spacing (120 cm) than followed for varieties (75 cm). These might be the exclusive reasons for two rows giving higher biomass of green manure than single row with little or no competition from the associate cotton.

The nitrogen content has been in the order of 2.43 to 2.46 per cent in sunnhemp, while it was 1.84 to 1.93 in marigold and 1.65 to 1.75 per cent in sesame (Table.1). Sunnhemp being a legume has obviously more N content. It is the nitrogen contribution that has more bearing. Sunnhemp, on account of higher biomass and N content, contributed N to the tune of 48 to 49 kg ha^{-1}, while it was 30 kg ha^{-1} with marigold and 30 kg ha^{-1} with sesame. Yet identification of a green manure requires a collective look on cotton nutrition and pest reduction.

Intercropping green manures and pest incidence

Natural enemies: Marigold and sesamum are unconventional green manures, while sunnhemp is a known green manure. Natural enemies' population was continuously more till the last

Table 3. Effect of unconventional green manure intercrops on the incidence of aphids and leaf hopper in the associate cotton during summer 2004 and winter 2004-05 (No. per 15 leaves)

Treatment	aphids						Leaf hopper					
	Summer			Winter			Summer			Winter		
Stages	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS
Inter crop												
I_1 – Marigold	5.01	7.08	5.06	4.99	6.60	3.53	2.26	3.88	3.06	3.82	2.96	2.96
	(27.22)	(50.18)	(25.65)	(24.95)	(43.74)	(12.52)	(5.14)	(15.18)	(9.41)	(14.65)	(18.60)	(8.81)
I_2 – Sesamum	5.52	7.39	5.14	5.20	6.85	3.73	2.58	4.32	3.17	4.04	3.10	3.12
	(30.55)	(54.61)	(26.49)	(27.03)	(47.15)	(13.94)	(6.66)	(18.71)	(10.09)	(16.37)	(22.50)	(9.20)
I_3 – Sunnhemp	5.51	7.22	5.12	5.13	6.68	3.65	2.43	3.90	3.13	4.01	2.93	2.93
	(30.66)	(52.12)	(26.19)	(26.31)	(44.72)	(13.33)	(5.94)	(15.29)	(9.82)	(16.07)	(20.01)	(8.57)
SEd	0.20	0.12	0.06	0.05	0.25	0.09	0.08	0.26	0.06	0.06	0.18	0.15
CD (P=0.05)	0.42	NS	NS	0.10	NS	NS	0.16	NS	NS	0.12	NS	NS
Row ratio												
R_1 – Single row	5.34	7.69	5.14	5.20	7.06	3.70	2.51	4.26	3.13	4.01	3.06	3.02
	(30.56)	(59.13)	(26.49)	(27.02)	(49.86)	(13.79)	(6.32)	(18.24)	(9.84)	(16.14)	(21.02)	(9.13)
R_2 – Double row	5.35	6.77	5.07	5.02	6.36	3.56	2.34	3.80	3.11	3.90	2.93	2.99
	(28.93)	(45.83)	(25.74)	(25.18)	(40.54)	(12.73)	(5.51)	(14.54)	(9.71)	(15.15)	(19.73)	(8.64)
SEd	0.16	0.10	0.05	0.04	0.21	0.07	0.06	0.21	0.05	0.05	0.14	0.13
CD (P=0.05)	NS	0.20	NS	0.08	0.42	NS	0.13	0.44	NS	0.09	NS	NS
Days of incorporation												
D_1 – 30 DAS	5.20	7.16	5.06	5.08	6.65	3.59	2.32	3.92	3.10	3.90	3.04	3.06
	(29.94)	(51.26)	(24.60)	(25.89)	(44.36)	(12.91)	(5.40)	(15.33)	(9.62)	(15.29)	(19.59)	(9.04)
D_2 – 40 DAS	5.49	7.30	5.16	5.13	6.77	3.68	2.52	4.14	3.15	4.01	2.95	2.95
	(30.35)	(53.29)	(26.61)	(26.31)	(46.05)	(13.62)	(6.43)	(17.26)	(9.63)	(15.15)	(21.15)	(8.74)
SEd	0.16	0.10	0.05	0.04	0.21	0.07	0.06	0.21	0.05	0.05	0.14	0.13
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.13	NS	NS	0.09	NS	NS
Cropping sys												
Without GM (S_1)	5.95	8.24	5.79	5.71	7.24	4.00	2.61	5.20	3.57	4.24	3.55	3.22
	(36.41)	(67.89)	(35.53)	(32.67)	(52.48)	(14.00)	(6.80)	(27.00)	(12.75)	(18.00)	(32.00)	(12.61)
Overall mean of GM (S_2)	5.35	7.23	5.11	5.11	6.71	3.63	2.42	4.03	3.12	3.96	3.00	3.00
	(29.64)	(52.27)	(26.11)	(26.10)	(42.50)	(13.26)	(5.91)	(16.39)	(9.77)	(17.70)	(30.27)	(8.89)
SEd	0.30	0.18	0.09	0.07	0.37	0.13	0.11	0.38	0.09	0.08	0.26	0.23
CD (P=0.05)	NS	0.37	0.18	0.15	NS	0.27	0.23	0.79	0.18	0.17	0.54	NS

