International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 3625-3630

Received: 22-03-2019
Accepted: 24-04-2019

SM Ahir
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

MB Tandel
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

SM Patel
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

MK Desai
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Correspondence
MB Tandel
ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Feasibility of different pulse crops under *Jatropha curcas* L

SM Ahir, MB Tandel, SM Patel and MK Desai

Abstract
The present investigation was carried out at the Taluka Seed Farm, Mangrol, Navsari Agricultural University during the Rabi season 2009. The treatments involving three years old Jatropha (*Jatropha curcas* L.) (C_1) and open field condition (C_0) as growing conditions and five pulse crops P_1 (*Vigna radiata* L.), P_2 (*Vigna sinensis* L.), P_3 (*Vigna mungo* L.), P_4 (*Dolichos lablab* L.) and P_5 (*Cajanas cajan* L.) were tried in factorial completely randomized design with four replications. Significantly higher fresh weight of plant (76.17 g), number of branches per plant (10.35), number of pods per plant (16.43), number of grains per pod (10.45), grain yield per plant (6.86 g), grain yield per plot (713.61 g) and grain yield per hectare (945.01 kg) were recorded in open condition as compared to inter-cropping with Jatropha. Moreover, plant height was noted significantly maximum under Jatropha (67.33 cm). In case of different pulse crops, significantly maximum plant height (85.04 cm), fresh weight of plant (103.49 g), number of branches per plant (14.23) and number of pods per plant (18.91) were reported in P_5 (*Cajanas cajan* L.), whereas number of grains per pod (17.37) and grain yield per plant (7.13 g) were noted in P_3 (*Vigna mungo* L.). Moreover, grain yield per plot (986.29 g) and grain yield per hectare (1177.26 kg) were observed in P_1 (*Vigna radiata* L.). Pulse crops grown in open condition gave higher net realization as compared to pulse crops grown under Jatropha. Economically, among five pulse crops under investigation, Greengram gave higher returns as compared to others. Jatropha found more suitable with Indian bean. Jatropha seed yield may be economical if the age of plantation is five years or more.

Keywords: Jatropha and pulse crops (greengram, cowpea, blackgram, Indian bean and pigeon pea)

Introduction
The recent agroforestry system involve a combination of herbaceous crops and trees and sometimes animals in the land use system in such a way so as to obtain maximum production of food, fodder, fuel, timber and other products and provide greater financial return. Agroforestry system involving a mixture of agricultural crops, pasture/animals and trees provide better production when compared to agriculture alone as they are able to trap solar radiation and utilize soil more efficiently on a sustainable basis.

In India, *Jatropha curcas* L. is found in most the states and is generally grown as live fence for protection of agricultural field. In Gujarat, it is well known by the name of *Ratanjyot, Jamalgota, Parsi erenda, Kala erenda,* etc. Globally it is known as Physic nut and Purging nut. The botanical name *Jatropha curcas* L. is derived from the Greek word "Jatros" meaning a 'doctor' and "trophe" meaning 'nutrition' because of its medicinal properties. *Jatropha curcas* L. belongs to *Euphorbiaceae* family. *Jatropha curcas* L. is nearby glabrous tree or soft wooded shrub, 3-4 m high, with long petiole, entire, 3-5 lobed or angled, orbicular, cordate leaves 10 to 15 cm long. The flowers are yellowish green, glabrous or pubescent cymes at the end of the branches. Plant flowers in April- May and October - November. Fruit is a capsule, 2.5 to 5.0 cm in diameter; seed ovoid oblong, dull brownish black.

The farmers, mainly the economic benefits have adopted growing trees on agricultural land. But it will be worthwhile to work out an integrated approach depending on the suitability of crop and locations. Therefore, there is a great need to identify the suitable agricultural and horticultural crops, which can grow well along with tree plantation with limited solar energy available underneath the trees. The choice of intercrop is important as the economic returns depends on particular tree species (root system, canopy, allelopathic effect of litter etc.) though the choice is also determined by the technical factors like agro-climatic and edaphic conditions. The cereals, vegetables, flowers and pulse crops are grown as an intercrops with trees. Pulse crops have been found to be more remunerative due to short duration and easy cultivation.

Looking to above, an attempt was made to evaluate the feasibility of growing different pulse crops with Jatropha.

