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Influence of Incorporation of Unconventional Green Manures on Growth, Yield attributes and Yield of Cotton (*Gossypium* sp.)

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Abstract: Field experiments were conducted in summer 2003 and winter 2003-04 to find out the effect of unconventional green manure incorporation on growth and yield of cotton. Three green manures viz., marigold and sesamum and sunnhemp as intercrops were raised in single and double row incorporating them in the interspace of hybrid cotton TCHB 213 on 30 and 40 DAS with the objective to find out diverse use of green manures as a source of nutrients and as a way of weed and pest control in cotton with an aim of improved growth and yield. The results revealed that intercropping with marigold in two rows in between cotton rows and incorporating it *in situ* on 30 DAS had contributed ultimately more kapas and lint yield securing higher yield advantage in both summer and winter crops.

Key words: Unconventional green manure, growth, yield attributes, yield, cotton

Introduction

Cotton (*Gossypium* sp.), considered as King of fibre and white gold, is one of the most important commercial crops grown in as much as 80 countries in the world occupying 33 m ha. In the year 2000-01, cotton has been cultivated in our country over an area of 9 m ha with a production of 145 lakh bales. The productivity has been arrived at 276 kg ha^{-1} (Mayee *et al*., 2002), which is very low as compared to the world average of 550 kg ha^{-1} (Gopalaswamy *et al*., 2000). 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.

Green manuring is an age-old practice and even research on it has been for long. Maiden experiment on green manuring was first commenced as early as 1882 at Kanpur in India (Krishnamurthy, 1978). It continues to be researched, while the practice of green manuring is, infect, getting phased out as it is not appealing to the farmers who do not want to give a time slot in their cropping programme to raise a green manure. Further, fertilizers came handy to them.

Green manures are neither cash crops nor food crops and this is yet another factor 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 unfavorable effects caused by chemical agriculture cited clearly.

Innovativeness should stretch even beyond intercropping green manures and optimization of their rows. Cotton and plant protection are inseparable. In fact, cotton is cultivated in 5% of arable area consuming as much as 50-55% of pesticides used in our country (Jayaraj, 1999). Therefore the green manure that is considered as an intercrop in cotton has to serve as a plant Protestant too. More

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importance has to be attached on such green manures. To fulfill these requirements, unconventional green manures having already established for the control of specific pests such as marigold for nematodes could be explored to find out their effect on cotton pests also. This logic goes by the philosophy that even some reduction in pesticides use due to innovative green manuring could go a long way in cotton culture maintaining environment and sustaining its cultivation.

Therefore an attempt has been made in the present study to explore the possibility of unconventional green manures such as marigold, sesame and of course, popular green manure sunnhemp on different rows and time of incorporation with the following objectives. To find out the optimal row ratio of unconventional green manures as intercrop in between cotton rows, to find out optimum time of incorporation of intercropped green manures in the interspace of cotton rows and to identify ultimately an effective unconventional green manure for hybrid cotton on the basis of manurial value.

Materials and Methods

Field experiments were carried out at Agricultural Research Station, Bhavanisagar in order to find out the effect of unconventional green manures as intercrops on the associate hybrid cotton during the year 2003 to 2004. The soil of the experimental fields was well drained sandy clay loam of Irugur series. 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, Cotton + sesamum and cotton + sunnhemp in Factor A, green manure rows i.e., Single row and Double row in Factor B and days of green manure incorporation i.e., 30 DAS and 40 DAS under Factor C were fitted and the experiments were laid out in a factorial randomized block design replicated thrice. Sesamum and sunnhemp seeds were sown as solid rows in between cotton rows at 60 and 40 cm row spacing for single and double rows respectively. Similarly, marigold seedlings were transplanted at a spacing of 10 cm between the plants in the respective rows.

Nitrogen as urea (46%), phosphorus as super phosphate (16% P_2O_5) and potassium as muriate of potash (60% K_2O) were applied at the rate of 120: 60: 60 kg N, P_2O_5 and K_2O ha^{-1}, respectively. Full dose of P and K and 1/2 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 unconventional green manures viz., marigold, sesamum and sunnhemp were harvested and buried in the interspace on 30 and 40 DAS while manual earthing up of cotton. Border rows all around the experimental plots were harvested first and net plots were then harvested. The seed cotton was harvested in five pickings. The good and poor quality kapas were separated, sun dried, cleaned and weighed.