(Figures in parenthesis are original values**)**

observations in greenmanured treatments than cotton without greenmanuring. An *inter se* comparison between cotton without greenmanuring and marigold intercropping showed higher build up of natural enemies in the latter at all stages in both seasons. Row ratios and timing of incorporation of green manures had no significant impact on the population of natural enemies in both seasons.

Pests incidence: The population of thrips, aphids, leaf hopper, white fly, boll worm and stem weevil (in terms of galls) was counted on 15 leaves in sucking pests and 15 plants with respect to boll worm and stem weevil galls and the average incidence was shown (Tables 2- 5). On an average, all these pests had lower incidence due to intercropping of green manures studied with different row ratios and timing of incorporation as compared to cotton without greenmanuring. This trend was seen in both seasons and at all stages. The impact of different green manures *viz.,* marigold, sesamum and sunnhemp was significant in controlling all these pests but generally confined to early stage (30 DAS). Thereafter the difference due to different green manures intercropping was narrowed down and became insignificant barring stem weevil incidence. Both source of green manures raised by intercropping and row ratio had their influence in checking stem weevil incidence from 60 to 120 DAS in both seasons. Marigold intercropping had relatively low incidence of galls. Two rows of raising / planting green manures was more effective in controlling stem weevil than single row sowing / planting of green manures.

Marigold in relation to control of different pests had its prominence in checking stem weevil as could be seen from a comparison of results of sole cotton without greenmanuring and marigold intercropping (Table 5).This striking difference was seen in both seasons. Double row intersowing / interplanting of green manures in cotton had more control on pests *viz.,* thrips, leaf hopper, white fly and boll worm in the early stages, while its effect on stem weevil was observed even at the late stages upto 120 DAS. The timing of incorporation of green manures had no relevance in controlling many of the pests including stem weevil. Thus greenmanuring of cotton by

Table 4. Effect of unconventional green manure intercrops on the incidence of white fly and boll warm in the associate cotton during summer 2004 and winter 2004-05 (No. per 15 leaves)

