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Economic evaluation of crop management practices under cotton based intercropping system in Vertisol

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Abstract
Economic evaluation of crop management practices under cotton based intercropping system in Vertisol was investigated during 2015-16 and 2016-17 on Research Farm, Department of Soil Science and Agriculture Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The treatments comprised of control (only cotton), and cotton based intercropping systems *viz.* cotton + dhaincha (1:1), cotton + sunhemp (1:1), cotton + green gram (1:1), cotton + cow pea (1:1), cotton + black gram (1:1), cotton + pigeon pea (6:2) and cotton + soybean (1:1) which were executed in randomized block design with three replications. The highest seed cotton yield, gross monetary return and B: C ratio was registered with cotton + black gram intercropping system (1:1).

Keywords: Intercropping, dhaincha, black gram, gross monetary return

Introduction
Cotton is one of the most important fiber and cash crop of India. It plays a key role in Indian economy. It is globally known as 'king of fiber'. Cotton seed contain 15-20% oil and used as vegetable oil in soap industries. The left over cake, a byproduct of cotton mill is very good feed for livestock. In India cotton is grown on 122.38 lakh ha area, with 361 lakh bales production and 501 kg ha^{-1}yield. In Maharashtra it is grown on 41.19 lakh ha area with 81.00 lakh bales production and 334 kg ha^{-1}yield (Anonymous, 2018) [1]. The reasons for low productivity includes erratic distribution of rainfall, imbalanced fertilizer use, poor quality seed, low adoption of improved agro-techniques and decline in soil health. Therefore, adoption of proper crop management strategies is necessary to increase productivity and fertility of soil by increasing soil carbon sequestration under cotton based intercropping system. The amount of SOC declines (Arrouays and Pelisser, 1994) [2] when the land area under agricultural activity is increased to produce more food grains. In Vertisols, of central India, integrated soil management (e.g., conservation tillage for erosion control, water harvesting, soil-fertility management, and legume-based rotations), increased grain yield from 1 Mg ha^{-1} under traditional systems to 4.7 Mg ha^{-1} with an attendant increase in the SOC pool and improvement in soil quality Wani *et al*. (2003) [15].
The decline in SOC leading to poor soil health, it is necessary to adopt proper intercropping in soil health and economic point of view. The impact of different intercropping and their biomass addition to soil on soil physical, chemical and biological properties and different carbon pool needs to be ascertained with economic benefit.

Material and Method
The field experiment was conducted on Research Farm, Department of Soil Science and Agriculture Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. There were eight treatments with three replications in randomised block design. The experimental site was located between 22.42°N latitude and 77.02°E longitude at an altitude of 307.42 m above the mean sea level and has a subtropical climate. The soil of the experimental site was clayey in nature and slightly alkaline having pH 8.02 (Jackson, 1973) [4], non – saline with medium calcarious (Jackson 1973) [4] and moderate in soil organic carbon (Jackson 1973) [4].

Soil fertility status indicated low in available nitrogen (Subbiah and Asija 1956) [13], medium in available phosphorous (Watanabe and Olsen, 1965) [16], high in available potassium (Jackson 1973) [4] and medium in available sulphur (Chesnin and Yien, 1951) [3]. In case of micronutrients sufficient in DTPA – Zinc, iron, manganese and copper (Lindsay and Norvell 1978) [8] at the start of experiment (Table1).

Table 1: Physical and chemical properties of soils at start of experiment (*kharif*, 2015-16)

Sr. No.	Particulars	Value
A. Physical properties		
1	Bulk density (Mg m^{-3})	1.36
2	Mean weight diameter (mm)	0.60
3	hydraulic conductivity (cm hr^{-1})	0.68
B. Chemical properties		
1	pH (1:2.5)	8.02
2	EC (dS m^{-1})	0.44
3	$CaCO_3$ (%)	7.60
4	Organic carbon (g kg^{-1})	6.10
5	POC (mg kg^{-1})	116.30
6	Available nitrogen (kg ha^{-1})	188.97
7	Available phosphorus (kg ha^{-1})	15.99
8	Available potassium (kg ha^{-1})	328.16
9	Available sulphur (mg kg^{-1})	10.05
10	DTPA Zn (mg kg^{-1})	0.61
11	DTPA Fe (mg kg^{-1})	5.80
12	DTPA Mn (mg kg^{-1})	15.30
13	DTPA Cu (mg kg^{-1})	2.23

