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EFFECTS OF LEGUME INTERCROPS ON GROWTH, YIELD AND ECONOMICS OF HYBRID *AMERICAN* COTTON UNDER CONTROLLED CONDITION

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ABSTRACT
The field experiment entitled **"**Effects of legume intercrops on growth, yield and Economic of American hybrid cotton under controlled condition" was conducted during kharif seasons of 2016-17 at the farm Of Agronomy in Bhagwant University, Ajmer (Rajasthan). The soil of experimental plot was sandy loam in texture, slightly alkaline in reaction, low in organic carbon and in available nitrogen and low in available phosphorus but having fairly rich status of available potassium. During the *kharif* season of 2016-17, the total rainfall received 7509* mm in 34 rainy days. The experiment was laid out in randomized block design, replicated thrice with eleven treatments. The gross and net plot size was 9.00 x 6.80 m^2 and 7.20 x 6.00 m^2, respectively. The various treatments tried under study showed no significant influence on the initial and final plant stands. The height of plants, number of functional leaves, leaf area, leaf area index, total dry matter accumulation per plant were recorded higher in sole cotton than rest of various treatments. Number of monopodial branches per plant was not affected significantly due to different treatments. However, at 30, 150 DAS and at harvest treatment differences as regards leaf area were not evident. Leaf area index increased from 30 DAS to 120 DAS and declined thereafter due to fall of the leaves. Treatments of sole cotton recorded significantly higher number of picked bolls per plant. Boll weight was not affected significantly due to different treatments of intercrop. Treatment of sole cotton recorded significantly higher seed cotton, cotton stalk and biological yield and harvest index (1350, 1945 and 3270 kg ha^{-1} and 41.45 per cent, respectively). However, treatments of intercrop cotton + cowpea and cotton + clusterbean were being at par recorded higher value of seed cotton equivalent yield and land equivalent ratio. Treatments of intercrop of cotton + cowpea recorded significantly higher gross monetary returns (88400), net monetary returns (46164) and B: C ratio (2.09). However, quality studies were did not reach to the level of significance.

KEYWORDS- DAS, DAE, FYM, SEY.

INTRODUCTION

Cotton (*Gossypium sp.*) is one of the most important fibers and cash crop in India belongs to *Malvaceae* family and known as *"King of Fiber"* and *"White gold"* plays a pivotal role in the rural, national and international economy. It is grown mainly in tropical and subtropical region of more than 80 countries in the world. It is grown mostly for fiber used in the manufacture of cloths for mankind. In recent years, cotton apparels are being preferred to the synthetic ones due to the increasing the health consciousness among the people. Besides fiber, cotton is also valued for its oil (15 - 20%) which are used as vegetable oil and shop industries and cotton seed cake is very proteinous and used as cattle feed and can also be used as manure which contain 6.4, 2.9 and 2.2 per cent N, P and K, respectively. It is likely to play a pivotal role in paper, particle board and cardboard industries. With the advanced technology, short fiber or fuzz or lint can now be used to make excellent grade paper like currency paper, linoleum cellophane, rayon's, and photographic films, dynamic and molded plastics. Cotton provides livelihood to more than 60 million people in India by way of support in agriculture, processing, and use of cotton in textile. India is major producer of cotton. India stands first in area and third in production. The cotton cultivation sector not only engages around six million farmers, but also involve 40 to 50 million people relating to cotton trade and its processing. India is the pioneer country for the cultivation of hybrid cotton on commercial scale. Nearly one third of India's export earnings are from textile sectors of which cotton alone constitutes nearly 70-75 percent of raw material. Cotton contributes 30 % of the Indian agriculture gross domestic product. In India its grown over an area of 118.81 lakh hectares with production of 352 lakh bales and productivity of 504 kg/ha (Annonyms). Cotton cropping system is ideally suitable for intercropping because of the relatively longer duration and its slow growth in the initial stages. The objectives of intercropping are to obtain a maximum yield of cotton crop along with additional returns from intercrops. The common practice of cotton cultivation is inter or mixed cropping with pulses. However, the monetary advantage of pulses intercropping is meager. In addition to that existing low price situation for cotton produce is discouraging cotton cultivation. To overcome the above situation, intercropping of high value vegetable crops is one of the viable options. While considering the inconsistency in

performance and price fluctuation of vegetable crops, intercropping of vegetables with different growth habits are aimed. The intercropping system experiment was conducted with objective to find out the suitable cotton based legume intercropping system for higher production and economic return. The component vegetable intercrops *viz.,* greengram, cluster bean and cowpea was harvested with in 61, 64 and 65 days, respectively. Component grain crops blackgram and soybean were harvested in 75 and 100 days. Due to wider row spacing of cotton 90 x 20 cm and different intercrops, none of the above crops competed with the main crop of cotton during the growth and development. As a result, almost statistically similar growth characters, yield attributes and seed cotton yield were recorded in base crop cotton under intercrop systems. Thus, cropping system through intercrop was successful as a components in the system have different nutrient and moisture requirement, varied feeding zones in the soil profile, differential growth duration for enabling the utilization of natural resources optimally (Sankaranarayanan *et al*., 2011). In fact in traditional cotton belt, cotton based intercropping systems are popular for more tangible reasons such as risk in cotton cultivation due to pest problem , long gestation period for the realization of income, price instability, market uncertainty and increasing input costs not in commensuration with income. Moreover, any short duration intercrop used in system will pay farmer the much needed interim income or meet the domestic requirement of food and fodder. Therefore, compatible pulses (greengram, blackgram, cowpea, etc.), oilseeds (soybean, groundnut, etc.) and commercial crops (onion, chili), vegetables, (cluster bean and cowpea, etc.) are commonly intercropped with cotton. The main concept of intercropping is to get increased total productivity per unit area and time, besides equitable and judicious utilization of land resources and farming inputs including labour, not to mention of insurance against failure of one or the other crops could be achieved. There are ample evidences to show that, the total yield can be increased with intercropping over sole cropping. One of the main reasons for higher yields in intercropping is that the component crops are able to use growth resources differently, so that when grown together, they complement each other and make better overall use of growth resources than grown separately. Legumes when intercropped with cotton improve soil fertility status and maintain the nutrient status in soil, besides fulfilling the basic need of pulses for consumption purpose. As the legume intercropped *viz.*, blackgram, greengram, soybean, cowpea and Clusterbean are tolerant to shade, flood, drought and adverse temperature, improves physical condition of soil, efficiency in use of water, early onset of biological nitrogen fixation. Now-a-days, soybean as a major crop. Which contain 40 per cent protein and 20 per cent oil, oil is mostly used as domestically purpose. Soybean crop is biological nitrogen fixing crop add huge amount of nitrogen in the soil (Approximate 58 kg ha^{-1}). In view of this situation, it was found worthwhile to explore the possibilities of intercropping of soybean crop in cotton and to know how far it compares with other legumes. Cowpea and Clusterbean intercropping system with cotton are very popular and mostly grows for vegetable purpose. It belongs to the *leguminaceae* family which is the nutritious vegetable for human kind. Seeds are extremely tasty and have great nutritional value (containing 24–28 per cent protein and 1.5-2.0 per cent fat). They are used for food and forage. The un-ripened beans are eaten as vegetables in fresh and canned forms. It is the important source of nutrition to human and animals. The legume, it regenerates soil nitrogen and the endosperm of blackgram and cluster bean seeds is an important hydrocolloid widely used across a broad spectrum of industries.

Objectives of study

Keeping in view the above facts in improving production by way of intercropping, it was felt worthwhile to plan and undertake an experiment entitled: "Performance of intercrops on growth and yield of *American* cotton under dryland condition" with following objectives. (i) To find out the suitable legume intercrops with *American* cotton. (ii) To assess the economics of intercropping in cotton.

Hypothesis

Intercropping has been recognized as potentially beneficial and economic system of crop production. Intercropping is most common in American cotton. Cotton crop is ideal for intercropping due to its long duration and having initial slow rate of growth is highly amenable for intercropping with any short and medium duration crop. Improvement in cropping intensity is one of the possible ways to enhance agricultural production through better utilization of available resources. Cropping could be improved by adopting multiple cropping. However, under rain fed situation often not more than one growing season is available for crop cultivation. Intercropping system which involves raising of more than one crop on the same piece of land more or less simultaneously increase cropping intensity both in time and space dimension is one of main reason for higher land in intercropping is that the component crops are able to use growth resources differently and make better overall use of resources than grown separately. At present cotton cultivation is becoming risky and less profitable and especially under rain fed condition, so to make cotton cultivation more profitable and competitive with other high value crop in cotton.

Scope and limitation

In controlled agriculture, there is a instability factor in crop production both the natural resources namely land and water poses problem which limits productivity and monetary returns. Hence, it is worthwhile to make use of two or more technological options rather than depending on single options. The outcome of proposal investigation is likely to widen the scope so far as risk aversion factor is concerned, with integration of intercropping. It also offers choice of intercrops with changing situation. Recently we are experiencing weather changes due to global warming. Those may affect agricultural production to a great extent. Uncertainly factor intensifies under this situation. In future, water will become more scare and also likely to affect irrigation potential and irrigated area. Unless there is significant change in cropping pattern may be due to weather uncertainly or price fluctuations or commodity use, it is not likely to bring limitation on use and adoption

of evolved technology. In India though irrigation is developed to its fullest potential dryland area will not diminish beyond 60% of net cultivated area. Intercropping has opened up new avenues for stepping up production. In Ajmer region, agro-climatic conditions are favorable for growing cotton, greengram, blackgram, soybean, cowpea and clusterbean crops during last three decades, several workers have undertaken studies on intercropping of legumes with fiber crop. In this chapter, an attempt has been made to present a review of the available research work on intercropping of greengram, blackgram, soybean, cowpea and Clusterbean in cotton pertaining to growth, yield, yield attributes, fertility status, fiber quality and their economics. It has been experienced that sole cropping does not assure satisfactory and stable crop yield due to fragile environment. Intercropping has been used as an effective tool for risk aversion. In widely spaced and long duration crops viz. pigeon pea, cotton, sorghum intercropping has been found feasible. An attempt has been made to show how far the intercropping system affects important parameters and to what extent it is beneficial as compared to sole cropping. Intercropping in cotton has various benefits associated with it *viz.*, better utilization of resources, soil moisture, nutrients, space, stable returns and reduced risk of crop failure due to insect pests, diseases, weeds and climatic vagaries. The system made it possible to achieve normal yield level of base crop cotton in addition to bonus yield from intercrops and maintain high returns from the system as a whole. The different intercrops studied in the cotton include greengram, blackgram, soybean, groundnut, chilies, maize, cowpea, Clusterbean and onion, etc. fetching additional returns.

MATERIALS & METHODS

A field experiment entitled "Effects of legume intercrops on growth, yield and Economics of *American* hybrid cotton under controlled condition" was conducted during *kharif* season of 2015-16. The details of the materials used and methods adopted during the course of investigation are outlined in this chapter.

Details of experimental material:-Experimental site

The present investigation was carried out on the plot number 18 in the field of Bhagwant University Agriculture farm, Ajmer, during 2015-2016. Topography of the field was fairly uniform and level. The soil was medium black cotton soil belonging to *vertisols*.

Soil

Before starting the field experimentation in 2015-16, the soil was analyzed for pH, EC, organic carbon status and available nutrients contents. In order to evaluate the Physico-chemical properties, soil samples from 0-30 cm depth were taken from five random spots of the experimental field prior to layout and representative composite sample was prepared by mixing and processing of all soil samples together. The homogeneous composite soil sample was subjected to mechanical, physical and chemical analysis. The results of these analyses along with methods used for determination are presented in table 3.3. It is apparent from data that the soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen and phosphorus, medium in potassium and low in zinc content (Table-1).