Treatment	whitefly						Bollworm incidence					
	Summer			Winter			Summer			Winter		
Stages	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS
Inter crop												I_1 – Marigold
3.68	4.42	3.62	2.76	3.94	3.62	33.04	30.93	20.84	31.70	35.39	33.39	
	(13.60)	(19.64)	(13.31)	(7.69)	(15.61)	(12.80)	(29.77)	(26.44)	(12.69)	(27.63)	(33.55)	(30.40)
I_2 – Sesamum	3.96	4.96	3.86	3.17	4.10	3.86	36.19	31.91	21.30	33.53	36.42	35.51
	(15.88)	(24.67)	(14.95)	(10.18)	(16.88)	(13.75)	(34.89)	(27.98)	(13.23)	(30.53)	(34.58)	(33.77)
I_3 – Sunnhemp	3.76	4.68	3.68	2.97	3.91	3.68	34.36	31.70	21.89	32.94	35.52	34.97
	(14.77)	(22.07)	(13.51)	(8.94)	(15.38)	(12.31)	(31.87)	(27.62)	(13.93)	(29.61)	(33.76)	(32.91)
Sed	0.13	0.08	0.11	0.12	0.07	0.11	0.42	0.50	0.59	0.47	0.82	0.93
CD (P=0.05)	NS	0.16	NS	0.24	0.15	NS	0.86	NS	NS	0.97	NS	NS
Row ratio												
R_1 – Single row	3.92	4.98	3.66	3.05	4.13	3.66	35.08	31.88	21.55	33.30	35.89	34.71
	(15.47)	(24.84)	(13.46)	(9.39)	(17.12)	(13.33)	(33.06)	(27.92)	(13.52)	(30.17)	(33.86)	(32.48)
R_2 – Double row	3.69	4.39	3.79	2.88	3.84	3.79	33.98	31.15	21.14	32.14	35.67	34.53
	(13.63)	(19.39)	(14.42)	(8.48)	(14.79)	(12.58)	(31.29)	(26.78)	(13.04)	(28.35)	(34.07)	(32.24)
SEd	0.11	0.06	0.09	0.09	0.06	0.09	0.34	0.41	0.48	0.38	0.67	0.76
CD (P=0.05)	0.23	0.13	NS	NS	0.12	NS	0.70	NS	NS	0.79	NS	NS
Days of incorporation												
D_1 – 30 DAS	3.76	4.64	3.75	2.99	3.93	3.75	33.75	31.45	21.01	31.89	35.79	34.44
	(14.16)	(21.70)	(14.14)	(9.11)	(15.49)	(12.67)	(30.90)	(27.25)	(12.88)	(27.94)	(33.76)	(32.08)
D_2 – 40 DAS	3.85	4.73	3.70	2.94	4.04	3.70	35.31	31.58	21.68	33.56	35.76	34.81
	(14.94)	(22.57)	(13.74)	(8.77)	(16.42)	(13.73)	(33.45)	(27.44)	(13.68)	(30.58)	(34.17)	(32.64)
SEd	0.11	0.06	0.09	0.09	0.06	0.09	0.34	0.41	0.48	0.38	0.67	0.76
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.70	NS	NS	0.79	NS	NS
Cropping sys												
Without GM (S_1)	4.28	5.91	4.15	3.87	4.69	4.15	36.07	36.40	26.46	36.18	38.96	37.77
	(18.36)	(35.00)	(17.31)	(15.00)	(22.00)	(18.00)	(34.67)	(35.22)	(19.97)	(34.86)	(37.03)	(37.52)
Overall mean of GM (S_2)	3.80	4.69	3.72	2.97	3.99	3.72	34.53	31.52	21.34	32.72	35.78	34.62
	(14.55)	(22.13)	(13.94)	(8.94)	(15.69)	(12.95)	(32.18)	(27.35)	(13.28)	(29.26)	(33.96)	(22.36)
SEd	0.20	0.12	0.16	0.17	0.10	0.16	0.62	0.74	0.87	0.69	1.21	1.36
CD (P=0.05)	0.41	0.24	0.33	0.35	0.21	0.33	1.27	1.53	1.79	1.43	2.49	2.82

(Figures in parenthesis are original values**)**

intercropping had its influence in checking various pests with marigold having marked effect on reducing stem weevil incidence.

When yield reducers in cotton are examined, it is the pests that get prominence. The simple statistics of cotton occupying 5 per cent of the area consuming 50-55 per cent of total pesticides used in our country could reveal the menace of pests in cotton. In this cropping system study, there is evidence of some pest control due to intercropping green manures. Natural enemies' population got increased due to intercropping green manures and their incorporation in the interspaced of cotton. Higher population was maintained continuously even during later period, whereas in sole cotton the population of these predators and similar other enemies were pretty low. Increase in predator population due to cowpea intercropping with cotton and more parasitation of boll worm egg and larvae due to cotton + sorghum intercropping as observed by Hegde *et al*. (2003) are supportive of observations in the present study. Saminathan *et al.* (2002) reported that there believed to be less common pests' outbreak in mixed stands in line with the resource concentration hypothesis and natural enemies' hypothesis. This holds good for the present study also as observed by crop diversity (cotton + green manures) recording relatively less population of all sucking, chewing and gall farming pests as compared to sole cotton.

Maradufu *et al*. (1978) and Weaver *et al*. (1994) reported the potential benefit of marigold for controlling certain specific pests. Davide (1979) reported its positive impact on nematode control. All their observations lend credence to the check on various pests observed in the present study due to intercropping of marigold which had relatively more effect than sunnhemp and sesamum.

The standing crop of sesamum has the affinity for pests such as *Heliothis* (Laster and Fur, 1972). Seed rate is also less. The branching character may also suppress the weeds. Similarly there is enough evidence to test marigold as a green manure is the interspace of cotton. Compounds extracted from the leaves and flowers of *T. minuta* are toxic to *Aedes*

Table 5. Effect of unconventional green manure intercrops on the stem weevil incidence in the associate cotton and cotton yield during summer 2004 and winter 2004-05 (No. per 15 leaves)