The experiment was laid out in a randomized block design (RBD) on the same site with three replications having eight treatments, that is, T_1 - control (only cotton), T_2 - Cotton + Dhaincha (1:1), T_3 -Cotton + Sunhemp (1:1), T_4 - Cotton + Green gram (1:1), T_5 - Cotton + Cow pea (1:1), T_6 - Cotton + Black gram (1:1), T_7 - Cotton +Pigeon pea (6:2), T_8 - Cotton + Soybean (1:1). Sowing of cotton was done at 90 X 45 cm spacing. Intercrops were grown in between two rows of cotton crop. The *in situ* incorporation of dhaincha and sunhemp was done 45 and 30 days after sowing respectively. The incorporation of green gram, cow pea, black gram and soybean was done after pod picking. Shaded leaf litter biomass of pigeon pea was observed. The intercrops samples were collected before its incorporation and analysed in laboratory. The weight of biomass of intercrops on green basis and oven dry basis were recorded. Among all the intercrop the highest average biomass was observed by dhaincha (23.72 q ha^{-1}) followed by sunhemp (21.86 q ha^{-1}), cowpea (19.78 q ha^{-1}), soybean (17.22 q ha^{-1}) and black gram (16.60 q ha^{-1}).

Formulae used for economic evaluation

A. Gross monetary return = Yield X Minimum support price
B. Net monetary return = Gross monetary return - Cost of cultivation
C. B:C ratio = Gross monetary return/Cost of cultivation

The nitrogen, phosphorus and potassium nutrients were applied through fertilizers *viz*. urea, single super phosphate (SSP) and muriate of potash containing 46, 16.0 and 60 per cent N, P_2O_5 and K_2O respectively. The recommended dose of fertilizers for cotton @ 100 per cent was 60:30:30 N, P_2O_5 and K_2O kg ha^{-1} was applied. The basal dose was applied as 50%N and 100% P_2O_5, K_2O was applied at the time of sowing and remaining 50% N was applied after 30 DAS.

Results and Discussion

Seed cotton yield

The seed cotton yield was significantly influenced during both the years of investigation. It ranged from 8.10 to 10.41 and 11.22 to 16.72 q ha^{-1} during first and second year respectively. Scrutiny of the results during first year of study revealed that, highest seed cotton yield (10.41 q ha^{-1}) was recorded in the treatment of cotton + dhaincha (1:1) intercropping system which was found at par with cotton+ sunhemp (1:1) (10 q ha^{-1}), cotton + black gram (1:1) (9.75 q ha^{-1}), cotton + cow pea (1:1) (8.96 q ha^{-1}), cotton + green gram (1:1) (8.73 q ha^{-1}) intercropping system. The pooled results revealed that cotton + dhaincha (1:1) intercropping system recorded significantly highest seed cotton yield (13.57 q ha^{-1}) as compared to all treatments and found at par with cotton + sunhemp (1:1) (12.68 q ha^{-1}) and cotton + black gram (1:1) (12.45 q ha^{-1}). This could be attributed to the green manuring effect of dhaincha and sunhemp in cotton.

This may be ascribed to the improvement in the soil physical, chemical and biological properties due to *in situ* incorporation of dhaincha along with recommended dose of fertilizers which might have hastened the nutrient availability as well as better soil condition for root penetration. The results are in close agreement with the findings reported by Singh *et al.* (2013) [11, 15], Thimma Reddy *et al.* (2013) [14].

Monetary return

Gross monetary returns (GMR)

The gross monetary returns ranged from Rs. 33210 to 52829 and Rs. 46675 to 84122 per hectare during first and second year respectively. The results during first year and second year of study indicated that, treatment of cotton + black gram (1:1) intercropping system recorded highest gross monetary returns i.e. (Rs. 52829 ha^{-1}) and (Rs. 84122 ha^{-1}) respectively. The highest average gross monetary returns Rs. 68476 ha^{-1} was also observed with treatment cotton + black gram (1:1) intercropping system

The findings are in line with the results reported by Katkar *et al.* (2008) [5, 6] reported that highest GMR in the treatment of cotton crop residue @ 2.5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} + 50% RDF (T_9) (Rs. 28,763 ha^{-1}) and at par with 100 per cent recommended dose of fertilizer (Rs. 28,488 ha^{-1}), cotton crop residue @ 2.5 t ha^{-1} + glyricidia green foliage lopping at 30 DAE @ 2.5 t ha^{-1} + 50% RDF (T_8) (Rs. 27,427 ha^{-1}), sunhemp *in situ* green manuring at 30 DAE + 50% RDF (T_6) (Rs. 27,326 ha^{-1}) (Hongal *et al*, 2004) and greengram intercrop residue incorporation after plucking of pods + 50% RDF (T_4) (Rs. 24,656 ha^{-1}).

