Studies on organic cotton production under rainfed conditions

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ABSTRACT

The experiment was conducted at ARS Dharwad on permanent site for five years under rainfed conditions aimed with clear objective of producing eco friendly quality cotton free from pesticide residues, on sustainable basis. As a mean of five years (1996-2000) data indicated a significant yield reduction of 38.9% when only biopesticides were used for control of cotton pests as compared to recommended plant protection measures. Besides, cotton plants treated with biopesticides alone for control of pests reduced plant height, boll weight and number of bolls harvested per plant and ultimately yield per plant. Among the organics farmyard manure (FYM) was the best source and its application has boosted the yield as compared to application of crop residue (CR), vermicompost (VC), in situ green manuring (IGM) and their combinations. Least yields were obtained with CR and IGM as compared to other organics and their combinations. Irrespective of plant protection measures FYM application resulted in higher yields of cotton. Hence, FYM has registered as most suitable source of organic manure to produce organic cotton, however yield obtained was less than the recommended dose of fertilizer. Results clearly indicated that reduction in yield is bound to occur when only biopesticides and organic manures are used in cotton production.

Introduction

Long-term use of chemicals coupled with intensive farming leads to problems of soil degradation, pesticide accumulation, atmospheric and water pollution, which renewed the interest on alternate methods of crop production. Present global concern is to preserve the environment by devising eco friendly technologies for cotton production and processing, so that the biosphere remains least polluted. The experiment, conducted on a permanent site for five years, aimed to produce quality cotton free from pesticide residues on sustainable basis. As for as chemical fertilizers are concerned, cotton is the 4th largest consumer in India. Due to increasing costs of fertilizer associated with environmental hazards and lack of sustainability in yields under application of sole fertilizers are raising concerns in cotton production. The low soil organic matter and multiple nutrient deficiencies are the main reasons for lack of sustainability. This shifted the focus to organic cotton production. Although cotton yields are less with this type of farming, the subsequent improvement in cotton export can generate higher income, which can compensate for losses in yields. The main idea of the experiment was to produce organic cotton with the least expenditure under rainfed conditions, so that the economy of small and marginal farmers can be improved by exporting such cotton to developed countries for premium price.

Experimental procedure

A permanent field experiment was laid out in medium deep black soil at ARS, Dharwad farm, Dharwad, Karnataka during 1996-97 to 2000-01 to study the production of organically grown cotton under northern transitional tract of semi arid tropic conditions (750 mm rainfall). The experiment was conducted for five years on a permanent site assigning the same treatment in the same plot year after year in a split plot design with three replications. The experiment was sown during June-July every year with Sahana variety at the recommended spacing (60 x 30 cm). Recommended plant protection measures and biopesticides were assigned to two main plots. In the sub plots, different organics and their combinations *viz.*, farm yard manure (FYM) @ 10 t/ha, crop residue (CR) @ 5 t/ha, vermicompost (VC) @ 2.5 t/ha, *in situ* green manuring of sunhemp (IGM) were compared with recommended dose of fertilizer and absolute control treatments. Sunhemp was sown between two rows of cotton and was incorporated after 45 days into the soil for *in situ* green manuring. Timely plant protection measures were taken by using biopesticides and chemical pesticides as per the treatments. Biopesticides like cotton seed oil, neem based insecticide, *Nuclear Polyhedral Virus* (NPV), Bt powder, Trichocards etc were used. Initial and five years after soil samples were taken for estimation of soil properties.

Results and Discussion

The cotton yields during 1997-98 and 2000-01 were low due to relatively higher intensity of pest load and low rainfall received during the season.

Effect of plant protection measures on cotton

Mean of five years data (Table 1) indicated a significant yield reduction of 38.9% with biopesticides for control of pests as compared to recommended plant protection measures. Earlier, similar results were obtained (Anonymous, 2002). Plant height, number of monopodials per plant, number of sympodials per plant, number of bolls harvested per plant, boll weight and yield per plant all were reduced when biopesticides were used for control of pests, which lead to lower yields of cotton (Tables 2 and 3).