Materials and Methods

The present investigation entitled "Feasibility of different pulse crops under *Jatropha curcas* L." was carried out at the Taluka Seed Farm- Mangrol, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. The treatments involving two growing conditions *viz.*, three years old C_1: Jatropha (*Jatropha curcas* L.) plantation and C_0: Open field condition and five pulse crops *viz.*, P_1: Greengram (*Vigna radiata* L.), P_2: Cowpea (*Vigna sinensis* L.), P_3: Blackgram (*Vigna mungo* L.), P_4: Indian bean (*Dolichos lablab* L.) and P_5: Pigeon pea (*Cajanas cajan* L.) were tried with factorial completely randomized design with four replications. The present study was conducted on three years old "*Jatropha curcas* L.". All the plants selected were uniform in growth and size planted at the distance of 2.5 x 2.5 meters. The Jatropha bushes were pruned at 60 cm above the ground level on 15th June-2009. All the plants were subjected to uniform application of cultural practices like pruning, irrigation, application of manures and fertilizer, plant protection measures etc. The pulse crops were sown in 30th November- 2009 at different spacings as per recommendation for particular crop. Farm Yard manure was applied @ 10t/ha to all the plots uniformly and was incorporated in to the soil at the time of land preparation. Nitrogen and phosphorus were applied uniformly to all the plots at the rate of 20 kg N and 40 kg P per hectare as a basal dose as per recommended dose of fertilizer by Navsari Agricultural University for pulse crops. The observations on plant height, fresh weight of plant, number of branches per plant, number of pods per plant, number of grains per pod, number of grains per plant, grain yield per plot and grain yield per hectare were recorded in all the crops in open condition as well as under Jatropha at final harvesting stage. The observations on yield parameters of jatropha were also recorded. The experimental data of all the characters studied were subjected to the statistical analysis as per methods prescribed by Panse and Sukhatme (1967) [5].

Results and Discussion

A. Growth Parameters

1. Plant height (cm)

The data pertaining to plant height of pulse crops as affected by growing conditions at harvest are presented in Table – 1. The individual effect of growing conditions on different pulse crops and interaction effect were found significant.

1.1 Effect of growing condition

The plant height was recorded significantly higher in C_1 (67.33 cm) as compared to C_0 (53.96 cm). This may be due to more competition of light under Jatropha as compared to open condition which increased height of the plants. The present findings are in accordance with Stansel *et al*. (1965), Janardhan and Murty (1982) and Shinde (2001) [11, 2, 9].

1.2 Effect on Pulse crops

Among different pulse crops, significantly maximum plant height (85.04 cm) was observed in P_5 (Pigeon pea) which was followed by P_4 (Indian bean, 62.26 cm). This may be due to different genetic make-up of different pulse crops. The present findings are in conformity with the findings of Stansel *et al*. (1965), Janardhan and Murty (1982) and Shinde (2001) [11, 2, 9].

1.3 Interaction effect

Significantly maximum plant height (95.95 cm) was recorded in treatment combination P_5C_1 which was followed by P_5C_0 (74.13 cm). This might be due to difference in shade effect under different treatments. Less light intensity under plants might have reduced rate of evaporation of water from the soil and thereby more moisture available to pulse crops and ultimately the nitrogen supply may be more which increased the vegetative growth. Further, this may be due to different genetic make-up of different pulse crops. These findings are in conformity with those of Stansel *et al*. (1965), Janardhan and Murty (1982) and Shinde (2001) [11, 2, 9].

2. Fresh weight (g) per plant

The data on fresh weight per plant of pulse crops at final harvesting stage are presented in Table – 1. The individual effect of growing conditions and pulse crops was found significant whereas the interaction effect was found non-significant.

2.1 Effect of growing condition

Significantly higher fresh weight was recorded in C_0 (76.17 g) as compared to C_1 (63.26 g). Under reduced light intensity available to intercrop, it is obvious that photosynthetic process are adversely affected leading to reduced growth and is reflected by reduced fresh weight in the crop grown as an intercrop.

2.2 Effect on Pulse crops

In case of different pulse crops, maximum fresh weight of plant (103.49 g) was observed in P_5 (Pigeon pea) which was followed by P_4 (Indian bean, 66.81 g). In P_5 (Pigeon Pea) and P_4 (Indian bean) the prevailing edaphic and climatic conditions are more suitable when compared to $P_3 > P_1 > P_2$ and this is reflected in forms of better fresh weight (Rajmani, 2009).

2.3 Interaction effect

The interaction effect between different pulse crops and growing condition was found non-significant in affecting fresh weight of plant.

3. Number of branches per plant

The data regarding number of branches per plant at harvesting stage are furnished in Table – 1. The individual effect of growing conditions on different pulse crops and interaction effect were found significant.