TABLE 1: Mechanical and chemical composition of soil of experimental plot

S. No.	Particular	Value	Analytical method adopted
A.	Mechanical composition		
1	Sand (%)	21.32	Bouyoucos Hydrometer Method(Piper, 1966)
2	Silt (%)	10.1	
3	Clay (%)	17.1	
4	Textural class	Loamy sand	
B.	Chemical composition		
1	Available nitrogen (kg ha^{-1})	134.10	Alkaline permanganate method (Subbiah and Asija, 1956)
2	Available phosphorus (kg ha^{-1})	16.56	Olsen's method, (Jackson, 1967)
3	Available potassium (kg ha^{-1})	160.56	Flame emission Spectro-photometer (Jackson, 1967)
4	Organic Carbon (g kg^{-1})	2.7	Walkley and Black's rapid titration method(Jackson, 1967)
5	Soil P^H	8.4	Beckman's glass electrode pH meter (Jackson, 1967)
6	Electrical conductivity (d Sm^{-1})	1.24	Solu-bridge (Richards,1954)
C.	Soil Physical composition		
1.	Bulk density (Mg m^{-3})	1.52	Core sampler method (Piper,1966)

TABLE 2: Cropping history of experimental field

Year	Season	
	Kharif / Rabi	Summer
2010-11	Wheat	Fallow
2011-12	blackgram crop	Fallow
2012-13	Cotton crop	Fallow
2013-14	sorghum crop	Fallow
2014-15	Bajara	
2015-16	present experiment	

The soil of experimental plot was loamy sand in texture. Soil was slightly alkaline in reaction. The fertility status of the soil indicates that the soil was medium in organic carbon, medium in available nitrogen and available phosphorus and moderately high in available potassium. The bulk density of the soil is 1.52 Mg $m^{-3.}$

Cropping history of experimental field

The cropping history of the experimental plot for last five years is presented in Table 2. Plot number 33 in the field of Agriculture farm.

Climate and weather conditions

Ajmer is situated in the sub-tropical zone at the latitude of 24°32' North longitude of 67°02' east. The altitude of the place is 307.41 meter above mean sea level. The climate of Ajmer is semi-Arid and characterized by three distinct seasons' *viz.*, hot and dry summer from March to May, warm and rainy monsoon from June to October and mild cold winter from November to February. Most of the rain received from south-west monsoon during June to October. Ajmer received average annual rainfall of about 750 mm, out of which 80 per cent of rainfall is received in *Kharif* season (July-September) by the southwest monsoon. During summer, the maximum temperature may go as high as 37^0C while in the winter it may fall as low as 5^0C. This region is prone to high wind velocity and soil erosion due to dust storms in summer. Table 3 shows that maximum temperature ranged between 35.40^0C and 35.45^0C during the crop growing season were recorded in the 20^{th} and 22^{th} standard meteorological weeks Likewise, the minimum temperature between 10.3^0C and 10.6^0C were recorded in the 50^{th} and 52^{nd} standard meteorological weeks, respectively. During crop season, total 750.0mm rainfall received. The maximum relative humidity ranged between 58 and 87.0 per cent during the crop growing season were recorded in the 22^{th} and 33^{th} standard meteorological weeks.

TABLE 3: Mean weekly meteorological data of Ajmer for the *kharif*, 2015-16 (Actual - 2015-)

MW	Date	T MAX (°C)		T MIN (°C)		BSH (hrs)		WS (km/hr)		RH I (%)		RH II (%)		Evap. (mm)		RF (mm)		CRF (mm)	Rainy Days	
		N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A		N	A
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
									2015											
22	28-3 Jun	35.40	37.6	26.4	27.3	10.0	8.9	17.2	8.2	58	48	22	20	14.6	13.2	7.5	6.5	74.6	1.7	1
23	4-10	35.23	36.0	26.6	28.4	9.7	7.2	15.4	9.9	65	49	31	26	14.4	14.5	19.8	2.5	74.75	2.2	2
24	11-17	34.45	37.3	25.4	26.3	7.6	7.2	16.4	9.4	70	66	40	28	12.2	13.3	46.4	22.5	85.2	2.0	2
25	18-24	35.42	36.2	24.7	26.1	6.1	5.8	15.1	13.6	75	63	49	31	9.8	14.3	48.5	5.5	66.7	2.8	0
26	25-1Jul	34.1	35.2	24.2	26.8	5.2	5.2	12.4	14.0	75	61	55	31	8.4	14.3	36.6	6.7	88.4	2.1	1
27	2-8	31.5	34.4	24.0	26.3	5.3	4.1	12.9	13.5	75	74	58	44	7.4	12.2	36.7	67.4	98.8	2.2	0
28	9-15	32.3	34.1	23.6	25.7	3.9	3.8	11.0	8.1	80	84	62	51	7.7	7.3	43.2	48.6	128.4	2.6	1
29	16-22	31.9	30.7	23.5	23.9	5.2	2.5	11.2	7.8	82	88	63	70	6.2	6.7	53.5	35.8	194.2	2.4	6
30	23-29	31.6	27.2	23.3	23.6	4.3	2.2	12.9	10.4	85	90	63	70	5.5	6.6	41.2	19.2	3328.4	2.5	3
31	30-5 Aug	31.1	31.4	23.2	24.1	4.7	3.0	11.7	8.6	87	89	66	66	5.2	6.3	39.5	16.4	404.8	2.4	1
32	6-12	30.3	32.2	22.9	23.5	3.6	5.9	11.5	11.4	87	87	69	48	5.2	7.3	58.8	13.7	418.5	2.8	2
33	13-19	30.5	33.6	22.9	23.4	3.4	6.5	11.7	8.6	87	89	67	46	5.3	8.1	45.6	6.9	425.4	2.1	2
34	20-26	30.5	33.8	22.7	23.6	4.4	5.7	11.0	2.4	86	92	67	58	5.2	5.1	46.6	28.9	454.3	1.9	4
35	27-2 Sep	30.4	29.1	22.7	22.4	4.1	2.8	10.6	3.6	85	93	67	81	5.2	6.6	47.4	73.6	527.9	2.34	5
36	3-9	31.2	28.8	22.3	22.8	5.8	3.3	8.1	8.7	87	93	61	74	5.7	7.4	28.7	109.2	637.1	1.4	3
37	10-16	32.3	30.3	22.3	22.6	6.9	4.2	9.0	6.3	84	88	56	65	5.4	7.6	19.9	0.7	637.8	0.0	0
38	17-23	33.4	32.5	22.3	23.1	7.2	6.0	8.5	6.2	83	90	53	56	5.3	7.5	24.8	0.5	648.3	1.4	0
39	24-30	33.7	34.6	21.8	20.7	7.6	8.5	6.4	1.0	83	81	50	37	5.0	8.8	24.3	1.0	538.3	1.4	0
40	1-7 Oct	33.9	36.5	21.1	21.7	7.1	7.4	6.5	1.4	82	69	46	29	5.4	6.2	21.8	1.0	538.3	1.0	0
41	8-14	34.1	36.8	19.6	21.9	7.3	5.7	5.1	1.7	79	66	40	26	5.3	5.9	16.0	1.0	628.3	0.8	0
42	15-21	34.0	34.5	18.3	21.7	8.6	5.6	4.4	1.4	74	76	35	37	5.5	5.7	3.2	1 0.0	538.3	1.3	0
43	22-28	33.2	31.9	17.1	18.0	8.5	4.3	4.1	1.1	73	77	36	37	5.6	4.6	11.0	2.0	640.3	0.6	0
44	29-4 Nov	32.7	33.8	15.8	15.9	8.2	7.9	5.7	1.3	71	68	31	21	5.4	4.9	2.3	1.0	645.3	1.2	0
45	5-11	32.4	33.5	14.8	16.6	8.8	6.5	4.5	1.4	70	69	30	28	5.9	5.9	3.6	1.0	640.6	0.3	0
46	12-18	31.7	30.0	14.0	20.4	7.6	3.3	4.6	2.2	70	87	30	46	5.0	4.5	11.2	20.1	660.23	0.1	2
47	19-25	30.9	31.7	13.2	12.9	8.4	7.4	4.4	0.9	71	72	30	16	4.6	5.4	10.0	0.0	640.4	0.3	0
48	26-2 Dec	30.4	29.2	12.3	12.4	8.2	7.2	4.6	0.6	71	75	31	15	4.5	4.7	7.3	0.0	670.4	0.4	0
49	3-9	29.8	28.8	11.5	10.9	7.7	8.3	4.7	0.9	70	73	30	18	4.3	5.3	11.4	0.0	660.4	0.1	0
50	10-16	29.4	29.5	10.3	15.4	7.8	3.7	4.5	1.5	70	74	27	33	4.9	5.6	1.0	0.9	761.3	0.1	0
51	17-23	29.5	26.4	10.7	6.9	8.4	8.2	6.7	1.6	69	71	29	16	4.2	5.5	1.2	0.0	661.3	1.1	0
52	24-31	29.0	28.2	10.6	8.3	8.2	8.6	4.8	1.5	70	69	30	20	4.3	6.2	2.9	0.0	261.3	0.2	0
									2016											
1	1-7 Jan	28.3	20.7	10.8	12.4	8.7	4.2	4.9	1.1	70	88	30	49	4.2	5.4	1.7	51.4	51.4	0.0	2
2	8-14	27.4	22.8	11.4	7.0	8.6	9.1	6.3	1.7	70	81	31	14	4.3	5.4	3.4	0.0	51.4	0.2	0
3	15-21	26.7	21.8	11.8	10.1	8.9	8.3	5.4	1.5	68	70	28	28	4.7	6.7	2.9	0.0	51.4	0.1	0

Experimental Details:-Experimental design and treatments details

The present investigation entitled "Effects of legume intercrops on growth, yield and Economic of *American* cotton" was laid out in Randomized Block Design (RBD) with three replications. The treatments details and other relevant details are given in Table 4.

TABLE 4: Treatments details along with symbols used

Symbol	Treatments and verities
T_1	Sole Cotton
T_2	Sole greengram
T_3	Cotton + greengram (1:1)
T_4	Sole blackgram
T_5	Cotton + blackgram (1:1)
T_6	Sole soybean
T_7	Cotton + soybean (1:1)
T_8	Sole clusterbean
T_9	Cotton + clusterbean (1:1)
T_{10}	Sole cowpea
T_{11}	Cotton + cowpea (1:1)

Experiment layout:-The details of the experimental layout are as follows

1	Crop	Cotton	
2	Experimental design	RBD (Randomized Block Design)	
3	Replications	Three (3)	
4	No. of treatments	Eleven (11)	
5	Total plots	Thirty three (33)	
6	Plot size		
	a. Gross plot size	9.00 x 6.80 m^2	
	b. Net plot size	7.20 x 5.20 m^2	
7	Distance between two replications	1.80 m	
8	Distance between two plots	0.90 cm	
9	Spacing	One row of intercrops was alternated with another row of cotton base crop at 90 cm spacing. Cotton-greengram, cotton-blackgram, cotton-soybean, and cotton-cowpea row to row spacing was kept at 45 cm. Plant to plant spacing at 20 cm for American cotton and intercrops spacing as per recommendations. Details are given below:	
	Cotton	90 x 20 cm	
	Greengram	45 x 10 cm	
	Blackgram	45 x 10 cm	
	Soybean	45 x 5	
	Cowpea	45 x 5	
10	Seed rate (kg ha^{-1})	Sole crop	Intercrops
	Cotton	15	15
	Greengram	10	5.0
	Blackgram	15	7.5
	Soybean	75	37.5
	Cowpea	15	7.5
11	Fertilizer application (Kg ha^{-1}) N:P:K		
	Cotton	60:30:30	Half nitrogen, full phosphorus and potassium applied at the time of sowing and remaining half nitrogen applied 30 DAE to cotton crop only.
	Greengram	20:40:00	Full nitrogen , phosphorus and potassium applied at the time of sowing
	Blackgram	20:40:00	
	Soybean	30:70:30	
	Cowpea	20:40:00	

Seed material:-In the present experiment, crops and their varieties used for experimentation are presented in Table 5.

