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Intercropping and Sources of Nitrogen on Biological Efficiency in Cotton

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Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, during winter (August-January) 2002-03 and 2003-04 in Cotton to evaluate the effect of intercropping and sources of nitrogen involving organic and inorganic sources. The treatments in the main plot consisted of Sole cotton, Cotton+Onion, Cotton+Blackgram, Cotton+ Greengram and Cotton +Lucerne. The subplot consisted of combinations of inorganic and organic manures namely, 100% recommended inorganic N, 75% inorganic N+ 25% N through poultry manure, 75% inorganic N+25% N through sunnhemp, 75% inorganic N+25% N through farm wastes and 75% inorganic N+25% N through weed compost. The experimental results revealed that cotton+blackgram intercropping with 75% inorganic N+25% N through poultry manure recorded lower weed density, higher cotton yield, cotton equivalent yield, better economics and higher post harvest nutrient status.

Key words: Cotton, intercropping, organics, yield, biological efficiency

Cotton is grown in about 80 countries in the world with 33 million ha in Asia contributing about 44 per cent of world's cotton production. In India, cotton is cultivated in 9 million ha with a production of 155 lakh bales and productivity of 529 kg lint ha^{-1}(Mayee *et al*., 2002) which is low compared to the world average of 590 Kg lint ha^{-1} (Gopalswamy *et al.,* 2000). In Tamil Nadu, cotton occupies a total area of 2.3 lakh ha in which 65 per cent area comes under rainfed condition with a production of 4 lakh bales and productivity of 324 Kg lint ha^{-1}. Despite the recent setbacks in production due to drought, cotton continues to remain the backbone of the rural economy particularly in the dry land areas.

Cotton being a long duration and widely spaced crop having slow growth rate in the initial stages, intercropping is an option for income augmentation. This gives ample scope for growing short duration intercrops, which will make use of the potential resources of the environment, with an advantage of additional income per unit area. Intercropping also provides an efficient canopy cover over the inter row spaces of the main crop resulting in suppression of weed and conservation of soil moisture.

Enhancement of cotton yield is also possible by intercropping with a short duration legume and other leguminous forage crops due to their complementary effect of fixing atmospheric nitrogen.The competition should be the least between the associate mixture of legume and non-legume cotton crop and therefore, cropping should also be in a proper ratio to have the least smothering effect. Intercropping in cotton may also have adverse effect on the main crop, but could be adequately compensated by the extra yield of intercrops. Application of organic manures along with inorganic fertilizers helps to regenerate the degraded soils and ensure sustainability in crop production.

Suitable management practices like inter cropping and judicious combination of organic and inorganic manures are considered as ecologically viable, economically feasible and also avoid environmental pollution (Rajendran, 1993). In addition, combination of organic and inorganic manures works like slow release fertilizers for providing balanced nutrients to plants (Bhawalkar and Bhawalkar, 1991 and Gour, 1984). Hence, with these ideas in view, this study was undertaken to evaluate the effect of combined application of organic and inorganic sources of N on the biological efficiency of cotton based intercropping systems.

Materials and Methods

Field experiments were conducted during winter (August-January) 2002-03 and 2003-04 at Tamil Nadu Agricultural University, Coimbatore, on sandy clay loam soil with pH of 8.0. The experiment was laid out in a split plot design replicated thrice. The treatments in the main plot consisted of Sole cotton, Cotton+Onion, Cotton+Blackgram, Cotton + Green gram and Cotton+Lucerne. The subplot consisted of combination of inorganic and organic manures *viz.,* 100% recommended inorganic N, 75% inorganic N + 25% N through poultry manure, 75% inorganic N + 25% N through sunnhemp, 75% inorganic N + 25% N through farm wastes and 75%

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inorganic N + 25% N through weed compost. The experimental soil was low in available N (229.8 kg ha^{-1}), low in available P (10.8 Kg ha^{-1}) and high in available K (429.0 Kg ha^{-1}). Cotton Cv. MCU 12 (150-155 days duration) was raised for the study.