Results and Discussion

Plant Height

The impact of green manuring on cotton growth in terms of height was pronounced during later stages at 90 and 120 DAS in both summer and winter crops as compared to sole cotton (Table 1). Marigold intercropping and *in situ* incorporation resulted in comparatively more growth (height) of cotton followed by sunnhemp. Raising two rows and *in situ* incorporation of green manures promoted more cotton height than single row. Incorporation of green manures at 40 DAS had relatively less growth (height) of cotton. The trend of green manure sources, rows and incorporation timings was similar in both summer 2003 and winter 2003-04 crops. Cotton growth in terms of its height was promoted by intercropping and *in situ* incorporation of green manures as compared to sole cotton. Such manurial effect on the growth of principle component by intercropping green manures was reported in different field crops by many authors (Mahendran, 1994; Ramesh, 2001; Selvi, 2001).

Table 1: Effect of unconventional green manures incorporation on cotton growth and growth attributes

Treatment	Plant Height (cm)		DMP (kg ha^{-1})		Monopodial branches (No./plant)		Sympodial branches (No./plant)		No. of Bolls/plant	
season	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Inter crop										
I_1-Marigold	121.8	159.8	3863	4879	3.04	3.33	21.20	23.75	30.41	36.98
I_2-Sesamum	117.6	153.8	3553	4600	3.23	3.22	18.0	20.28	27.67	31.75
I_3-Sunnhemp	121.5	158.5	3674	4730	3.33	3.31	19.48	21.82	29.21	32.86
SED	0.7	1.2	37	73	0.13	0.10	0.74	0.88	0.78	0.73
CD (p = 0.05)	1.5	2.5	76	150	NS	NS	1.52	1.83	1.60	1.51
Row ratio										
R_1-Single row	118.2	155.2	3606	4538	3.25	3.25	17.77	20.60	26.15	29.07
R_2 -Double row	122.4	159.5	3787	4935	3.14	3.33	21.35	23.29	32.04	38.65
SED	0.6	1.0	30	59	0.10	0.08	0.60	0.72	0.68	0.60
CD (p = 0.05)	1.3	2.0	62	122	NS	NS	1.24	1.49	1.31	1.23
Days of incorporation										
D_1 -30 DAS	121.7	159.7	3729	4856	3.22	3.21	19.88	22.14	30.01	35.21
D_2-40 DAS	118.9	155.0	3664	4617	3.17	3.36	19.23	21.76	28.18	32.51
SED	0.6	1.0	30	59	0.10	0.08	0.60	0.72	0.63	0.60
CD (p = 0.05)	1.3	2.1	62	122	NS	NS	NS	NS	1.31	1.23
Cropping system										
Without GM (S_1)	103.7	142.6	3303	4166	2.63	2.56	16.00	19.00	27.94	28.06
Overall mean of GM (S_2)	120.3	157.4	3697	4737	3.20	3.29	19.56	21.95	29.10	33.86
SED	1.1	1.8	66	107	0.19	0.15	1.09	1.30	1.14	1.08
CD (p = 0.05)	2.3	3.6	137	220	0.38	0.31	2.24	2.69	NS	2.22

Jayapaul *et al*. (2000) and Yadav *et al*. (2000) reported higher number of millable canes due to intercropping and *in situ* incorporation of daincha. All these research evidences are supportive of the present findings. The result of adverse effect of delayed incorporation is in agreement with the earlier works of Joseph (1998) who reported that intercropping and *in situ* incorporation of daincha beyond 35 days was found detrimental to the associate rice.

Thus, in terms of cotton growth, greenmanuring of cotton by intercropping had beneficial effects. Marigold has been found more promising and raising two rows in the interspace of cotton promoted more growth of cotton. Earlier incorporation on 30 DAS similarly improved the growth.

Dry Matter Production

As the duration of cotton advanced, the dry matter of cotton got increased regardless of treatments. Intersowing and *in situ* incorporation of marigold had relatively more influence on cotton drymatter production in both the seasons followed by sunnhemp and the trend was throughout the cotton period. Sesame as a green manure had relatively less influence on cotton dry matter accumulation (Table 1).