TABLE 5: Crop and their varieties used for experimentation

Crops	Botanical name	Varieties
Base crop – *American cotton*	*Gossypium hirsutum* L.	MaruVikash
Intercrops –Greengram	*Vigna radiate* (L.)	RMG-62
Blackgram	*Vigna mungo* (L.)	TAU-1
Soybean	*Glycine max* (L.)	JS-4060
Cowpea	Vigna ungiculata	Kashai kanchan
Clusterbean	Cymopsis tetragonoloba	RSG-1003

Cotton variety Maruvikash is an American hybrid cotton variety. .Growth habit is erect and total duration of this variety is about 170-180 days. It attains a height of 135-145 cm. The boll weight is 4.5 to 4.0 g, the test weight of 100 seeds is of 7 to 8 g. Its seed yield potential is 12 to 14 q ha^{-1}. The ginning percentage is 40 to 42 per cent. Resistance to water stress and sucking pest. The variety is recommended for kharif cultivation in Rajasthan conditions. Greengram variety of "*RMG-62*" was released by SKN, Jobner, and has duration of about 65-70 days in *kharif* season under Ajmer Condition. The grains are shining green, bold and green pods are also used for vegetable purpose.100 seed weight is 5.0 to 6.5g.The average yield of this variety is 10-12 q ha^{-1}.This variety is suitable for intercropping and recommended for kharif season of Ajmer region of Rajasthan conditions.

Blackgram variety of TAU-1 was released during 1985 and has duration of about 68-72 days in kharif season under Ajmer condition. The grains are bold having 100 seed weight of 4.4; its seed yield potential is 10 to 12 q ha^{-1}. This variety is suitable for intercropping and recommended for kharif season of Ajmer region. Soybean variety JS-4060 was release in 1993 and recommended for Ajmer region of Rajasthan, Duration of its variety is 95-100 days in kharif season under rain fed conditions. The flower colour are purple, grains are bold, test weight 11 - 12 g, oil content 19- 20 per cent, yield potential of this variety about 22 - 25 q ha^{-1} and suitable for intercropping system.

Field operations:-The schedule of various culture operations carried out in the experimental field during the period of experimentation is given in Table 6.

TABLE 6: Details of cultural operation of experiment

S. No.	Field Operations	Frequency	Implements used	Date of operation
A.	Preparatory tillage			
1.	Ploughing	1	MB plough	20.04.2015
2.	Harrowing	2	Harrow	05.06.15 & 11.06.15
3.	Stubbles picking	1	Manually	12.06.2015
4.	Leveling	1	Manually	14.06.2015
5.	Layout of experiment	1	Manually	15.06.2015
B.	Sowing and weedicide application			
1.	Dibbling of cotton seed and intercrops	1	Manually	16.06.2015
C.	Manures and fertilizer application			
1.	Application of FYM	1	Manually	04.06.2015
2.	Application of basal dose of inorganic fertilizers	1	Manually	12.07.2015
3.	Top dressing of inorganic fertilizers	1	Manually	10.08.2015
D.	Intercultural operation			
1.	Gap filling	1	Manually	20.07.2015
2.	Thinning	1	Manually	27.07.2015
3.	Hoeing	3	Bullock drawn	10.08.2015 25.08.2015 06.09.2015
4.	Hand weeding	4	Manually	11.08.2015 27.08.2015 06.09.2015 16.10.2015
E.	Spraying schedule			
1.	Monocrotophos	1	Knapsack sprayer	06/08/2015
2.	Trizophos	1	Knapsack sprayer	18/08/2015 11/09/2015
3.	Dimethoate	1	Knapsack sprayer	12/09/2015
4.	Methyl dematone	1	Knapsack sprayer	23/09/2015
F.	Harvesting			
1.	Greengram pods for vegetables	3	Manually	26.08.2015 05.09.2015 11.09.2015
2.	Uprooting of blackgram plants and pods for grains	1	Manually	30.09.2015
3.	Threshing and cleaning of blackgram	1	Manual labour	06.10.2015
4.	Uprooting of soybean plants and pods for grains	1	Manually	30.10.2015
5.	Threshing and cleaning of soybean	1	Manual labour	06.11.2015
6.	Cowpea green pods for vegetables	3	Manually	27.08.2015 11.09.2015 19.09.2015 (64 days)
7.	Picking of cotton	4	Manually	19.11.2015 03.12.2015 24.12.2015 17.01.2016
8.	Removal of cotton plants (uprooting)	1	Manually	20.01.2016

Preparation of land:-The field was ploughed with tractor drawn plough (MB Plough) and was brought to fine tilth by following disking and harrowing. The stubbles of previous crop were collected and removed. The field was leveled by a bullock drawn planker.

Seed and Sowing:-The sowing of cotton and intercrops was done by 55,555 at 60 x 30 cm maintained as per by 90 x 20 cm. The plant population was maintained by gap filling and subsequently by thinning and kept single plant per hill. Without change in space of cotton, intercrops were sown after every single rows of cotton (1:1). The seed of cotton and intercrops are treated with *Thiram* and bio fertilizers (*viz.*, *Azotobactor* and *Rhizobium*) as per treatments schedule. Germination test carried out in

laboratory prior to sowing which indicated that germination percentage was above 90%. Dry sowing was undertaken on 16/06/2015 and crops are germinated on 17.07.2015 after received significant monsoon rains from 11th July, 2015 (42.4 mm in 27 MW).

Fertilizer application:-The cotton crop and intercrop was fertilized with a recommended dose of fertilizer for cotton (60:30:30 kg NPK ha^{-1}). Half dose of nitrogen and full dose of phosphorus and potash was applied at the time of sowing as basal application through urea (46% N), SSP (16% P_2O_5) and KCL (60% K_2O), respectively. Remaining half dose of nitrogen was given through urea at 30 days after emergence to cotton crop only.

Gap filling and thinning:-The optimum plant population of cotton and intercrops was maintained by gap filing and subsequently by thinning at 12 DAE and 20 DAE, respectively by keeping one plant $hill^{-1}$. Plant to plant 20 cm spacing was maintained within a row of cotton and 5 and 15 cm with in a row of intercrops of greengram, blackgram, soybean, and cowpea, respectively.

Inter culture operations:-The crop was maintained weed free by giving three hoeing and four hand wedding's operations. To keep the crops weed free, for soil loose and friable for good aeration and well establishment of root system and for satisfactory growth of crops.

Plant protection measures:-Appropriate and timely spraying of plant protection schedule was followed for control of sucking pests such as ap*hids*, *jassids* and *bollworm* complex. The details of plant protection measures undertaken are given in Table 6.

Picking of cotton:-The economic part of the cotton seed was picked first in the two border rows on all sides of the plots and then the net plots were picked separately. Picking of seed cotton was done as soon as the adequate number of bolls was opened. Five picking were done. Care was taken to avoid bracts and trash adherence while removing the seed cotton from the bolls. The plot wise seed cotton was dried in the shade and weighed.

Picking, drying of pods and threshing of pods Intercrops:-Greengram, cowpea green pods used for vegetable purpose. However, blackgram and soybean were harvested when the pods turned black and attained the physiological maturity stage. Plants were uprooted tied in the bundles plot wise, labeled and allowed to sun dry and weight was recorded. The harvested crop were allowed to dry and then threshed. Then these intercrops plants were incorporated *in situ* into the soil in between the cotton rows.

Sampling techniques and details of biometric observations:-Five plants of cotton were selected randomly from each net plot for recording various growth observations. Selected plants were labeled and observations were taken on them at periodic intervals. Similar sampling techniques were adopted for intercrops also. Five plants were selected at random and biometric observations were recorded periodically. The details of observations recorded during the present investigation are given in Table 7.

TABLE 7: Details of biometric observations recorded during the course of investigation

S. No.	Particulars	Frequency	Stages at which observations recorded Days After Emergence (DAE)
Cotton Crop			
		Agronomical studies	
	A. Stand of crop		
1.	Emergence count	1	At 20 DAE
2.	Final plant stand	1	At harvest
	B. Growth studies		
1.	Plant height (cm)	6	30, 60, 90, 120, 150 and at harvest
2.	Number of monopodial branches $plant^{-1}$	2	60 and 90
3.	No. of sympodial branches $plant^{-1}$	5	60, 90, 120, 150 and at harvest
4.	No. of the functional leaves $plant^{-1}$	6	30, 60, 90, 120, 150 and at harvest
5.	Total dry matter accumulation $plant^{-1}$ (g)	6	30, 60, 90, 120, 150 and at harvest
6.	Leaf area (m^{-2})	6	30, 60, 90, 120,150 and at harvest
7.	Leaf index	6	30, 60, 90, 120, 150 and at harvest
	C. Yield attributes and yield		
1.	Number of picked bolls $plant^{-1}$	1	At harvest
2.	Seed cotton yield per plant (g)	1	At harvest
3.	Boll weight (g)	1	At harvest
4.	Seed cotton yield (q ha^{-1})	1	At harvest
5.	Stalk yield (q ha^{-1})	1	At harvest
6.	Biological yield (q/ha^{-1})	1	At harvest
7.	Harvest index (%)	1	At harvest
8.	Seed cotton equivalent yield (q ha^{-1})	1	At harvest
9.	LER	1	At harvest
	D. Economic observation		
1.	Gross monetary returns (Rs ha^{-1})	1	At harvest
2.	Net monetary returns (Rs ha^{-1})	1	At harvest
3.	Benefit :cost ratio	1	At harvest
	E. Quality studies		
1.	Ginning percentage	1	After harvest
2.	Seed index	1	After harvest
3.	Lint index	1	After harvest
	F. Chemical analysis		
1.	Mechanical analysis	1	Before sowing

2.	Soil analysis for organic carbon (g kg^{1}), Ec (dSm^{1}), pH, bulk density (g cm^{-3})	1	Before sowing
Intercrops			
1.	Plant height (cm)	1	At harvest
2.	Number of branches	1	At harvest
3.	Total dry matter production per plant	1	At harvest
4.	Number of pods per plant	1	At harvest
5.	Grain and pods yield (kg ha^{-1})	1	After harvest
6.	Straw yield (kg ha^{-1})	1	After harvest

Growth studies:-Emergence count and final plant stand:-The plant population was recorded by actually counting the number of plants in the net plot after complete emergence and thinning as well as at harvest of the crops.

Height of plant (cm):-The height of sampled plants was measured in cm from the base of the plant i.e. from ground level to the tips of terminal bud at an interval of 30, 60, 90, 120, and 150 and at harvest. Average height was calculated and expressed as height per plant.

Number of monopodial and sympodial branches per plant:-The numbers of monopodial (vegetative) branches were counted at 60 and 90 days interval up to harvest. The number of sympodial (fruiting) branches were counted at 60, 90, 120, 150 DAS and at harvest. The average number of branches per plant was calculated.

Number of functional leaves per plant:-Number of functional leaves i.e. fully opened green leaves per plant was recorded on selected plants at an interval of 30 days till harvest of crop growth.

Leaf area per plant:-In this study, functional leaves from the selected plants uprooted for the dry matter study were removed and classified into three categories according to size. Leaf area (cm^2) from one representative leaf from each category was measured by electronic leaf area meter. The leaf area in each category was recorded per plant and the leaf area of each category was determined as follows:-

Leaf area of category = Leaf area of one leaf from that category X number of leaves of that category

The leaf area so obtained from the various categories was then summed up and the mean leaf area per plant was computed in cm^2.