The recommended dose of fertilizers (80: 40: 40 N, P_2O_5 and K_2O kg ha^{-1}) were applied as urea, single super phosphate and muriate of potash. Sowing was done with a spacing of 75 X 30 cm with two seeds per hill. The intercrops were sown between cotton rows. Other cultivation practices normally recommended for the cotton crop were followed. Fertilizer nitrogen was applied in the form of prilled urea (46%N) in two splits, at seedling (20-25 DAS) and vegetative stage (40-45 DAS) as per the treatment schedule. The entire phosphorus was applied as basal in the form of single super phosphate (16% P_2O_5). The potassium was applied in the form of muriate of potash (60% K_2O) in two splits at seedling and vegetative stage.

Table 1. Nutrient content of organic manures and quantity applied year wise

Organic manure	Nutrient content (%) on dry weight basis						Quantity applied (Kg ha^{-1})	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
	N		P_2O_5		K_2O			
Poultry manure	2.85	2.70	1.41	1.22	1.54	1.34	720	741
Sunnhemp	2.38	2.30	0.59	0.50	1.88	1.80	840	870
Weed compost	0.40	0.44	0.48	0.50	0.48	0.53	5000	4546
Farm waste	0.63	0.85	0.53	0.40	0.66	0.68	3175	2353

Table 2. Weed population at 40 DAS (No. m^{-2}) as influenced by intercropping systems and nitrogen sources in cotton (Pooled mean)

Treatment	Grasses	Sedges	Broad leaved weeds	Total weeds
Intercropping systems				
M1 - Cotton alone	4.62 (20.98)	4.08 (16.10)	6.69 (44.59)	9.06 (82.06)
M2 - Cotton + onion	4.18 (17.02)	3.78 (13.84)	6.38 (39.70)	8.42 (70.60)
M3 - Cotton + blackgram	3.78 (13.86)	3.42 (11.26)	5.86 (33.98)	7.57 (57.10)
M4 - Cotton + greengram	3.93 (14.98)	3.55 (12.14)	6.06 (36.38)	7.59 (57.50)
M5 - Cotton + lucerne	4.05 (15.92)	3.68 (13.08)	6.26 (38.78)	7.98 (63.66)
SEd	**0.04**	**0.03**	**0.05**	**0.04**
CD (P=0.05)	**0.08**	**0.07**	**0.11**	**0.09**
Nitrogen sources				
S1 - 100% recommended inorganic N	4.04 (15.96)	3.62 (12.72)	6.17 (37.80)	8.03 (66.48)
S2 - 75% inorganic N + 25% N through poultry manure	4.09 (16.38)	3.69 (13.22)	6.22 (38.42)	8.24 (68.02)
S3 - 75% inorganic N + 25% N through sunnhemp	4.11 (16.52)	3.71 (13.34)	6.24 (38.60)	8.15 (68.46)
S4 - 75% inorganic N + 25% N through farm waste	4.13 (16.66)	3.72 (13.46)	6.25 (38.76)	8.04 (68.88)
S5 - 75% inorganic N + 25% N through weed compost	4.19 (17.24)	3.76 (13.77)	6.33 (39.89)	8.18 (70.90)
SEd	**0.03**	**0.03**	**0.04**	**0.01**
CD (P=0.05)	**0.08**	**0.06**	**0.08**	**0.02**

Values in Paranthesis are orginal values

Different sources of organic manures *viz.,* poultry manure, sunnhemp, weed compost and farm wastes were applied as per the treatments to meet the recommended 25 per cent 'N' level. Poultry manure was applied as well decomposed deep litter manure; sunnhemp was grown as intercrop in cotton up to preflowering stage and then incorporated into the field. Weeds and farm wastes were collected from the surrounding field, composted by pit method and then applied. Well decomposed manures were analyzed for the nutrient content. The amount and source of manures applied are given in Table 1.

Observations were recorded on dry matter production, seed cotton yield and weed density. Seed cotton equivalent yield, economics were estimated. Post harvest available soil nitrogen (Subbiah and Asija,1956), phosphorus (Olsen *et al,* 1954) potassium (Stanford and English, 1949) were estimated and expressed in kg ha^{-1}. Weed density was recorded at 40 DAS (Burnside and Wicks, 1965).