Double row intercropping and *in situ* incorporation of green manures did increase the drymatter of cotton more than that of single row (R_1) in both seasons and the difference was to the tune of 400 kg approximately (4538- 4935 kg ha^{-1}) on 120 DAS.

Earlier incorporation on 30 DAS had more manurial effect on the cotton DMP and this was the trend throughout cotton period up to 120 DAS in both the seasons. Winter 2003-04 crop had in general higher DMP than the summer crop. Cotton growth in terms of its dry matter production is more promoted by intercropping and *in situ* incorporation of green manures as compared to sole cotton. All these research evidences are supportive of the present findings (Mahendran, 1994; Ramesh, 2001; Selvi, 2001). The result of adverse effect of delayed incorporation is in agreement with the earlier works of Joseph (1998) who reported that intercropping and *in situ* incorporation of daincha beyond 35 days was found detrimental to the associate rice.

Cotton Yield Attributes and Yield

Monopodial and Sympodial Branches

Between seasons, winter 2003-04 had more sympodial branches as compared to summer crop. There was no striking difference in monopodial branching due to the seasonal influence. Intersowing and *in situ* incorporation of green manures in cotton had overall positive influence in promoting both monopodial and sympodial branches in both summer 2003 and winter 2003-04 crops as compared to non green manured cotton. The monopodial branches during summer and winter crops were 2.63 and 2.56, respectively in sole cotton, whereas green manure intercropping and *in situ* incorporation resulted in 3.20 and 3.29 monopodial branches in the respective seasons. The sympodial branches were 16.00 and 19.00 in summer 2003 and winter 2003-04 crops in sole cotton and the respective values due to green manure intercropping and *in situ* incorporation were 19.56 and 21.95 (Table 2).

The sources of intercrop green manures, their row ratio with cotton and their incorporation timing had no influence on the production of monopodial branches.

Marigold intersown and incorporated *in situ* in between cotton rows produced more sympodial branches followed by sunnhemp. Sesamum incorporation resulted in less number of sympodial branches. Double row sowing/planting of green manures resulted in more sympodial branching as compared to single row sowing. Incorporation timings had no influence on the production of sympodial branches. The interactive effect was almost absent between variables and even where existed, the effect was inconsistent at different cotton stages. Satheeshkumar (1999) reported higher values for many of the cotton yield attributes due to intercropping and *in situ* incorporation of sunnhemp. The present study goes in line with his observations.

Boll Production, Fruiting Points, Boll Setting and Boll Weight

Green manures intersown and incorporated *in situ* in between cotton rows had more bolls than in sole crop (without intercropping green manures). On an average, the winter season crop produced 30.96 bolls plant^{-1} as compared to 28.52 in summer crop (Table 2).

Marigold intercropping and incorporation *in situ* resulted in more boll production in both seasons counting on an average 30.41 and 36.98 bolls plant^{-1} in summer and winter seasons, respectively. Sunnhemp intercropping followed it. Green manuring of intercrop sesamum has not favoured the boll production much (Table 2).

As regards row ratio, raising two rows of green manures in between cotton rows and *in situ* incorporation resulted in increase in boll production to the tune of 22.5 and 24.8%, respectively in summer 2003 and winter 2003-04 crops as compared to single row raising of green manures. Boll production was more with early incorporation of intersown green manures on 30 DAS (Table 2).

Fruiting points were higher with intercropping green manures and *in situ* incorporation as compared to sole cotton. Similarly marigold intercropping had more fruiting points followed by sunnhemp. Sesamum had no favourable influence. Double row green manure had higher fruiting points as compared to single row. Early incorporation (30 DAS) favoured more fruiting points. Boll setting (%) was not affected by the sources of green manure in both the seasons. Double row raising of green manures improved the boll setting as compared to single row green manures. Green manures incorporation timing had no influence on the boll setting. Overall effect of green manuring was inconsistent between the seasons so far as boll setting was concerned.

Green manure intercropping had no effect on the boll weight. Neither the source of green manures nor their incorporation timing had any influence on the weight of the bolls. The boll weight was more with two rows of raising green manures.