Effect of organic and inorganic manures on cotton

As the mean of five years results indicated that application of RDF has produced significantly superior

yield over other treatments (Table 1). In general nutrient uptake as well as yields are related and dependent. Of all the elements, NPK are removed in greater amounts. Berger (1969) reported that yield depends upon the quantity of NPK available and their application. Similar observations were made by several workers *viz.*, Mannikar (1993), Tomar *et al*. (1993) and Pundarikakshudu (1985). In this study the highest yield was recorded when NPK were supplied through fertilizers in required quantities.

Among the organics, FYM was the best source and it has produced significantly superior yield over CR, VC, IGM and their combinations. Khaini and More (1984) observed increased soil organic carbon by nearly twice, apart from increased concentration of other available nutrients under continuous FYM application over a period of 45 years at Pune in cotton–sorghum rotation as compared to other organics. The yield of cotton was nearly doubled. Further, the results of present investigation indicated that CR, IGM, VC and their combined applications have produced numerically equal yields (Table 1). However, CR and IGM have given lower yields as compared to other organics and their combinations.

Soon after incorporation of green manures, if the decomposition process is not accelerated due to moisture deficit the negative effects are seen. Sunhemp as a green manure crop grows faster during early stages and thus suppress the growth of cotton under low rainfall situation. Incorporation involves opening of furrows and covering the soil. In this study in most of the years moisture stress caused due to insufficient rains and opening of furrows lead to poor decomposition of GM and CR and suppression of cotton growth. Under such situations incorporated biomass fails to decompose, instead it absorbed remaining moisture from soil and thus caused competition for moisture. Only in 1996-97, where the decomposition was good due to high moisture content in the soil, has given highest yield favoring good growth of cotton.

IGM with other organics were also failed to produce more cotton yields. However, all the organic manures have produced significantly higher yields compared to the control (without organics).

Vermicompost has also produced good yields of cotton, but, the effect was significant when applied in combination with FYM or crop residue. Among the organics, crop residues was the lowest yielder, either alone or in combination with FYM. Hence, crop residues followed by IGM was a low yielder among the organic sources.

FYM was the most efficient organic manure, which boosted organic cotton production. But, it recorded nine percent lower yield than RDF. Generally, the responses to FYM or compost application have not been spectacular, especially under rainfed conditions during early years (Chokhey, Singh and Wankhade, 1983). In this study, irrespective of the type of plant protection measures, FYM application resulted in higher yields of cotton as compared to other sources of organics. In the Bhavanisagar project, application of 12.5 t/ha FYM increased the yield of cotton up to 37% over control (Ali *et al*., 1985). It is also demonstrated by many previous workers that combined application of inorganic and organic manures has a better influence on crop than their individual effects. The prime objective of the present experimentation was to produce the organic cotton without inorganic fertilizers and pesticides. Hence to produce organic cotton FYM was found as most suitable source of organic manure.

Interaction studies

Combined data of five years indicated that recommended plant protection (RPP) measures with 100% RDF has produced significantly highest yield (1100 kg/ha) as compared to other treatments with exception of RPP plus 10 t/ha of FYM (1039 kg/ha). Studies from previous work revealed that responses to application of FYM are not immediate. Studies at CICR, Nagpur, Pundarikakshudu (1988 and 1989) reported that substitution effects were not seen in the first three years during which chemical fertilizers fared better among the treatments. However, during the fourth year significantly higher yield was noticed when 50% of the N supplied as FYM. In fact 100% N substitution as FYM was comparable to pure chemical fertilization. Thus, full substitution of N could be possible from the fourth year onwards under continuous manuring. In the present study in the control (without any organic fertilizers and the use of biopesticides) the yield has been reduced to the extent of 59.5 percent compared to FYM 10 t/ha with RPP measures.