Leaf area index:-It is the ratio of the leaf area per plant to the land area expressed in the same unit. The LAI was computed by using the formula given by Watson (1947).

$$LAI = \frac{\text{Leaf area plant}^{-1}\ (cm^2)}{\text{Land area plant}^{-1}\ (cm^2)}$$

Total dry matter accumulation per plant:- One plant other than the plants selected for periodical observations, were selected from each net plot for dry matter study. The plant was cut at the soil surface and dried first in air for 24 hours, cut into pieces filled in brown paper bags labeled and then kept in hot air over at 65^0C temperature till the weight was constant. The average weight per plant was calculated on oven dry basis, periodically. The samplings were done at an interval of 30 days.

Post-harvest studies:-The plants selected for biometric observation were used for studying yield attributes viz. number of bolls picked per plant, boll weight and seed cotton yield per plant.

Number of picked bolls per plant:-Bolls picked per plant is one of the most important factors which decide the yield of seed cotton. The numbers of fully opened bolls picked at each picking from the observation plants were recorded separately. The total numbers of bolls picked per plant during crop duration were worked out by addition of the total number of bolls picked per plant at each picking successively.

Seed cotton weight per boll:-The total quantity of seed cotton obtained from each sample plant was weighted picking wise and divided by actual number of bolls picked in order to obtain the average weight of seed cotton per boll and expressed in g per boll.

$$\text{Boll weight (g)} = \frac{\text{Yield of seed cotton plant}^{-1}}{\text{Number of picked bolls plant}^{-1}}$$

Seed cotton yield per plant:-The total quantity of seed cotton of all picking from the observation plants in each net plot was weighted and the average weight of seed cotton per plant was worked out by dividing the with the seed cotton per plant was worked out by dividing with five and expressed in g per plant.

Yield studies:-Seed cotton yield:-Seed cotton from each net plot was picked and weighted separately as per treatments at each picking. The total yield per net plot (kg) was worked out by adding together the quantity of seed cotton obtained from all pickings inclusive of the yield of observation plant from each corresponding treatments. The net plot yield (kg) was converted into seed cotton yield (kg ha^{-1}).

Stalk yield:-After complete collection of seed cotton, the plants in the net plot were cut at ground level and kept separately in each plot. After sun drying the weight was recorded plot wise. This yield obtained from net plot was converted into stalk yield (kg ha^{-1}).

Biological yield:-Biological yield is the sum of seed cotton yield and stalk yield of cotton. It is calculated per plot and converted on hectare basis (kg ha^{-1}).

Harvest index:-Harvest index refers to the efficiency of translocation of dry matter into economic parts. It is defined as the percentage of economic yield to biological yield.

The net plot yield (kg) was converted into seed cotton yield (kg ha^{-1}).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Total biological yield}} \times 100$$

Quality studies:- Ginning percentage:-Seed cotton obtained from net plot was used as sample, each weighing 100 g and ginned on hand gun after cleaning. The weight of the lint and seed obtained in case of different samples

was recorded separately. Ginning percentage or ginning out turn was calculated by using following formula.

$$\text{Ginning percentage(\%)} = \frac{\text{Weight of cotton lint (kg)}}{\text{Weight of seed cotton (kg)}} \times 100$$

Seed index:-Seed index ensures evaluation of properly developed seed and leads to developments of lint index. To judge the development of cotton seeds as affected by different treatments, 100 seeds were counted and their weight was recorded for each treatment sample and expressed in grams.

Lint index:-The ginning percentage alone does not convey any idea about the total production of fibres. The lint index which is the ratio between lint and seed and expressed as weight of the lint obtained per seed cotton and gives absolutely production of lint per seed on an area basis. Ginning out turns gives only appropriate produce of lint. Hence, lint index can be calculated by the following formula:-

$$\text{Lint index} = \frac{\text{Weight of 100 seed}}{(100 - \text{Ginning percentage})} \times \text{Ginning \%}$$

Intercrops: - Growth studies

Plant stand:-The plant population was recorded by actually counting number of plants in net plot at 15 days after sowing and at harvest.

Plant height (cm):-The height of five selected plants was measured in cm from the ground level to the base of last terminal bud of main shoot and average height per plant was worked out.

Number of branches per plant:-The numbers of branches were actually counted on the sampling plants and from the data mean number of branches per plant was worked out.

Total dry matter accumulation per plant:-At harvest, one plant from each net plot was removed. The plants were thoroughly dried and weight of dry matter per plant was recorded.

Post Harvest Studies:-Number of pods per plant:-The pods from selected sample plant were plucked at harvested and counted. The average number pod per plant was then calculated in the case of blackgram and soybean crops. However, greengram, clusterbean and cowpea pods were plucked at green stage and used for the vegetable purpose. The number of the green pods for obtained in case of different samples was recorded separately.

Weight of grains per plant:-The grains from the blackgram and soybean pods of five selected plant were separated and weighed. The average weight of grains per plant was worked out.

Grain yield and pods yield:-The green pods/dry pods collected from each net plot were harvested/threshed separately and weight was recorded and yield of green pods/grain per hectare was estimated.

Straw yield (q ha^{-1}):-The plants were uprooted after picking of pods, tied in bundles plot wise, labeled and allowed to sundry and weight was recorded. Straw yield per hectare was estimated.

Economic Analysis:-The increase in yield and marketable produce due to various treatments was computed and money value of these produce were calculated based on market rates made available by APMC, Akola. Similarly, the cost involved in imposing each treatment was calculating taking into consideration the quantity of manures or fertilizers added their present market rates and cost of application. The economics of each treatment was worked out by deducting the cost involved for the treatments from additional money value obtained over control treatment.

Gross monetary returns:-Yield of cotton and intercrops were converted in money values (Rs $ha^{-1)}$ at the average prevailing market rates. The rates prevailing are given in Table 8.

Net monetary returns:-Net monetary returns were calculated by subtracting cost of cultivation from gross monetary returns. This provides more meaningful basis for economic comparison of different treatment combination since this represent the net income (Rs ha^{-1}).

NMR (Rs ha^{-1}) = Gross monetary returns (Rs ha^{-1}) - Cost of cultivation (Rs ha^{-1})

TABLE 8: Market prices during the year 2015-2016

S. No.	Name of crop	Seed cotton/ grains (Rs q^{-1})	Stalk/ straw (Rs q^{-1})
1	Cotton	4000	100
2	Greengram (Green pods)	1800	125
3	Blackgram (Grain)	5200	125
4	Soybean (Grain)	4500	125
5	Clusterbean	1800	125
6	Cowpea (Green pods)	1800	125

Benefit:-cost ratio:-Benefit cost ratio was calculated by dividing the gross monetary returns by the cost of cultivation.

$$\text{B:C ratio} = \frac{\text{Gross monetary returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

Seed cotton equivalent yield:-The grain yield of intercrop was converted into seed cotton equivalent yield. It was calculated on the basis of prevailing market prices of intercrops and the quantity of seed cotton can be purchased from the income of intercrop. It can be calculated as –

$$\text{Seed cotton equivalent yield} = \frac{\text{Yield of crop 'b' x Unit price of produce 'b' (Rs q}^{-1}\text{)}}{\text{Unit price of cotton (Rs q}^{-1}\text{)}}$$

Land equivalent ratio:-Land equivalent ratio is the relative land area under sole crop that is required to produce the yield achieved in the intercropping (Willey, 1979). In brief, LER is the summation of rations of yields of intercrop to the yield of sole crop. LER can be mathematically represented As follows.

$$LER = \sum_{i=1}^{M} \frac{Yij}{Yii} + \frac{Yji}{Yjj}$$

Where, Yij =Yield of i^{th} component crop as intercrop grown in association with j^{th} crop (kg), Yji = Yield of j^{th} component crop as intercrop grown in association with i^{th} (kg), Yii= Yield of i^{th}crop as sole. Yjj = Yield of j^{th} crop as sole.

Chemical studies:-Soil analysis:-Composite soil samples were collected from 0-30 cm depth before starting of the experiment and after harvest of the crops. The soil samples were analyzed chemically for various characteristics.

Soil reaction:-Soil pH was determined in soil suspension (1:2.5 soil: water) by a glass electrode pH meter after equilibrating the soil with water for 30 minutes with occasional stirring (Jackson, 1967).

Electrical conductivity:-Electrical conductivity was determined in soil suspension (1:2.5 soil : water) after equilibrating the soil with water and keeping the sample undisturbed till the supernatant solution is obtained and measured using conductivity meter (Jackson, 1967).

Organic carbon:-The organic carbon was determined by Walkley and Black's wet oxidation method, as described by Jackson (1967). Expressed in g kg^{-1}.

Available nitrogen:-It was estimated by alkaline permanganate method as outlined by Subbiah and Asija (1956). It is expressed in kg per ha.

Available phosphorus:-Available phosphorus content of soil was determined by Olsen's method as described by Jackson (1967). It is expressed in kg per ha.

Available potassium:-Available potassium was determined by flame photometer after extracting the soil with neutral normal ammonium acetate as described by Jackson (1967). It is expressed in kg per ha.

Statistical analysis:-The statistical method of variance was used for analyzing the data. The data were statistical analyzed by "Analysis of Variance" method prescribed by Panse and Sukhatme (1985). Wherever, the 'F' test was found significant, critical differences (C.D.) were worked out at 5 percent level of probability for the comparison of treated means. The treatment effect have been presented in appropriated tables and illustrated by graph and charts wherever necessary. The treatments consisting of sole cotton and its combination with intercrops are considered for statistical comparison.

RESULTS

An experiment entitled "Effect of legume intercrops on growth, yield and economics of *American* Hybrid cotton under controlled condition" was conducted at the Agriculture farm of Bhagwant University, Ajmer during 2015-16. An investigation was carried out to evaluate the effect of different intercrops in terms of growth and yield performance of *Hybrid* cotton Maruvikash and to find out the economic feasibility of the treatments. The experiment was laid out in Randomized Block Design, replicated thrice with eleven treatments, which comprised of five intercrops i.e. greengram, Clusterbean and cowpea for vegetable purpose and blackgram and soybean for grain purpose. During the course of field experimentation, the observations recorded on plant growth, yield attributes, yield and quality of cotton as influenced by various intercrops were presented and are discussed in this chapter supported with probable, logical reasoning and appropriate evidence.

Cotton:-Crop stand:-The data in respect of initial and final plant stand of cotton crop as influenced by various treatments are presented in Table 9.

TABLE 9: Emergence count and final plant stand of cotton as influenced by different treatments

Treatments	Plant count (ha^{-1})	
	After emergence	Final stand
T_1 - Sole Cotton	53056	51008
T_6- Cotton + greengram (1:1)	53050	50695
T_7 - Cotton + blackgram (1:1)	53071	51011
T_8 - Cotton + soybean (1:1)	54065	51045
T_9 - Cotton + clusterbean (1:1)	53045	51062
T_{10} - Cotton + cowpea (1:1)	53085	51044
S.E.(m)±	407.44	132.14
C.D. at 5 %	NS	NS
General mean	53229	50978

Data revealed that initial and final plant stands were 53229 and 50978, respectively. The various treatments tried under study showed no significant influence on the initial and final plant stands. It means no significantly difference between initial and final plant population. This clearly indicated that the treatment differences observed on various characters studied under investigation are the effect of treatments administered and not due to plant stand.

Growth attributes:-Plant height:-Data on plant height recorded at various stages of crop growth as affected by different treatments are presented in Table 10 and graphically shown in Fig. 3. Plant height increased as the crop advanced in age attaining its maximum values of 71.35 cm at harvest.