Seed cotton from each picking was shade dried and weighed for each treatment separately and sum of all pickings as final yield was computed. Seed cotton yield equivalent was worked out based on value of the intercrops and added to the cash value of the seed cotton of respective treatments. The data on weeds were subjected to log x + 2 transformation before statistical analysis (Bartlett, 1947).

Results and Discussion

Weed density

The weed density in cotton was significantly influenced by both intercropping systems and nitrogen sources (Table 2). Cotton+blackgram recorded lower weed density of grasses (13.86 m^{-2}), sedges (11.26 m^{-2}) and broad leaved weeds (33.98 m^{-2}) both in 2002-03 and 2003-04. This might be due to quick establishment and coverage of land by blackgram which has smothered the weeds. Blackgram showed a greatest promise for weed smothering ability. The intercrops, which grow vigorously during the early stages and cover the soil with their canopy, resulted in reduced weed growth under intercropped situations. Similar findings were reported by Rajagopal *et al.* (1998).

Post harvest soil available nutrients

The soil available nutrients were significantly influenced by intercropping and nitrogen sources (Table 3). Cotton+blackgram resulted in higher available N, P and K. This might be due to the enhanced N availability by the fixation of atmospheric N. Further, the organic acid produced by the residues of legumes during decomposition might have accelerated the liberation of nutrients especially available P in the soil. This is in agreement with the findings of Thamburaj (1991).

Table 3. Effect of intercropping systems and nitrogen sources on post harvest soil nutrient status (kg ha^{-1}) (Pooled mean)

Treatment	Nitrogen	Phosphorus	Potassium
Intercropping systems			
M1 - Cotton alone	211.2	9.9	429.3
M2 - Cotton + onion	217.6	10.6	432.2
M3 - Cotton + blackgram	233.6	11.2	458.8
M4 - Cotton + greengram	221.5	10.6	435.4
M5 - Cotton + lucerne	206.4	9.0	425.9
SEd	**5.0**	**0.3**	**9.2**
CD(P=0.05)	**11.5**	**0.7**	**21.2**
Nitrogen sources			
S1- 100% recommended inorganic N	213.1	10.2	430.3
S2- 75% inorganic N + 25% N through poultry manure	229.3	12.0	454.9
S3- 75% inorganic N + 25% N through sunnhemp	217.8	11.0	433.2
S4- 75% inorganic N + 25% N through farm waste	215.0	10.7	432.1
S5- 75% inorganic N + 25% N through weed compost	214.4	10.4	431.2
SEd	**4.9**	**0.3**	**9.1**
CD(P=0.05)	**10.0**	**0.6**	**18.3**

Application of 75% inorganic N + 25% N through poultry manure proved better with respect to available N, P and K. The higher available nutrient status was mainly due to conversion of applied fertilizer N from humic N to amino acid N. The increased P and K released by organic manures increased the availability of applied P and K fertilizers and also increased the availability of nutrients to the crops and also in the soil. Similar findings were reported by Mukherjee *et al.* (1991).

Biological yield

Dry matter production of cotton

Dry matter production was significantly influenced by the intercropping system at harvest stage of observation (Table 4). Higher DMP was under sole crop of cotton (5239 kg ha^{-1}). It was on par with cotton+blackgram, which registered the DMP of 4663 kg ha^{-1}. The least dry matter production was recorded under cotton+lucerne.

Nutrient management practices showed significant variation on dry matter production of cotton. Application of 75 per cent inorganic N with 25 per cent N through poultry manure recorded significantly more DMP (4913 kg ha^{-1}). It was followed by 100 per cent recommended inorganic N, 75 per cent inorganic N+25 percent N through sunnhemp, 75 per cent inorganic N+25 per cent N through farm waste and 75 per cent inorganic N+ 25 per cent N through weed compost.

Dry matter production of intercrops

The different nutrient management practices had significant influence on dry matter production of blackgram (Table 4). Cotton+greengram recorded higher DMP followed by cotton+blackgram than the other intercropping systems.