3.1 Effect of growing condition

Significantly higher number of branches per plant was recorded in open field condition C_0 (10.35) as compared to under jatropha plantation C_1 (6.59). This might be due to more light availability in C_0 (open condition) and thus more photosynthesis. These increases in photosynthetic activity have resulted in better growth formation of more number of branches in pulse crops. These results are in accordance with Palani *et al*. (1996), Mahajan (2001) and Parekh *et al.* (2005) [4, 3, 6].

3.2 Effect on Pulse crops

Significantly maximum number of branches per plant (14.23) was observed in P_5 (Pigeon pea) which was followed by P_4 (Indian bean; 8.85). The observed variation of number of branches per plants in crop might be due to different genetic make-up of different crops. These results are in accordance with Palani *et al*. (1996) and Parekh *et al.* (2005) [4, 6].

3.3 Interaction effect
The treatment combination P_5C_0 recorded significantly maximum number of branches per plant (17.15) which was followed by P_5C_1 (11.30). In all the pulse crop under investigation there was a reduction noticed when grown as an intercrop. The reduced light available to the crop is main reason for these reductions. The observed variation in number of branches per plant in different crops might be due to different genetic make-up of different crops and photosynthesis effect with different pulse crops. These results are in accordance with Palani *et al*. (1996) and Parekh *et al.* (2005) [4, 6].

B. Yield Parameters
4. Number of pods per plant
The data in relation to the number of pods per plant at harvest are presented in Table-2. The individual effect of growing conditions on different pulse crops and interaction effect were found significant.

4.1 Effect of growing condition
The number of pods per plant was recorded significantly higher in C_0 (16.43) as compared to C_1 (13.72). This may be due to crops grown under open condition, where there was less competition for light for synthesizing food material, which favoured increase in NAR resulting in higher pods per plants. These results are in conformity with those reported by Patel (1995), George and Nair (1987), Mahajan (2001) and Sreerekha and Dhurua (2009) [7, 1, 3, 10].

4.2 Effect on Pulse Crops
Among different pulse crops, significantly maximum number of pods per plant was observed in P_5 (18.91) which was followed by P_4 (14.95). The observed variation in number of pods in crops may be due to different genetic make-up of different crops.

4.3 Interaction effect
Significantly maximum number of pods per plant (19.43) was recorded in treatment combination P_5C_0 which was statistically at par with P_5C_1 (18.38). The observed variation in number of pods in crops may be due to different genetic variation of different pulse crops. These results are in close proximity with earlier findings of Patel (1995) and George and Nair (1987) [7, 1].

5. Number of grains per pod
The data with respect to grains per pod at harvest are presented in Table – 2. The individual effect of growing conditions on different pulse crops and interaction effect were found significant.

5.1 Effect of growing condition
Significantly higher number of grains per pod was recorded in C_0 (10.45) as compared to C_1 (8.18). This might be due to more light availability in C_0 (open condition) as compared to under Jatropha plantation and thus more photosynthesis coupled with absence of competition from the tree component. This increase in photosynthetic activity might have resulted in formation of more number of grains per pod in pulse corps studied. Similar observations were made by Sreerekha and Dhurua (2009) [10].

5.2 Effect on Pulse crops
The number of grains per pod (17.37) was observed significantly maximum in P_3 (Blackgram) which was followed by P_1 (Greengram; 12.52). The observed variation in grains per pod of pulse crops may be due to different genetic behavior of different crops. Similar observations were made by Sreerekha and Dhurua (2009) [10].

5.3 Interaction effect
Significantly maximum number of grains per pod (19.86) was recorded in treatment combination P_3C_0, which was followed by P_3C_1 (14.88). This may be due to crops grown under open condition where there was less competition for light for synthesizing food materials. Similar observations were made by Sreerekha and Dhurua (2009) [10].

6. Grain yield per plant (g)
The glance of Table -2 showed grain yield per plant (g) at harvest. The individual effect of growing conditions on different pulse crops and interaction effect were found significant.

6.1 Effect of growing condition
The grain yield per plant was recorded significantly higher in C_0 (6.86 g) as compared to C_1 (5.76 g). This may be due to crops grown under open condition where there was less competition for light for synthesizing food materials and may also be due to more fresh weight, number of branches and number of pods, recorded in present study, which favoured increase in yield of pulse crops per plant. These results are in accordance with those reported by Patel (1995) and Georage and Nair (1987) [7, 1].

6.2 Effect on Pulse crops
However in case of pulse crops, significantly maximum grain yield per plant was observed in P_3 (Blackgram; 7.13 g) which was statistically at par with P_5 (Pigeon pea; 7.05 g). The observed variation in yield of crops per plant may be due to different genetic make-up of different crops and suitability to climatic conditions prevails in these locations. These results are in accordance with those reported by Patel (1995) and Georage and Nair (1987) [7, 1].