TABLE 10: Plant height (cm) of cotton as influenced by different treatments

Treatments	Plant Height (cm)					
	DAE					
	30	60	90	120	150	At Harvest
T_1 - Sole Cotton	17.66	34.80	49.46	57.62	63.45	66.65
T_2 - Sole greengram	----	-----	-----	-----	-----	-----
T_3 - Cotton + Greengram (1:1)	17.55	36.40	48.52	56.65	61.35	65.92
T_4 - Sole blackgram	-----	----	-----	-----	-----	-----
T_5 - Cotton + Blackgram (1:1)	17.62	39.62	46.45	51.35	61.83	66.98
T_6 - Sole soybean	----	-----	----	-----	----	----
T_7 - Cotton + Soybean (1:1)	17.65	34.90	41.51	51.67	60.31	65.06
T_8- sole Clusterbean	-----	-----	----	------	----	-----
T_9 - Cotton + Clusterbean (1:1)	17.00	40.67	59.67	63.04	67.89	71.23
T_{10}- sole cowpea	----	----	-----	------	-----	-----
T_{11} - Cotton + Cowpea (1:1)	17.23	39.47	54.78	60.14	62.45	70.35
S.E.(m)±	0.78	0.74	1.22	0.71	0.62	0.16
C.D. at 5 %	NS	2.32	3.83	2.24	1.96	0.51
General mean	15.40	37.64	50.06	56.75	62.88	67.69

Use of intercrops in cotton significantly affected the mean plant height in all the stages of crop growth except at 30 DAE. At 60 DAE treatments of intercrops cotton+ Clusterbean, cotton+ cowpea and cotton + blackgram being at par exhibited significantly taller plants of cotton than the treatment of intercrop of cotton + cowpea, cotton + soybean, cotton + greengram and sole cotton. At 90, 120, 150 DAE and at harvest treatments of intercrops of cotton + Clusterbean recorded significantly higher plant height than the rest of the treatments. At 90, 120, 150 and at harvest treatment of intercrops of cotton + cowpea stood second position and this treatment was being at par with sole cotton at 120 DAE and sole cotton, cotton + greengram and cotton+ blackgram at 150 DAE. Height of cotton was significantly affected by use of intercrops from 60 DAE to harvest. Treatment of sole cotton recorded significantly lower plant height than treatments of intercrops of greengram, blackgram, soybean, Clusterbean and cowpea (Flowering to boll development stage). Intercrop of cotton + Clusterbean and cotton + cowpea recorded significantly taller plant of cotton over the rest of the treatments of intercrops. However, cotton + soybean recorded lower plant height at most of the stages of cotton plant growth. Satish *et al.* (2012) and Shankarnarayan *et al.* (2012).

Number of monopodial branches per plant:-Data recorded on mean number of monopodial branches per plant on 60 and 90 DAE as influenced by different treatments are presented in Table 11.

TABLE 11: Number of monopodial branches plant^{-1} of cotton as influenced by different treatments

Treatments	Number of monopodial branches plant-1	
	Days After Emergence	
	60	90
T1 - Sole Cotton	1.20	2.40
T2 - Sole greengram	----	----
T3 - Cotton + Greengram (1:1)	1.26	2.00
T4 - Sole blackgram	-----	----
T5 - Cotton + Blackgram (1:1)	1.30	1.65
T6 - Sole soybean	-----	----
T7 - Cotton + Soybean (1:1)	1.00	1.66
T8- sole clusterbean	-----	----
T9 - Cotton + Clusterbean (1:1)	1.58	1.66
T10- sole cowpea	-----	----
T11 - Cotton + Cowpea (1:1)	1.34	1.67
S.E.(m)±	0.17	0.16
C.D. at 5 %	NS	NS
General mean	1.28	1.84

It is revealed that there was no significant difference between number of monopodial at 60 and 90 days. The result was found no significant by the effect of various treatments.

Number of sympodial branches per plant:-Mean number of sympodial branches per plant as influenced by different treatments at various growth stages is shown in Table 12.

TABLE 12: Number of sympodial branches plant^{-1} of cotton as influenced by different treatment

Treatments	Number of sympodial branches plant^{-1}				
	DAE				
	60	90	120	150	At Harvest
T_1 - Sole Cotton	11.00	11.90	13.00	14.91	15.30
T_2 - Sole greengram	----	----	---	----	----
T_3 - Cotton + Greengram (1:1)	10.91	11.45	12.67	13.65	14.35
T_4 - Sole blackgram	-----	----	----	----	----
T_5 - Cotton + Blackgram (1:1)	10.65	11.48	12.55	13.29	14.56
T_6 - Sole soybean	----	----	----	----	-----
T_7 - Cotton + Soybean (1:1)	11.12	11.66	12.45	13.25	14.50
T_8- sole Clusterbean	----	----	-----	-----	----
T_9 - Cotton + Clusterbean (1:1)	9.56	10.38	11.87	13.15	14.48
T_{10}- sole cowpea	---	----	----	----	----
T_{11} - Cotton + Cowpea (1:1)	10.85	11.76	12.80	13.30	14.66
S.E.(m)±	0.14	0.17	0.15	0.12	0.26
C.D. at 5 %	0.51	0.50	0.41	0.42	0.87
General mean	10.68	11.43	12.53	13.59	14.64

The mean number of sympodial branches per plant increased continuously up to harvest. At 60, 90 and 120 DAE, treatments of sole cotton, cotton + greengram, cotton + blackgram, cotton + Clusterbean and cotton + cowpea intercrops were being at par showed significantly higher number of sympodial branches per plant over treatment of intercrop cotton + soybean. Numbers of sympodial branches at harvest were more in treatment of sole cotton than other treatments of intercrop. The lesser number of sympodial branches per plant in the treatment plots of intercrop were due to competition of these intercrops for growth factors along with the crop of cotton. These results are in conformity with the work of Hallikeri *et al.* (2005) and Shrivastava *et al.* (2010) however, numbers of branches per plant were relatively higher in sole cotton than cotton intercropped with greengram, blackgram, soybean, Clusterbean and cowpea. Cotton + soybean intercropping recorded were at par with each other.

Number of functional leaves per plant:-Mean number of functional leaves per plant increased progressively up to 120 DAE and reduced thereafter towards maturity because of leaf senescence. Maximum number of leaves per plant at the average rate of 56.96 was observed at 120 DAE. Treatment T_1 sole cotton recorded higher no. of sympodial branches the rest of treatments. At 60 and 90 days the treatment of intercrop (sole cotton) gave significantly higher number of leaves over other treatments of intercrops with cotton. However, At 120 DAE, treatments of sole cotton and cotton + cowpea intercrop recorded higher number of functional leaves per plant over all other treatments. Thus, cropping system through intercrop was successful as components in the system have different nutrients and moisture requirement, varied feeding zones in the soil profile, differential growth duration for enabling the utilization of natural resources optimally. However, inconsistent trend of the results as regards functional leaves was observed due to different intercrops. These results are in line of work reported by Wankhade *et al.* (2000), Kalyankar (2001) and Sankaranarayanan *et al.* (2011).

TABLE 13: Number of functional leaves plant^{-1} of cotton as influenced by different treatments

Treatments	Number of functional leaves plant^{-1}					
	DAE					
	30	60	90	120	150	At Harvest
T_1 - Sole Cotton	5.90	36.81	54.13	58.78	57.01	47.50
T_2 - Sole greengram	-----	----	-----	-----	----	-----
T_3 - Cotton + Greengram (1:1)	4.95	33.21	42.63	55.56	55.58	45.59
T_4 - Sole blackgram	----	----	-----	-----	----	-----
T_5 - Cotton + Blackgram (1:1)	6.16	32.19	44.13	54.98	54.90	45.95
T_6 - Sole soybean	----	----	----	----	----	----
T_7 - Cotton + Soybean (1:1)	6.73	30.20	39.32	54.60	51.92	45.25
T_8- sole Clusterbean	----	----	----	----	----	-----
T_9 - Cotton + Clusterbean (1:1)	5.89	33.10	47.87	54.03	56.00	43.98
T_{10}- sole cowpea	----	-----	-----	-----	-----	----
T_{11} - Cotton + Cowpea (1:1)	6.10	34.89	50.23	56.96	54.56	46.11
S.E.(m)±	0.24	0.40	0.58	0.42	0.31	0.32
C.D. at 5 %	NS	1.30	1.67	1.39	1.01	1.10
General mean	5.95	33.40	46.38	55.81	54.92	45.73

Leaf area per plant:-The data recorded in respect of leaf area per plant as influenced by different treatments periodically is presented in Table 14.

TABLE 14: Leaf area plant^{-1} (cm^2) of cotton as influenced by different treatments

Treatments	Leaf area plant^{-1} (cm^2)					
	DAE					
	30	60	90	120	150	At Harvest
T_1 - Sole Cotton	114.87	1190.33	1693.33	1998.20	1668.77	1390.57
T_2 - Sole greengram	-----	-----	-----	-----	----	----
T_3 - Cotton + Greengram (1:1)	113.90	1050.37	1654.23	1850.30	1656.67	1434.33
T_4 - Sole blackgram	----	----	----	----	-----	-----
T_5 - Cotton + Blackgram (1:1)	115.00	1045.57	1610.67	1856.57	1598.33	1390.40
T_6 - Sole soybean	----	-----	----	-----	-----	----
T_7 - Cotton + Soybean (1:1)	113.20	890.67	1447.20	1832.67	1674.67	1443.33
T_8- sole Clusterbean	-----	-----	-----	-----	-----	----
T_9 - Cotton + Clusterbean (1:1)	117.25	1088.67	1667.00	1862.00	1647.33	1468.00
T_{10}- sole cowpea	----	-----	----	----	----	----
T_{11} - Cotton + Cowpea (1:1)	116.93	1084.00	1652.33	1845.67	1644.00	1434.33
S.E.(m)±	2.99	27.33	28.32	21.23	13.91	27.00
C.D. at 5 %	NS	87.25	92.44	63.98	NS	NS
General mean	115.19	1058.26	1348.15	1874.23	1659.78	1426.82

The leaf area per plant increased progressively with progressive age of the crop up to 120 days. At 120 DAE, the mean maximum leaf area was 1874.23 cm^2 per plant, later on it was declined. At 60 and 90 DAE, treatment of sole cotton recorded significantly maximum leaf area per plant over other treatments. Treatments of no intercrop (sole cotton) and intercrop with cotton + greengram, cotton + blackgram, cotton + Clusterbean and cotton+ cowpea were being at par exhibited greater leaf area over the treatments intercrop of soybean. At 120 DAE, treatments of sole cotton recorded significantly higher leaf area plant^{-1} over rest of the treatments. However, intercrop of greengram/ blackgram/ soybean/ Clusterbean and cowpea were found equally effective. Leaf area increased progressively from 60 DAS to 120 DAS and declined thereafter. Increase in leaf area of cotton with the treatment of sole cotton might be due to no competition of intercrops for various growth factors.

Leaf area index:-Data relating to leaf area index as influenced by different treatments are presented in Table 15 and depicted in Fig. 7. Leaf area index increased from 30 DAE to 120 DAE and declined thereafter. The maximum value of LAI was recorded at 120 DAE and it was to the tune of 1.04.