Among the nutrient management practices, application of 75 per cent inorganic N+25 per cent N through poultry manure recorded significantly higher dry matter production of 1488 kg ha^{-1}. It was followed by 75 per cent inorganic N+25 per cent N through sunnhemp and 75 per cent inorganic N+25 per cent N through farm waste.

Yield of cotton

Yield of seed cotton was significantly influenced by the intercropping systems and nitrogen sources (Table 4). Sole crop of cotton recorded higher seed cotton yield (2040 Kg ha^{-1}) than intercropped cotton. Enhanced growth without intercrop competition resulted in better development of yield attributes such as sympodial branches, fruiting points and number of bolls ultimately leading to increased seed cotton yield. Further uptake of NPK was also significantly higher in sole cropping of cotton at all stages, which might have also contributed to higher yield efficiency. Similar findings were reported by Balasubramanian (1987) and Deshpande *et al*. (1989). Intercropping led to reduction in yield of cotton by 6.9 to 22.2 per cent depending on intercrop species. Yield reduction was higher with lucerne (20-22%) followed by green gram (15-17), onion (10-13%) and blackgram (5-7%).

The seed cotton yield was greatly influenced by the nitrogen sources. Substitution of 25% N through organic sources resulted in increase in yield (4-25%) over application of entire N through inorganic sources. Largest increase in yield (24 to 25%) was achieved with integration of poultry manure to substitute 25% N. It was followed by the incorporation

Table 4. Effect of intercropping systems and nitrogen sources on DMP (kg ha^{-1}) and yield (kg ha^{-1}) of cotton and intercrops, seed cotton equivalent yield (kg ha^{-1}) (Pooled mean)

Treatment	DMP			Yield		
	Cotton	Inter crop	Cotton+ Inter crop	Cotton	Inter crop	Seed cotton equivalent yield
Intercropping systems						
M1 - Cotton alone	5239	-	5239	2040	-	2040
M2 - Cotton + onion	4430	1311	5741	1783	3724	2435
M3 - Cotton + blackgram	4663	1698	6361	1900	447	2289
M4 - Cotton + greengram	4296	1730	6026	1687	396	2031
M5 - Cotton + lucerne	4094	1466	5560	1586	20740	1947
SEd	**29**	**NS**	**129**	**40**	**36**	**25**
CD (P=0.05)	**67**	**NS**	**295**	**91**	**84**	**58**
Nitrogen sources						
S1 - 100% recommende d inorganic N	4347	1091	5438	1641	4634	1956
S2 - 75% inorganic N + 25% N through poultry manure	4913	1488	6401	2045	5767	2453
S3 - 75% inorganic N + 25% N through sunnhemp	4582	1263	5845	1840	5127	2192
S4 - 75% inorganic N + 25% N through farm waste	4464	1196	5660	1774	4980	2113
S5 - 75% inorganic N + 25% N through weed compost	4417	1165	5582	1701	4797	2027
SEd	**3**	**NS**	**85**	**34**	**14**	**11**
CD (P=0.05)	**7**	**NS**	**170**	**69**	**29**	**22**

of sunnhemp to supply 25% N (12%). The increased yields achieved with poultry manure might be due its high N content and narrow C: N ratio, which accelerated the release of nitrogen. Similar findings were reported by Bishnoi and Bajwa (1994) and Mohamed Amanullah (1997). Poultry manure as a rich source of nitrogen and phosphorus had positive influence on seed cotton yield was also reported by Ghosh *et al.* (2003).

Yield of intercrop

The yield of blackgram, green gram, onion and lucerne was significantly influenced by different nutrient management practices tried (Table 4). Cotton+Lucerne recorded significantly higher intercrop yield of 20740 kg ha^{-1} of fodder as compared to other intercropping systems during both years respectively.

Application of 75 per cent inorganic N+25 per cent N through poultry manure recorded significantly higher intercrop yield during both the years respectively.