Yield reduction was significant at all the sources of organic fertilizers and with biopesticides compared to all the sources of organics with RPP measures. Similar observations were recorded in all the years in respect of number of bolls harvested per plant, boll weight and yield per plant. FYM @ 10 t/ha with the use of biopesticides as a measure to control pests has produced the highest yield (642 kg/ha) followed by FYM + VC (627 kg/ha) which was not significantly different and they can be used for organic cotton production for export purpose. RPP alone, without added manures, yielded on par yield when compared to FYM 10 t/ha with biopesticides. It is evident from the data that yield reduction is bound to occur in organic cotton production. Application of FYM @ 10 t/ha or FYM @ 5 t/ha + VC 1.25 t/ha along with biopesticides were found to be better for organic cotton production and produce good yields under rainfed conditions.

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Table 1. *Effect of different organics and plant protection measures on the yield of organic cotton.*

Organic manures	Plant protection measures																	
	1996-97			1997-98			1998-99			1999-2000			2000-01			Mean of 5 years		
	RPP	Biocide	Mean	RPP	Biocide	Mean	RPP	Biocide	Mean	RPP	Biocide	Mean	RPP	Biocide	Mean	RPP	Biocide	Mean
Farmyard manure (FYM) 10 t/ha	1346	1114	1230	663	379	521	1045	617	831	1379	717	1048	764	383	573	1039	642	841
Vermi compost (VC) 2.5 t/ha	1076	1130	1103	723	344	534	970	419	694	1129	685	907	552	311	431	890	578	734
Crop residue (CR) 5 t/ha	1123	877	1000	562	345	454	1057	405	731	951	603	777	518	325	421	842	511	677
In situ green manuring (IGM) (Sunhemp)	1478	1324	1401	590	379	485	576	257	416	895	434	665	560	357	458	820	550	685
FYM 5 t + CR 2.5 t/ha	1203	1089	1146	517	318	417	918	408	663	1096	687	892	486	309	397	844	602	723
VC 1.25 t + CR 2.5 t/ha	1368	949	1159	576	283	429	978	449	713	1295	653	974	555	291	423	954	525	740
FYM 5 t + VC 1.25 t/ha	1342	1206	1274	557	262	409	1062	495	779	1389	797	1093	610	374	492	992	627	809
FYM 5 t/ha + IGM	1448	972	1210	623	372	497	690	293	491	1138	620	879	616	504	560	903	552	728
VC 1.25 t/ha +IGM	1524	1161	1343	628	325	476	532	325	429	1001	521	761	612	273	442	859	521	690
Recommended dose of fertilizer (RDF) (40:25:25 kg N: P: K/ha)	1556	1374	1165	670	328	499	967	491	729	1408	966	1187	899	538	718	1100	739	920
Control	---	---	---	532	200	366	619	373	493	930	434	682	336	226	281	692	421	557
Mean	1346	1120		609	321		855	412		1147	647		591	354		903	570	
For comparing means of	Standard Error of Mean (S Em) ±	Critical difference (CD) 5%	Coefficient of variance (C V) %	SEM±	CD at 5%	CV%	SEM±	CD at 5%	CV%	SEM±	CD at 5%	CV%	SEM±	CD at 5%	CV%	SEM±	CD at 5%	CV%
Plant protection measures (PP)	45.9	NS	9.6	111.7	NS	14.6	89.6	241	13.01	62.6	181	10.7	103	NS	14	10.6	29.6	18.5
Organics (O)	48.2	138		27.5	78.7		33.6	96		39.3	112		35	100		24.8	69.5	
Plant protection measures at same or different levels of Organics	79.3	227		55.4	NS		60.2	172		82.0	NS		113	NS		35.1	98.2	

Table 2. *Yield components of cotton as affected by organics and plant protection measures (mean of five years).*