TABLE 15: Leaf area index plant^{-1} of cotton as influenced by different treatments

Treatments	Leaf area index plant^{-1}					
	DAE					
	30	60	90	120	150	At Harvest
T_1 - Sole Cotton	0.07	0.77	0.99	1.20	0.99	0.76
T_2 - Sole greengram	----	----	-----	-----	----	----
T_3 - Cotton + Greengram (1:1)	0.07	0.67	0.90	1.0	0.90	0.81
T_4 - Sole blackgram	----	----	----	---	----	---
T_5 - Cotton + Blackgram (1:1)	0.07	0.59	0.89	1.00	0.92	0.79
T_6 - Sole soybean	----	-----	----	----	----	----
T_7 - Cotton + Soybean (1:1)	0.07	0.56	0.89	1.04	0.91	0.79
T_8- sole clusterbean	----	----	-----	----	----	-----
T_9 - Cotton + Clusterbean (1:1)	0.07	0.59	0.91	1.04	0.90	0.80
T_{10}- sole cowpea	----	-----	----	----	----	----
T_{11} - Cotton + Cowpea (1:1)	0.07	0.60	0.92	1.04	0.93	0.80
S.E.(m)±	0.001	0.02	0.02	0.01	0.01	0.01
C.D. at 5 %	NS	0.05	0.05	0.04	NS	NS
General mean	0.07	0.63	0.91	1.05	0.92	0.79

At 60 and 90 DAE, treatment of sole cotton recorded significantly maximum leaf area index per plant over other treatments. Treatments of intercrops, with cotton + greengram, cotton + blackgram, cotton + Clusterbean and cotton + cowpea were being at par exhibited greater leaf area over the treatment of intercrop of cotton + soybean.

Total dry matter accumulation:-Data recorded on the total dry matter per plant as influenced by different treatments periodically are shown in Table 16 and depicted in Fig. 8.

Total dry matter per plant increased progressively and reached to its maximum of **75.65, 74.82** and **69.65**g at 120, 150 DAE and at harvest, respectively. At 60 DAE, the treatment of sole cotton resulted in higher production of total dry matter per plant and being at par with the treatments of cotton + greengram and cotton + Clusterbean. Treatments of intercrop of cotton + greengram, cotton + blackgram and cotton + cowpea were being at par exhibited significantly larger accumulation of total dry matter per plant over the treatments of intercrop of cotton + soybean. In general sole cotton or no intercrop treatment resulted in greater production of dry matter per plant in cotton mostly at all the stages of growth, increase in total dry matter production per plant in the plots of sole cotton attributed to no competition to growth factor except cotton itself.

TABLE 16: Total dry matter accumulation plant^{-1} (g) of cotton as influenced by different treatments

Treatments	Total Dry Matter Accumulation (g)					
	DAE					
	30	60	90	120	150	At Harvest
T_1 - Sole Cotton	4.10	18.96	44.00	78.20	76.10	71.20
T_2 - Sole greengram	----	-----	-----	-----	-----	----
T_3 - Cotton + Greengram (1:1)	2.85	17.50	42.40	76.89	74.40	69.77
T_4 - Sole blackgram	-----	----	----	----	-----	----
T_5 - Cotton + Blackgram (1:1)	2.87	17.27	42.09	76.80	74.51	69.77
T_6 - Sole soybean	----	-----	-----	----	----	----
T_7 - Cotton + Soybean (1:1)	2.85	15.48	36.53	68.84	74.54	66.33
T_8- sole clusterbean	----	----	----	----	----	----
T_9 - Cotton + Clusterbean (1:1)	3.10	18.87	41.79	76.29	74.62	70.85
T_{10}- sole cowpea	----	----	----	----	----	----
T_{11} - Cotton + Cowpea (1:1)	3.10	17.04	41.41	76.90	74.80	70.00
S.E.(m)+	0.12	0.57	0.88	0.56	0.63	0.68
C.D. at 5 %	NS	1.90	3.00	1.87	1.99	2.10
General mean	3.14	17.52	41.37	75.65	74.82	69.65

Treatment of sole cotton was found at par with the treatments of intercrop of greengram/ blackgram/ clusterbean/ cowpea. This might be ascribed to shorter duration of intercrops of greengram, blackgram, clusterbean and cowpea coupled with initial slow growth rate of cotton and finally compensation of growth in cotton after harvesting of these intercrops. The treatment of intercrop of cotton + soybean reduced the total dry matter production effectively in cotton and this is attributed to severe competition of soybean intercrop for various growth factors and thereby reduction in total dry matter production of cotton. Such type of impact of sole cotton (no intercrop) and intercrops with cotton was reported by workers like Wankhade *et al.* (2000) and Deoche (2001) *at* Akola, Kalyankar (2001) at Parbhani and Hallikeri *et al.* (2005) at Dharwad reported that dry matter accumulation per plant was maximum in sole cotton than intercropping system.

Yield Attributes:-Data in respect of number of bolls picked per plant, boll weight and seed cotton yield per plant as affected by different treatments are presented in Table 17 and shown in Fig. 9a, 9b and 9c.

Number of picked bolls per plant:-The mean number of bolls harvested per plant, during the year of experimentation was 8.44. Treatments of sole cotton recorded significantly higher number of picked bolls per plant than rest of the treatments. Treatment cotton+ cowpea was in second position in no. of bolls per plant. Treatments of different cotton + intercrops were being at par produced comparable number of picked bolls per plant.

Boll weight:-The Mean boll weight was (2.85g), the boll weight was not affected significantly due to different treatments of intercrop (Table 17).

Seed cotton yield per plant:-Mean seed cotton yield per plant was (23.99g). Treatment of sole cotton resulted in higher production of seed cotton yield per plant over other treatments.

TABLE 17: Number of picked bolls plant^{-1}, boll weight and seed cotton yield plant^{-1} of cotton as influenced by different treatments

Treatments	Number of picked bolls plant^{-1}	Boll weight (g)	Seed cotton yield plant^{-1} (g)
T_1 - Sole Cotton	9.0	2.85	25.65
T_2 - Sole greengram	----	----	----
T_3 - Cotton + Greengram(1:1)	8.40	2.85	23.85
T_4 - Sole blackgram	----	----	----
T_5 - Cotton + Blackgram(1:1)	8.60	2.86	23.80
T_6 - Sole soybean	----	----	----
T_7 - Cotton + Soybean(1:1)	7.47	2.86	21.35
T_8- sole clusterbean	----	----	----
T_9 - Cotton + Clusterbean (1:1)	8.46	2.86	24.40
T_{10}- sole cowpea	-----	----	----
T_{11} - Cotton + Cowpea (1:1)	8.75	2.86	24.90
S.E.(m)+	0.19	0.02	0.51
C.D. at 5 %	0.55	NS	1.61
General mean	8.44	2.85	23.99

Treatment of sole cotton recorded significantly higher values for yield attributes namely number of picked bolls per plant and seed cotton yield per plant. But the treatments of different intercrops were found being at par, Lowest yield attributes recorded with the treatment of intercrop of soybean. The components vegetable intercrops *viz.*, greengram, clusterbean and cowpea were harvested with in 60, 63 and 64 days, respectively. However, components grain crops blackgram and soybean were harvested in 76 and 106 days. Due to wider row spacing of cotton 90 x 20 cm and different intercrops, none of the above crops competed with the main crop of cotton during the growth and development. As a result, almost statistically similar growth characters and yield

attributes were recorded in cotton under intercrop systems. Thus, cropping system through intercrop was successful as a components in the system have different nutrient and moisture requirement, varied feeding zones in the soil profile, differential growth duration for enabling the utilization of natural resources optimally. Number of bolls plant^{-1}, seed cotton yield plant^{-1} was highest in sole cotton than intercropped with greengram, blackgram, soybean, vegetables likes Clusterbean, potato, garlic, cowpea, etc. as well as weight of seed cotton per boll was not significantly influenced by intercropping also reported by the Wankhade *et al*. (2000), Deoche (2001), Khan *et al*. (2001), Sanjay *et al.* (2003), Halemani *et al*. (2004), Venkataraman (2008), Shrivastava *et al.* (2010) Satish *et al.* (2012) and Khargkharate *et al*. (2014).

Yield Studies:-Data on seed cotton yield, stalk yield, biological yield and harvest index as influenced by different treatments are shown in Table 18 and graphical depicted in Fig. 10a, 10b, 10c and 10d.

Seed cotton yield:-The average seed cotton yield per hectare was **1196** kg ha^{-1}. Treatment of sole cotton recorded significantly higher seed cotton yield (**1350** kg ha^{-1}). However, treatments of various intercropping system, cotton + Clusterbean (1:1) recorded significantly higher seed cotton yield (**1249** kg ha^{-1}) and found being at par with rest of the treatments of intercropping

TABLE 18: Seed cotton yield, stalk yield, biological yield (kg ha^{-1}) and harvest index as influenced by various treatments

Treatments	Seed cotton yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest Index (%)
T_1 - Sole Cotton	1350	1945	3270	41.45
T_2 - Sole greengram	-	-	-	-
T_3 - Cotton + Greengram (1:1)	1150	1345	2468	45.26
T_4 - Sole blackgram	-	-	-	-
T_5 - Cotton + Blackgram (1:1)	1135	1357	2445	44.58
T_6 - Sole soybean	-	-	-	-
T_7 - Cotton + Soybean (1:1)	1086	1271	2265	46.61
T_8- sole clusterbean	-	-	-	-
T_9 - Cotton + Clusterbean (1:1)	1249	1417	2557	47.12
T_{10}- sole cowpea	-	-	-	-
T_{11} - Cotton + Cowpea (1:1)	1212	1454	2586	46.98
S.E.(m)+	42.5	119.6	78.22	1.45
C.D. at 5 %	131	370	229	4.36
General mean	1196	1464.83	2598.5	45.33

Treatments of intercrops of greengram, blackgram, clusterbean and cowpea were found equally effective in recording higher seed cotton yield. This might be attributed to the uniform duration of these intercrops. Soybean was found exhaustive intercrop than greengram, blackgram, clusterbean and cowpea intercrops due to its, longer duration and higher yield potential and ultimately it resulted into low productivity of seed cotton yield in the treatment plot of intercrop of soybean. These results are in the line of work reported by Prasad *et al.* (2000), Wankhade *et al*. (2000), Deoche (2001), Kalyankar (2001), Khan *et al*. (2001) Sanjay *et al.* (2003), Halemani *et al*. (2004) Khan and Khaliq (2004) Nandini and Chellamuthu (2004), Rami Reddy (2005), Hallikeri *et al.* (2007), Rekha *et al*. (2008), Mankar and Nawlakhe (2009), Sankaranarayanan *et al.* (2012) and Khargkharate *et al*. (2014) cotton intercropped with *kharif* legumes *viz.*, pigeonpea, soybean, greengram, blackgram clusterbean and found significant reductions in seed cotton yield ha^{-1} was recorded due to all intercropping treatments over sole cotton.

Stalk yield:-Stalk yield per hectare was 1464.98 kg ha^{-1} (Table 18). Treatments of sole cotton recorded significantly higher stalk yield per hectare (1945 kg ha^{-1}) over other treatments. Treatment of intercrop of cowpea ranked second position (1454 kg ha^{-1}) and was found being at par with the treatments of intercrop of cotton + greengram, cotton + blackgram, cotton + soybean, cotton + clusterbean and cotton + soybean. Enhanced cotton stalk yield per hectare was observed in the treatment plots of sole cotton. This might be ascribed to the increased growth attributes due to no competition for growth factors with the cotton. However, there was a reduction in stalk yield of cotton in the treatment plot of intercrop of soybean due to its exhaustive nature. These results are in the line of work reported by Wankhade *et al*. (2000) Kalyankar (2001), Sanjay *et al.* (2003), Kote *et al.* (2005[a]) and Khargkharate *et al*. (2014).