Treatment	Stem weevil galls incidence						Kapas yield (Kg ha^{-1})		Lint yield (Kg ha^{-1})	
	Summer			Winter						
Stages	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	Summer	Winter	Summer	Winter
Inter crop										
I_1 – Marigold	27.61 (5.50)	15.34 (7.06)	18.51 (10.10)	14.70 (6.46)	17.11 (8.68)	19.82 (11.52)	1515	1988	485.3	621.3
I_2 – Sesamum	29.12 (7.39)	17.36 (8.94)	21.01 (12.20)	17.95 (9.52)	19.94 (11.18)	22.43 (14.60)	1334	1633	407.6	492.2
I_3 – Sunnhemp	28.88 (7.34)	16.06 (7.72)	19.51 (11.20)	16.58 (8.19)	18.04 (9.60)	21.52 (13.48)	1470	1778	463.2	541.3
SEd	0.48	0.24	0.63	0.30	0.52	0.87	45.37	57.90	7.94	20.6
CD (P=0.05)	0.98	0.49	1.29	0.62	1.08	1.80	93.65	119.50	16.4	42.6
Row ratio										
R_1 – Single row	28.90 (7.44)	17.46 (9.02)	20.10 (11.80)	16.99 (8.59)	18.96 (10.30)	21.53 (13.50)	1376	1713	422.9	515.8
R_2 – Double row	28.17 (6.08)	15.05 (6.78)	19.25 (10.50)	15.84 (7.52)	17.77 (9.34)	20.98 (12.90)	1504	1887	481.1	587.4
SEd	0.39	0.19	0.51	0.25	0.43	0.71	37.05	47.30	6.5	16.9
CD (P=0.05)	NS	0.40	NS	0.51	0.88	NS	76.46	97.60	13.4	34.8
Days of incorporation										
D_1 – 30 DAS	28.46 (6.55)	16.13 (7.78)	19.21 (10.90)	15.91 (7.58)	18.20 (9.49)	21.09 (13.01)	1488	1855	475.3	573.1
D_2 – 40 DAS	28.60 (6.97)	16.38 (8.03)	20.14 (11.40)	16.91 (8.53)	18.53 (10.14)	21.42 (13.40)	1393	1744	428.7	530.1
SEd	0.39	0.19	0.51	0.25	0.43	0.71	37.05	47.30	6.5	16.9
CD (P=0.05)	NS	NS	NS	0.51	NS	NS	76.46	97.60	13.4	34.8
Cropping sys										
Without GM (S_1)	32.19 (14.85)	23.56 (16.00)	26.44 (19.80)	21.27 (13.24)	24.01 (16.56)	26.61 (20.09)	**1123**	**1423**	**331.3**	**406.0**
Overall mean of GM (S_2)	28.53 (6.76)	16.26 (7.90)	19.68 (11.10)	16.41 (8.05)	18.36 (9.82)	21.25 (13.20)	**1440**	**1779**	**452.0**	**551.6**
SEd	0.70	0.35	0.92	0.44	0.77	1.29	66.79	85.2	11.7	30.4
CD (P=0.05)	1.45	0.72	1.90	0.91	1.58	2.65	137.85	175.9	24.1	62.7

(Figures in parenthesis are original values**)**

aegyptii larvae as reported by Maradufu *et al*. (1978). Studies on controlling of Mexican bean weevils also indicated its usefulness (Weaver *et al.,* 1994). It is known for controlling nematodes also. Further unlike grain legumes or other intercrops, these green manures could be in the field in association with cotton for a maximum of 30-40 days only leaving large duration difference dispelling thereby any apprehension of competitiveness.

Cotton kapas and lint yield

Kapas and lint yield*:* The positive effect of intersowing and *in situ* incorporation of green manures on growth parameters and yield attributes reflected on kapas yield in both the seasons (Table 5) having thus higher yield than sole cotton (without intercropping any green manure). The yield increase was by 28.2 and 25.0 per cent due to green manuring in summer and winter seasons, respectively as compared to sole cotton. Winter season crop yielded more kapas.

As regards sources of green manures, marigold out yielded other sources and the difference was clear in winter crop. It was followed by sunnhemp. The marigold as compared to sole cotton had nearly 35.0 per cent higher kapas yield in summer 2004 crop and 39.7 per cent in winter crop. The sunnhemp had 31.0 and 24.9 per cent higher yield, respectively. The increase in kapas yield due to sesamum green manuring was marginal as compared to sole cotton. In both the seasons, double row intersowing / interplanting of green manures produced more kapas yield than single row and similarly earlier incorporation on 30 DAS had favourable effect.

The interactive effect was significant and consistent with respect to row ratio and their incorporation timing. In both the years, double row of sowing / planting with early incorporation resulted in distinctly higher kapas yield. Single row and early incorporation resulted in low yield in both the seasons. The effect of green manure sources, row ratio and duration of greenmanures had similar effect on lint yield and this is in line with the fact that lint yield is a function of kapas yield.

Conclusion

The results revealed that intercropping with marigold in two rows in between cotton rows and incorporating it on 30 DAS had contributed to less incidence of pests and more kapas and lint yield of cotton securing higher yield advantage in both summer and winter crops Sunnhemp and sesamum had moderate and low effects, respectively on pest incidence.

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