Green manures had interaction with the row ratio consistently in both the seasons regarding boll production. With single row, sunnhemp green manuring had more bolls during summer 2003, whereas in winter crop, marigold influenced the boll production better (Table 2). With double row planting,

Table 2: Effect of unconventional green manures intercropping on cotton kapas yield and yield attributing characters

Treatment	Fruiting points (No./Plant)		Boll setting percentage (%)		Boll weight (g/Boll)q		Kapas yield (kg/ha)		Lint yield (kg/ha)	
season	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Inter crop										
I_1-Marigold	99.85	120.86	30.33	30.55	4.54	4.72	1515	1988	485.3	621.3
I_2-Sesamum	93.24	109.83	29.73	28.99	4.29	4.45	1334	1633	407.6	492.2
I_3-Sunnhemp	95.03	117.14	30.78	29.50	4.35	4.52	1470	1778	463.2	541.3
SED	2.26	4.38	0.86	1.14	0.17	0.37	45.37	57.90	7.94	20.6
CD (p = 0.05)	4.66	9.03	NS	NS	NS	NS	93.65	119.50	16.4	42.6
Row ratio										
R_1-Single row	93.69	109.12	27.94	26.64	4.05	4.24	1376	1713	422.9	515.8
R_2 -Double row	98.39	119.16	32.62	32.72	4.73	4.88	1504	1887	481.1	587.4
SED	1.85	3.57	0.70	0.93	0.14	0.30	37.05	47.30	6.5	16.9
CD (p = 0.05)	3.81	7.37	1.44	1.91	0.25	0.62	76.46	97.60	13.4	34.8
Days of incorporation										
D_1 -30 DAS	98.81	117.29	30.29	29.84	4.44	4.72	1488	1855	475.3	573.1
D_2-40 DAS	93.26	110.99	30.28	29.52	4.35	4.41	1393	1744	428.7	530.1
SED	1.85	3.57	0.70	0.93	0.14	0.30	37.05	47.30	6.5	16.9
CD (p = 0.05)	3.81	NS	NS	NS	NS	NS	76.46	97.60	13.4	34.8
Cropping system										
Without GM (S_1)	84.26	113.67	33.16	24.99	4.07	4.09	1123	1423	331.3	406.0
Overall mean of GM (S_2)	96.04	114.14	30.28	29.68	4.39	4.56	1440	1779	452.0	551.6
SED	3.30	6.44	1.26	1.67	0.25	0.54	66.79	85.2	11.7	30.4
CD (p = 0.05)	6.87	NS	2.54	3.45	NS	NS	137.85	175.9	24.1	62.7

marigold in both the seasons secured more bolls plant^{-1}. All the green manure sources in double row produced more bolls in both the seasons. The interaction was either absent or inconsistent between seasons regarding row ratio and days of incorporation (R×D) and green manure sources and days of incorporation (I×D). Mahendran (1994) reported improvement in sugarcane yield attributes due to intercropping of daincha. Selvi (2001) reported positive impact on rice yield due to intercropping of daincha. The present study goes in line with their observations.

Kapas and Lint Yield

The overall effect of intersowing and *in situ* incorporation of green manures on kapas yield was significant in both the seasons as compared to sole cotton (without intercropping any green manure). The yield increase was by 28.2 and 25.0% due to green manuring in summer and winter seasons, respectively as compared to sole cotton. Winter season crop yielded more kapas (Table 2).

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% higher kapas yield in summer 2003 crop and 39.7% in winter crop. The sunnhemp had 31.0 and 24.9% higher yield, respectively. The increase in kapas yield due to sesamum green manuring was marginal as compared to sole cotton with respective values during summer and winter crops being 18.8 and 14.8%.

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 (R×D). 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 overall green manure effect, seasonal influence and the impact of green manure sources, their row ratio and timing of incorporation all had similar trend on lint yield as that of kapas production.

There was better growth of cotton due to intercropping and *in situ* incorporation of marigold. Crop physiology was also more favoured by this intercrop. Pest population was also less here. This resulted in higher yield of kapas and lint due to this unconventional green manure (Marigold) intercropping in both seasons. All these research evidences are supportive of the present findings (Mahendran, 1994; Ramesh, 2001; Selvi, 2001).

Conclusions

It is concluded from the present study that intercropping with marigold in two rows in between cotton rows and incorporating it *in situ* on 30 DAS had contributed ultimately more kapas and lint yield securing higher yield advantage in both summer and winter crops.

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