Cost of cultivation (COC)

The cost of cultivation ranged from Rs.45406 to 47505 and Rs. 35624 to 37691 per hectare during first and second year respectively. The results during first year and second year of study noted that, treatment cotton + soybean (1:1) intercropping system recorded highest cost of cultivation i.e. (Rs. 47505 ha^{-1}) and (Rs. 37691 ha^{-1}) respectively. The highest average cost of cultivation Rs.42598 ha^{-1} was also recorded with treatment cotton + soybean (1:1) intercropping system.

Net monetary returns (NMR)

The net monetary returns ranged from Rs. -12196 to 6615 and Rs. 11051 to 47376 per hectare during first and second year respectively. The results during first year and second year of study observed that, treatment of cotton + black gram (1:1)

intercropping system recorded highest net monetary returns i.e. (Rs. 6615 ha^{-1}) and (Rs. 47376 ha^{-1}) respectively. The highest average net monetary returns Rs. 26996 ha^{-1} was also recorded with treatment of cotton + black gram (1:1) intercropping system**.**

B:C ratio

The B: C ratio ranged from. 0.73 to 1.14 and 1.31 to 2.29 during first and second year respectively. The results during first year and second year of study emanated that, treatment of cotton + black gram (1:1) intercropping system recorded highest B:C ratio i.e. 1.14 and 2.29 respectively. The highest average B:C ratio 1.72 was also resulted with treatment cotton + black gram (1:1) intercropping system.

The Similar results were in line with the results reported by katkar (2008) [5, 6], treatment receiving 100 per cent recommended dose of fertilizer recorded highest BC ratio followed by sunhemp *in situ* green manuring at 30 DAE + 50% RDF (T_6) during both the years of investigations and pooled mean also indicated the similar trend. This can be attributed to the higher costs of organic manures.

Similar results were also recorded by Kulandaivel *et al.* (2001) [7] revealed that dry matter production of cotton at boll maturity was significantly higher in cotton + black gram intercropping system than sole cropping of cotton. Due to slow growing nature of cotton much of vacant interspaces remains unutilized during initial stages of crop growth this situation offers ample scope for raising intercrops Nehra *et al* (1990) [10].

Similar results were also emanated by Muruganandam (1984) [9] reported that intercropping with short, early maturing pulses like black gram, green gram and cluster bean can be advantageously improves the fertility status of soil. Sivakumar (2003) [12] observed increased productivity with higher market value and enhanced profitability when pulses were intercropped with cotton.

Table 2: Effect of crop management strategies on seed cotton yield (q ha^{-1}), gross monetary returns (GMR), cost of cultivation (COC), net monetary returns (NMR) and B:C ratio under cotton based intercropping system (Rs. ha^{-1})

Treatments		Seed cotton yield			Gross monetary returns			Cost of cultivation			Net monetary returns			B:C ratio		
		2015-16	2016-17	Pooled mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
T_1	Control (only cotton)	8.10	11.22	9.66	33210	46675	39942	45406	35624	40515	-12196	11051	-572	0.73	1.31	1.02
T_2	Cotton + Dhaincha (1:1).	10.41	16.72	13.57	42681	69555	56118	45756	35974	40865	-3075	33581	15253	0.93	1.93	1.43
T_3	Cotton + Sunhemp (1:1)	10.00	15.36	12.68	41000	63897	52448	45756	35974	40865	-4756	27923	11583	0.90	1.78	1.34
T_4	Cotton + Green gram (1:1)	8.73	12.18	10.46	47862	68690	58276	46176	36506	41341	1686	32184	16935	1.04	1.88	1.46
T_5	Cotton + Cow pea (1:1)	8.96	12.28	10.62	51676	78348	65012	47486	37624	42555	4190	40724	22457	1.09	2.08	1.59
T_6	Cotton + Black gram (1:1)	9.75	15.15	12.45	52829	84122	68476	46214	36746	41480	6615	47376	26996	1.14	2.29	1.72
T_7	Cotton +Pigeon pea (6:2)	7.71	10.28	9.00	46575	65088	55832	46173	36489	41331	402	28599	14501	1.01	1.78	1.40
T_8	Cotton + Soybean (1:1)	8.36	11.98	10.17	46888	68719	57803	47505	37691	42598	-616	31028	15205	0.99	1.82	1.41
SE(m)±		0.55	0.97	0.58	-	-	-	-	-	-	-	-	-	-	-	-
CD at 5%		1.68	2.26	1.80	-	-	-	-	-	-	-	-	-	-	-	-

Conclusion

Research evidences revealed that as black gram is an economically cash crop had enhanced the growth and yield of cotton. Black gram being a leguminous crop with a characteristic of atmospheric nitrogen fixation had complemented the base crop through supply of nutrients tends to highest gross monetary returns in cotton + black gram (1:1) intercropping system.

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