Biological yield:-Biological yield of cotton was 2598 kg ha^{-1} (Table 18). Treatment of sole cotton (3270 kg ha$^{-1)}$ recorded significantly higher biological yield per hectare over rest of the treatments cotton + intercrops. Treatments of intercrop cotton + Clusterbean, cotton + cowpea, cotton + greengram and cotton + blackgram were being at par with each other and found superior than the intercrop of cotton + soybean. Reduction in biological yield of cotton in the treatment plot of soybean due to its exhaustive nature. These results are in the line of work reported by Nandini and Chellamuthu (2004) reported that biological yield was highest in sole crop of cotton which was significantly higher than that of the intercropped. Similarly, Rekha *et al*. (2008) reported that, intercropping system of cotton + greengram (1:1) out yielded highest biological yield. This might be due to less competition in greengram due to short crop duration.

Harvest index:-Harvest index of cotton was 45.33 per cent (Table 18). Treatment of intercrop cotton + Clusterbean recorded significantly maximum harvest index than sole cotton and found being at par with the treatments of intercrop of cotton + greengram, cotton + blackgram, cotton + soybean and cotton + cowpea. Intercrop reduced harvest index than sole cotton also reported by Kalyankar (2001).However, Nandini and Chellamuthu (2004) reported that harvest index was highest in sole crop of cotton which was significantly higher than that of the intercropped. Sree Rekha *et al.*

(2008) reported that, intercropping system of cotton + greengram (1:1) recorded highest harvest index. This might be due to less competition in greengram due to short crop duration.

Seed cotton equivalent yield:-Data on seed cotton equivalent yield as influenced by various treatments are shown in Table 19 and graphically presented in Fig. 11. Average seed cotton equivalent yield was 1574 kg ha^{-1}.

TABLE 19: Seed cotton equivalent yield (kg ha^{-1}) as influenced by different treatments

Treatments	Seed cotton yield (kg ha^{-1})	Intercrop yield (kg ha^{-1})	Seed cotton equivalent yield (kg ha^{-1})
T_1 - Sole Cotton	1350	----	1350
T_2 - Sole greengram	----	2167	910
T_3 - Cotton + Greengram (1:1)	1150	872	885
T_4 - Sole blackgram	----	535	1005
T_5 - Cotton + Blackgram (1:1)	1135	314	1504
T_6 - Sole soybean	----	1191	1510
T_7 - Cotton + Soybean (1:1)	1086	492	1524
T_8- sole clusterbean	----	3443	1540
T_9 - Cotton + Clusterbean (1:1)	1249	2000	1511
T_{10}- sole cowpea	----	3566	2040
T_{11} - Cotton + Cowpea (1:1)	1212	2100	2017
S.E.(m)±	42.25	----	49.10
C.D. at 5 %	131	-----	140.1
General mean	1196	----	1574

Treatments of intercrop cotton + cowpea and cotton + clusterbean were being at par recorded significantly higher seed cotton equivalent yield than the rest of the treatments. In general the trend of cotton seed equivalent yield in different treatments plots of intercrop was consistent However, seed cotton equivalent yield was increased due to different intercrops over sole crop of cotton. The maximum values of seed cotton equivalent yield were noticed with the treatment of intercrops of cowpea and clusterbean. This is attributed to better productivity of variety maruvikash of cotton and intercrops of cowpea and cluterbean and their remunerative market prices. When cotton intercropped with blackgram, greengram soybean, clusterbean, etc. the highest average seed cotton yield equivalent was recorded in intercropping system than sole cotton also reported by the workers by Prasad *et al.* (2000) at New Delhi, Chellaiah and Gopalswamy (2001) at Srivilliputtur (T.N.), Kalyankar (2001) at Parbhani, Nandini and Chellamuthu (2004) at Dharwad, Venkataraman, (2008) at Kovilpatti (T.N.).

Land equivalent ratio:-Data on land equivalent ratio as influenced by different treatments is tabulated in Table 20. The average land equivalent ratio was recorded (1.19).

TABLE 20: Land equivalent ratio as influenced by different treatments

Treatments	Land Equivalent Ratio
T_1 - Sole Cotton	1.00
T_2 - Sole greengram	1.00
T_3 - Cotton + Greengram (1:1)	1.00
T_4 - Sole blackgram	1.00
T_5 - Cotton + Blackgram (1:1)	1.00
T_6 - Sole soybean	1.00
T_7 - Cotton + Soybean (1:1)	1.20
T_8- sole clusterbean	1.31
T_9 - Cotton + Clusterbean (1:1)	1.23
T_{10}- sole cowpea	1.45
T_{11} - Cotton + Cowpea (1:1)	1.45
S.E.(m)±	0.05
C.D. at 5 %	0.13
General mean	1.19

Treatments of intercrops of cotton + Clusterbean and cotton + cowpea were being at par recorded greater values of land equivalent ratio and significantly superior than rest of the intercropping treatments of cotton + greengram, cotton + soybean and cotton + blackgram. Treatment of intercrop cotton + blackgram and cotton + greengram stood third and fourth position. However, cotton + greengram and cotton + blackgram and cotton + soybean were being at par than sole cotton and recorded lowest value of land equivalent ratio.

Economics:-Data on gross monetary returns, net monetary returns and benefit: cost ratio as influenced by various treatments are shown in Table 21 and graphically presented in Fig. 13a, 13b and 13c.

TABLE 21: GMR, NMR and B: C ratio of cotton as influenced by various treatments

Treatments	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C ratio
T_1 - Sole Cotton	55940	23606	1.73
T_2 - Sole greengram	40080	18933	1.65
T_3 - Cotton + Greengram (1:1)	63530	27909	1.78
T_4 - Sole blackgram	28860	13005	1.82
T_5 - Cotton + Blackgram (1:1)	63608	30889	1.94
T_6 - Sole soybean	54846	24147	1.78
T_7 - Cotton + Soybean (1:1)	67518	32300	1.91
T_8- sole Clusterbean	63210	29180	1.85
T_9 - Cotton + Clusterbean (1:1)	88074	46160	2.10
T_{10}- sole cowpea	65435	29823	1.83
T_{11} - Cotton + Cowpea (1:1)	88400	46164	2.09
S.E.(m) $\pm$	1940	1967	-----
C.D. at 5 %	5456	5567	-----
General mean	61712	29383	1.86

Gross monetary returns:-Average gross monetary returns were Rs. 61712/- ha^{-1}. Treatments of intercrop of cotton + cowpea and cotton + Clusterbean were being at par and significantly superior then the rest of treatments. Gross monetary returns are enhanced due to taking of intercrop with cotton. Use of Clusterbean and cowpea as a intercrop in cotton did not reduced the productivity of cotton at remunerative levels. However, taking of greengram, blackgram and soybean as a intercrops with cotton slightly reduced the productivity of cotton. Increased productivity of cotton with additional yield of intercrops helped in increasing gross monetary returns over treatment of no intercrop with cotton. Gross monetary returns recorded higher in cotton + intercrops of cowpea and Clusterbean was grown for vegetable purpose and the market price was higher. Reported by the Lakhdive *et al.* (2000), Nikam *et al*. (2000), Wankhade *et al*. (2000), Maitra *et al*. (2001), Nandini and Chellamuthu (2004), Hallikeri *et al.* (2007), Asewar *et al.* (2008), Venkataraman (2008) and Khargkharate *et al*. (2014) for greengram, blackgram, soybean, Clusterbean crops.

Net monetary returns:-Average net monetary returns were Rs. 29383/- ha^{-1}. Treatments of intercrop of cotton + cowpea and cotton + clusterbean were being at par recorded significantly higher net monetary returns over the rest of the treatments. Increased net monetary returns with the treatment of intercrops of cotton + cowpea and cotton + Clusterbean are due to the increased values of seed cotton equivalent yield. Generally intercropping was found to be more remunerative than sole crop also reported by Chellaiah and Gopalswamy (2001), Kalyankar (2001) and Maitra *et al*. (2001), Hallikeri *et al.* (2007), Asewar *et al.* (2008) and Venkataraman (2008) and Khargkharate *et al*. (2014).

Benefit: cost ratio:-The average B:C ratio was recorded (1.86). Intercropping of and cotton + clusterbean cotton + clusterbean and cotton + clusterbean cotton + cowpea registered greater values of B:C ratio i.e. 2.10 and 2.09, respectively. The treatment of cotton + soybean stood third position. Chellaiah and Gopalswamy (2001), Deoche (2001), Nandini and Chellamuthu (2004), Nawlakhe *et al.* (2010) and Sankaranarayanan *et al.* (2011) reported that among intercropping treatments cotton + intercrops recorded higher B:C ratio than sole cotton.

Quality Studies:-Data on quality studies like Ginning percentage, seed index, lint index and earliness index as influenced by different treatments are tabulated in Table 22.

Ginning percentage:-Ginning percentage in cotton was 40.80%. Treatments of intercrops tried under study did not reach to the level of significance.

TABLE 22: Ginning percentage, seed index and lint index as influenced by different treatments

Treatments	Ginning percentage	Seed index	Lint Index
T_1 - Sole Cotton	41.7	9.47	5.76
T_3 - Cotton + greengram (1:1)	41.6	9.43	5.84
T_5 - Cotton + blackgram (1:1)	41.4	9.42	5.71
T_7 - Cotton + soybean (1:1)	41.5	9.37	5.71
T_9 - Cotton + Clusterbean (1:1)	41.6	9.43	5.84
T_{11} - Cotton + cowpea (1:1)	41.3	9.47	5.72
S.E.(m)$\pm$	0.35	0.07	0.08
C.D. at 5 %	NS	NS	NS
General mean	41.51	9.43	5.76

Seed index:-Seed index of cotton (Table 22) was 9.43 g. The treatments differences were not significant in respect of the seed index.

Lint index:-Lint index of cotton (Table 22) was (5.76). Treatments of sole cotton and cotton + intercrops were found to be not significant.

Intercrops:-Crop stand:-The data in respect of initial and final plant stand of intercrops greengram, blackgram; soybean, Clusterbean and cowpea as influenced by various treatments are presented in Table 23.

TABLE 23: Emergence count and final plant stand of intercrops as influenced by the different treatments

Treatments	Plant count (%)	
	After emergence	Final stand
Intercrops		
T_2 - Sole greengram	96.56	90.45
T_3 - Cotton + greengram (1:1)	96.58	90.46
GM	96.57	90.45
T_4 - Sole blackgram	95.59	89.47
T_5 - Cotton + blackgram (1:1)	95.25	89.36
GM	95.42	89.41
T_6 - Sole soybean	93.25	88.89
T_7 - Cotton + soybean (1:1)	93.75	89.05
GM	93.50	88.97
T_8 – Sole clusterbean	94.88	89.73
T_9 - Cotton + clusterbean (1:1)	96.87	89.54
GM	95.87	89.63
T_{10} - Sole cowpea	96.67	87.81
T_{11} - Cotton + cowpea (1:1)	96.69	87.22
GM	96.68	87.51

Data revealed that initial and final plant stands expressed in per cent were 96.68 and 87.51. The various treatments tried under study showed no significant influence on the initial and final plant stands. This clearly indicated that the treatment differences observed on various characters studied under investigation are the effect of treatments administered and not due to plant stand.

Growth attributes:- Plant height:-Data on plant height recorded at various stages of crop growth as affected by different treatments are presented in Table 24. Plant height increased as the crop advanced in age, attaining its maximum values at harvest.