Treatments	Plant height (cm)			No. of monopodials/plant			No. of sympodials/plant		
	RPP	Biocide	Mean	RPP	Biocide	Mean	RPP	Biocide	Mean
FYM 10 t/ha	81.3	74.4	77.9	1.73	1.72	1.73	13.13	12.79	12.96
VC 2.5 t/ha	76.9	73.1	75.0	1.56	1.40	1.48	12.92	12.60	12.76
CR 5 t/ha	72.0	70.1	71.0	1.63	1.59	1.61	12.39	12.33	12.36
IGM (Sunhemp)	80.3	73.1	76.7	1.29	1.41	1.35	13.67	12.83	13.25
FYM 5 t + CR 2.5 t/ha	75.5	75.2	75.3	1.47	1.91	1.69	12.24	12.99	12.61
VC 1.25 t + CR 2.5 t/ha	78.1	72.8	75.5	1.77	1.49	1.63	12.99	13.08	13.03
FYM 5 t + VC 1.25 t/ha	79.0	79.1	79.1	1.79	1.67	1.69	13.27	13.15	13.21
FYM 5 t/ha + IGM	78.7	80.0	79.4	1.56	1.68	1.62	13.16	12.88	13.02
VC 1.25 t/ha +IGM	79.1	75.5	77.3	1.53	1.39	1.46	12.85	12.83	12.84
RDF (40:25:25 kg N: P:K/ha)	80.0	80.8	80.4	2.31	1.85	2.08	12.75	13.32	13.03
Control	73.4	67.3	70.3	1.45	1.36	1.40	12.35	11.93	12.14
Mean	77.7	74.7		1.64	1.59		12.88	12.79	
For comparing means of	SEM±	CD 5%	CV%	SEM±	CD 5%	CV%	SEM±	CD 5%	CV%
Plant protection measures (PP)	0.556	1.54	9.4	0.44	NS	35.2	0.105	NS	10.5
Organics (O)	1.305	3.62		0.104	0.29		0.247	0.68	
PP at same or diff levels of O	1.846	NS		0.146	NS		0.349	NS	

Table 3. *Yield components of cotton as affected by organics and plant protection measures (mean of five years).*

Treatments	No. of bolls/plant			Boll weight (g)			Yield /plant (g)		
	RPP	Biocide	Mean	RPP	Biocide	Mean	RPP	Biocide	Mean
FYM 10 t/ha	8.83	7.03	7.93	3.70	3.36	3.53	25.4	19.1	22.3
VC 2.5 t/ha	8.25	6.39	7.32	3.54	3.42	3.48	24.3	16.1	20.2
CR 5 t/ha	7.49	6.08	6.78	3.49	3.24	3.36	19.2	17.0	18.1
IGM (Sunhemp)	8.12	6.12	7.12	3.69	3.36	3.53	24.9	17.1	21.0
FYM 5 t + CR 2.5 t/ha	7.27	6.03	6.65	3.64	3.26	3.45	20.0	15.7	17.8
VC 1.25 t + CR 2.5 t/ha	8.57	6.92	7.75	3.61	3.21	3.41	25.5	15.7	20.6
FYM 5 t + VC 1.25 t/ha	8.69	6.73	7.71	3.55	3.31	3.43	26.0	19.5	22.8
FYM 5 t/ha + IGM	8.11	6.81	7.46	3.70	3.36	3.53	23.1	19.4	21.3
VC 1.25 t/ha +IGM	8.40	6.57	7.49	3.77	3.50	3.64	26.1	14.4	20.2
RDF (40:25:25 kg N:P:K/ha)	8.49	7.35	7.92	3.47	3.49	3.48	27.5	20.0	23.7
Control	6.83	6.11	6.47	3.50	3.37	3.43	19.9	15.1	17.5
Mean	8.10	6.56		3.60	3.35		23.8	17.2	
For comparing means of	SEM±	CD 5%	CV%	SEM±	CD 5%	CV%	SEM±	CD 5%	CV%
Plant protection measures (PP)	0.138	0.38	24.2	0.018	0.05	6.78	0.462	1.28	28.9
Organics (O)	0.324	0.89		0.043	0.12		1.084	3.01	
PP at same or diff levels of O	0.458	1.10		0.061	0.17		1.533	4.45	