Cotton equivalent yield

The cotton equivalent yield varied significantly with intercropping systems and nitrogen sources (Table 4). Cotton+onion resulted in the maximum cotton equivalent yield of 2435 Kg ha^{-1} followed by cotton + blackgram (2289 Kg ha^{-1}). This might have been due to the higher yield from blackgram and onion intercrops and lesser reduction in cotton yield when compared with green gram and onion intercrops. This is in agreement with the findings of Chellaiah and Gopalswamy (2000).

Application of 75% N as inorganics+25% N through poultry manure resulted in higher equivalent yield during 2002-03 and 2003- 04, respectively. This might be due to increase in the yield of both cotton and intercrops under this treatment. Similar findings were reported by Ghosh *et al.* (2003).

Land Equivalent Ratio

Intercropping system and nutrient management practices had significant influence on the land equivalent ratio (LER) (Table 5). Cotton+blackgram recorded significantly higher LER during both the years, which was on par with cotton + greengram.

Application of 75 per cent inorganic N+25 per cent N through poultry manure recorded significantly higher LER of cotton (1.37) followed by application of 75 per cent inorganic N + 25 per cent N through sunnhemp. Application of 100 per cent inorganic N registered the lowest land equivalent ratio during both the years.

Economics

The gross, net return and B:C ratio of cotton were significantly influenced by the intercropping systems and nitrogen sources (Table 5). The maximum gross return (Rs.57,948 ha^{-1}), net return (Rs.40, 558 ha^{-1}) and B: C ratio (3.34) was recorded with the cotton + blackgram intercropping system due to higher monetary return from seed cotton and the intercrop. Though increased gross return was obtained in cotton + onion, the net return was higher only under cotton + blackgram system. This was mainly due to higher seed cotton yield and higher price fetched by blackgram than onion. This is in agreement with the findings of Chellaiah and Gopalswamy (2000) and Wankhade *et al* (2000). Kulandaivel *et al.* (2001) have also reported that blackgram as intercrop recorded significantly maximum economic return than onion

Table 5. LER, gross return, net return and B: C ratio as influenced by intercropping system and nitrogen sources in cotton (Pooled mean)

Treatment	LER	Gross Return (Rs. ha^{-1})	Net Return (Rs. ha^{-1})	BC ratio
M1S1	-	40365	23668	2.41
M1S2	-	56695	39904	3.38
M1S3	-	45080	28334	2.69
M1S4	-	43355	25518	2.43
M1S5	-	41860	23553	2.28
M2S1	1.05	50853	28656	2.35
M2S2	1.27	61398	39608	2.82
M2S3	1.17	56477	31316	2.37
M2S4	1.12	54153	31316	2.37
M2S5	1.08	49120	25814	2.11
M3S1	1.19	47104	29807	2.75
M3S2	1.49	57948	40558	3.34
M3S3	1.34	52900	34044	3.05
M3S4	1.29	50945	32508	2.76
M3S5	1.23	48613	29704	2.57
M4S1	1.14	41802	24505	2.42
M4S2	1.42	50896	33486	2.93
M4S3	1.28	47449	30103	2.74
M4S4	1.23	45678	27241	2.48
M4S5	1.18	43803	24896	2.32
M5S1	1.07	40330	22193	2.23
M5S2	1.31	49864	32774	2.90
M5S3	1.20	45172	26986	2.48
M5S4	1.16	43608	24331	2.26
M5S5	1.12	41423	23116	2.26

The application of 75% inorganic N+25% N through poultry manure produced higher gross return, net returns and B: C ratio of cotton. The percentage increase in gross returns was 43% and net return was 25% in both the seasons respectively,

as compared with recommended dose of N alone. The increased net return achieved with poultry manure might be due to the higher seed cotton yield recorded under this treatment. Similar findings were reported by Thavaprakash (2004).

Conclusion

It can be concluded that considering biological and economic performance of cotton intercropping systems, intercropping of blackgram in cotton with 75% inorganic N+25% N through poultry manure is an ideal combination. This combination has recorded the least weed density, higher seed cotton yield and BC ratio in addition to maintaining the available N, P and K status of the soil and sustained the soil fertility.

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