TABLE 24: Plant height (cm) of intercrops as influenced by different treatments

Treatments	Plant height (cm)		
	30	60	At harvest
Intercrops			
T_2 - Sole greengram	20.30	39.32	38.25
T_3 - Cotton + greengram (1:1)	20.60	41.47	39.76
GM	20.45	40.39	39.05
T_4 - Sole blackgram	21.21	43.01	42.55
T_5 - Cotton + blackgram (1:1)	21.75	43.56	42.65
GM	21.48	43.58	42.10
T_6 - Sole soybean	22.23	44.35	43.76
T_7 - Cotton + soybean (1:1)	22.80	45.26	46.53
GM	22.51	44.80	45.64
T_8 – Sole clusterbean	20.24	53.50	52.89
T_9 - Cotton + clusterbean (1:1)	20.83	54.89	53.76
GM	20.53	54.19	54.82
T_{10} - Sole cowpea	20.42	46.41	45.90
T_{11} - Cotton + cowpea (1:1)	20.51	46.94	46.76
GM	20.46	46.67	46.33

Treatment of sole intercrops recorded lower plant height than treatments of intercrops of cotton + greengram/ blackgram/ soybean/ Clusterbean and cowpea. At 60 DAE and at harvest, among all intercrops treatments cotton + Clusterbean recorded higher plant height than the rest of treatments.

Number of branches per plant:-Data recorded on mean number of branches per plant on 30 60 DAE and at harvest as influenced by different treatments are presented in Table 29.

It is revealed that there was increase in mean number of branches at 30, 60 DAE and at harvest. Number of branches per plant was affected due to different treatments and increased continuously up to harvest. Number of branches at harvest was more in treatment of cotton+ intercrops than other treatments of sole intercrop. The higher number of branches per plant in the treatment plots of cotton + intercrop was due to competition of these intercrops for growth factors along with the crop of cotton.

Total dry matter accumulation:-Data recorded on the total dry matter per plant as influenced by different treatments are shown in Table 25.

TABLE 25: Number of branches plant^{-1} of intercrops as influenced by different treatments

Treatments	Number of branches plant^{-1}		
	30	60	At harvest
Intercrops			
T_2 - Sole greengram	1.84	2.89	2.90
T_3 - Cotton + greengram (1:1)	1.86	3.65	3.67
GM	1.86	3.21	3.28
T_4 - Sole blackgram	1.88	2.75	2.96
T_5 - Cotton + blackgram (1:1)	1.92	3.27	3.45
GM	1.88	3.07	3.12
T_6 - Sole soybean	2.64	4.78	4.68
T_7 - Cotton + soybean (1:1)	2.75	5.98	5.89
GM	2.69	5.27	5.35
T_8 – Sole clusterbean	2.67	5.66	5.65
T_9 - Cotton + clusterbean (1:1)	2.74	6.25	6.18
GM	2.60	5.88	5.95
T_{10} - Sole cowpea	2.64	6.10	6.17
T_{11} - Cotton + cowpea (1:1)	2.78	6.68	6.67
GM	2.24	6.32	6.40

TABLE 26: Total dry matter accumulation plant^{-1} (g) of intercrops as influenced by different treatments

Treatments	Total dry matter accumulation plant^{-1} (g)		
	30	60	At harvest
Intercrops			
T_2 - Sole greengram	6.56	13.45	14.45
T_3 - Cotton + greengram (1:1)	5.89	10.90	14.76
GM	6.22	12.17	14.60
T_4 - Sole blackgram	6.74	13.34	18.29
T_5 - Cotton + blackgram (1:1)	5.67	11.82	15.37
GM	6.20	12.58	16.83
T_6 - Sole soybean	6.45	14.76	35.29
T_7 - Cotton + soybean (1:1)	6.42	12.67	28.19
GM	6.43	13.71	31.74
T_8 – Sole Clusterbean	6.75	29.54	36.77
T_9 - Cotton + Clusterbean (1:1)	6.77	26.65	30.89
GM	6.76	28.09	33.83
T_{10} - Sole cowpea	6.65	23.75	30.23
T_{11} - Cotton + cowpea (1:1)	6.53	20.80	27.39
GM	6.59	22.27	28.81

TABLE 27: Number of pods, yield per plant, grain/green pods yield and straw yield of intercrops as influenced by different treatments

Treatments	Yield attributes of intercrops			
	Number of pods	Yield per plant	Grain/ Green pods yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Intercrops				
T_2 - Sole greengram	12.33	5.78	2167	859
T_3 - Cotton + greengram (1:1)	12.08	5.61	872	550
GM	12.20	5.69	1519	704.50
T_4 - Sole blackgram	7.42	2.07	535	832
T_5 - Cotton + blackgram (1:1)	6.67	2.04	314	435
GM	7.04	2.05	424	633
T_6 - Sole soybean	28.00	5.67	1191	1001
T_7 - Cotton + soybean (1:1)	27.67	5.90	492	534
GM	27.83	5.78	842	767.50
T_8 – Sole Clusterbean	35.34	25.12	3443	989
T_9 - Cotton + clusterbean (1:1)	34.00	24.75	2000	558
GM	34.67	24.93	2721.65	773.50
T_{10} - Sole cowpea	32.67	25.90	3566	998
T_{11} - Cotton + cowpea (1:1)	33.00	24.76	2100	535
GM	32.83	25.33	2833	768

At 30 DAE treatments differences between sole intercrops and cotton + intercrops more or less equal. However, 60 DAE and at harvest treatments of sole intercrop (greengram/ blackgram/ soybean/ Clusterbean/ cowpea) were exhibited larger accumulation of total dry matter per plant. In general sole intercrop treatment resulted in greater production of dry matter per plant in mostly at all the stages of growth Increase in total dry matter production per plant in the plots of sole intercrops attributed to no competition to growth factor except intercrops itself.

Yield attributes:-Data in respect of numbers of pods per plant, yield per plant, grain/ green pods yield and straw yield per hectare as affected by different treatments are presented in Table 31.

Number of pods per plant:-Data in respect of mean number of pods per plant is presented in Table 31. Sole treatments were recorded significantly higher number of pods plant^{-1} than intercrop treatments.

Yield per plant:-Treatment of sole intercrops recorded higher values for yield attributes namely number of pods per plant and yield per plant. Due to wider row spacing of cotton 90 x 20 cm and different intercrops, none of the above crops competed with the main crop of cotton during the growth and development. Thus, cropping system through intercrop was successful as a components in the system have different nutrient and moisture requirement, varied feeding zones in the soil profile, differential growth duration for enabling the utilization of natural resources optimally.

Yield Studies:-Data on intercrops yield and straw yield as influenced by different treatments are shown in (Table 31).Treatments of sole intercrop recorded higher grain yield/ green pods and straw yield per hectare over other treatments of cotton + intercrops. Due to wider row spacing of cotton 90 x 20 cm and duration of the different intercrops, none of the above crops competed with the main crop of cotton during the growth and development. Treatments of intercrops of greengram, blackgram, soybean, clusterbean and cowpea were found equally effective in recording higher yield as per their productivity either in sole or intercropping system. Reduction in intercrops yield of greengram/ blackgram/ soybean/ Clusterbean and cowpea can be attributed to less number of plants per unit area than sole cropping system.

CONCLUSION

The results of present experimentation are summarized and concluded in brief in this chapter. The field experiment entitled "Effect of legume intercrops on growth, yield and Economics of American hybrid cotton under controlled condition" was conducted during kharif seasons of 2015-16 at the Agriculture farm of Bhagwant University, Ajmer (Rajasthan). The soil of experimental plot was clayey in texture, slightly alkaline in reaction, medium in organic carbon and in available nitrogen and low in available phosphorus but having fairly rich status of available potassium. The experiment was laid out in randomized block design, replicated thrice with eleven treatments. The gross and net plot size was 9.0x 6.80 m2 and 7.20 x 5.20 m2, respectively. Important findings emerged from the present experimentation are as under:

Growth Attributes:-The various treatments tried under study showed no significant influence on the initial and final plant stands. Number of Monopodial branches per plant was not affected significantly due to different treatments. At 30 DAE, treatment differences among sole cotton and intercrops were found not significant in respect of plant height, sympodial branches, dry matter and number of leaves per plant. At 60 DAE, treatments of intercrops cotton + Clusterbean and cotton + blackgram being at par exhibited significantly higher plant height, sympodial branches, number of leaves of cotton than the treatment of intercrop of cotton + cowpea, cotton + soybean, cotton + greengram and sole cotton. At 90, 120, 150 DAE and at harvest treatments of intercrops of cotton + Clusterbean recorded significantly higher plant height than the rest of the treatment. At 60 and 90 days the treatment of no intercrop (sole cotton) gave significantly higher number of leaves over other treatments of intercrop with cotton. However, at 120 DAE, treatments of sole cotton and cotton + cowpea intercrop recorded higher number of functional leaves per plant over all other treatments. However, treatment differences among intercrops with cotton+ greengram, cotton + blackgram and cotton + Clusterbean were not significant. At 150 DAE, treatment of no intercrop (sole cotton) being at par with treatments of intercrop of cotton with greengram, blackgram, Clusterbean and cowpea recorded greater number of leaves over treatment of intercrop of soybean. However, at harvest treatment of sole cotton was found superior than the treatment of intercrop of greengram/ blackgram/ soybean/ Clusterbean and cowpea. However, at 30, 150 DAE and at harvest treatment differences as regards leaf area were not evident. Leaf area index increased from 30 DAS to 120 DAS and declined thereafter. The maximum value of LAI was recorded at 120 DAS and it was to the tune of 1.05. However, at 60, 90, 120, 150 DAE and at harvest, treatments of sole cotton recorded significantly higher total dry matter production and being at par with the treatments of cotton + greengram, cotton + blackgram, cotton + Clusterbean and cotton + cowpea than cotton + soybean intercropping system.

Yield attributes:-Treatments of sole cotton recorded significantly higher number of picked bolls per plant than rest of the treatments. Treatments of different intercrops were being at par produced more or less equal number of picked bolls per plant. Mean boll weight was (2.85 g) and the boll weight was not affected significantly due to different treatments of intercrop. Treatment of sole cotton recorded significantly higher seed cotton yield (1350kg ha^{-1}), cotton stalk yield (1945 kg ha^{-1}), biological yield (3270 kg ha^{-1}) and harvest index (41.45 per cent). However, treatments differences between various intercropping system, were found being at par with each other's. Treatments of intercrop cotton + cowpea and cotton + Clusterbean were being at par recorded higher value of seed cotton equivalent yield and land equivalent ratio than the rest of the treatments.

Economics:-Treatments of intercrop of cotton + cowpea and cotton + Clusterbean recorded significantly higher gross monetary returns; net monetary returns cotton + Clusterbean have higher value of B: C ratio.

Quality studies:-Ginning percentage, seed index, lint index did not reach to the level of significance.

Intercrops:-At 60 DAE, treatments of intercrops cotton + greengram; cotton + blackgram, cotton + soybean and cotton + cowpea were being at par exhibited significantly higher plant height, number of branches and total dry matter productions per plant. However, at harvest treatments of cotton + intercrops (greengram/ blackgram/ soybean/ Clusterbean/ cowpea) were being at par recorded significantly higher plant height than the treatment of sole intercrops. Treatment of sole intercrops recorded

significantly higher grain yield of blackgram and soybean and green pods yield of greengram, Clusterbean and cowpea. However, treatments of various sole intercropping system and cotton + intercrops (i.e. greengram, blackgram, Clusterbean, soybean and cowpea) found being at par.

On the basis of present experimentation the following conclusion are following:- (i) Treatment cotton + Clusterbean recorded higher plant height, number of Monopodial, sympodial, number of functional leaves, dry matter accumulation, leaf area and leaf area index . (ii) Treatment T_1 sole cotton observed significantly higher seed cotton yield of American cotton maruvikash than the rest of the treatment. (iii) Among the intercropping system cotton + cowpea and, cotton + Clusterbean (for vegetable) recorded significantly higher cotton equivalent yield than cotton + greengram, cotton + blackgram and cotton + soybean intercropping systems. (iv) Cotton + Clusterbean and cotton + cowpea vegetable intercropping system recorded maximum economical returns i.e. NMR and B: C ratio than rest of the treatments.

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