6.3 Interaction effect
The grain yield per plant (7.66 g) was recorded significantly maximum in treatment combination P_5C_0, which was statistically at par with P_3C_0 (7.56 g) and P_4C_0 (7.11 g), respectively. This may be due to crops grown under open condition where there was less competition for light for synthesizing food materials and may be due to more fresh weight, number of branches and number of pods per plant. Such findings are in conformity with Patel (1995) and Georage and Nair (1987) [7, 1].

7. Grain yield per plot (g)
The data relating grain yield per plot at harvest are furnished in Table – 3. The individual effect of growing conditions on different pulse crops and interaction effect were found significant.

7.1 Effect of growing condition
Significantly higher grain yield per plot (713.61 g) was recorded in C_0: open field as compared to under Jatropha C_1 (591.76 g). This might be due to crops grown under open condition had no competition for light for synthesizing food materials. More fresh weight, number of branches and number of pods per plant recorded in present study, are also the contributing factors for the increased yield. These results are in accordance with those reported by George and Nair (1987)

[1]. Similar results were also reported by Patel (1995) [1, 7] in Greengram, mustard and Indian bean.

7.2 Effect on Pulse crops

Among different pulse crops, significantly maximum grain yield per plot (986.29 g) was observed in P_1 (Greengram), which was followed by P_2 (Cowpea; 735.24 g). The observed variation in yield of crops per plot may be due to different genetic variation of different crops.

7.3 Interaction effect

Significantly maximum grain yield per plot (1085.23 g) was recorded in treatment combination P_1C_0 which was followed by P_1C_1 (887.35 g). This might be due to crops grown under open condition has less competition for light and synthesizing food materials and also may be due to more fresh weight, number of pods and number of grains per pod observed under present investigation. These findings are in line with earlier findings of Georage and Nair (1987) and Patel (1995) [7, 1].

8. Yield per hectare (kg)

The data pertaining to yield per hectare at harvest are recorded in Table-3. The individual effect of growing conditions on different pulse crops and interaction effect were found significant.

8.1 Effect of growing condition

The yield per hectare was recorded significantly higher in C_0 (945.01 kg) as compared to C_1 (831.15 kg). The reduced yield in intercrop is justified by availability of less light, there by resulting in to reduced growth and ultimately reflected as reduced yield, when compared to open field. The finding is supported by Rajmani (2009).

8.2 Effect on Pulse crops

Moreover in case of different pulse crops, significantly maximum yield per hectare was observed in P_1 (Greengram; 1177.26 kg) which was followed by P_2 (Cowpea; 1038.74 kg).

8.3 Interaction effect

The in treatment combination P_1C_0 noted significantly maximum yield per hectare (1248.06 kg) which was followed by P_1C_1 (1106.46 kg). This might be due to combined effect of growing condition in which there is no competition for light as well as different genetic makeup of different pulse crops.

C. Yield Parameters of Jatropha

The data pertaining to yield parameters of Jatropha are presented in Table – 4. It is evident from data presented in Table – 4 that all the yield parameters of Jatropha are significantly influenced due to intercropping of different pulse crops under Jatropha. The number of fruits per plant, seed yield per plant, seed yield per plot and seed yield per hectare were recorded significantly maximum in P_4 (Indian bean) i.e. 12.25, 33.92 g, 1.32 kg and 54.28 kg, respectively which was on same bar with P_5 (Pigeon pea; 11.71, 32.12 g, 1.25 kg and 51.38 kg, respectively) and P_2 (Cowpea; 11.13, 30.65 g, 1.20 kg and 49.05 kg, respectively).

D. Economics

The data with respect to economics of pulse crops as affected by different growing conditions are presented in Table – 5. It can be seen from data presented in Table – 5 that different pulse crops grown in open condition gave higher net realization and BCR as compared to grown under Jatropha. In case of different pulse crops, highest net realization and BCR were recorded in P_1C_0 (*Vigna radiata* L. grown in open field condition) (Rs. 51,204.46 and 1: 4.57, respectively) which was followed by P_2C_0 (*Vigna sinesis* L. grown in open field condition) (Rs. 47,782.01 and 1: 4.15, respectively).

Table 1: Effect of growing condition on growth parameters of pulse crops

Treatments	Plant Height (cm)			Fresh weight of plant (g/plant)			Number of branches per plant		
	C_0 (Control)	**C_1 (Intercrop)**	**Mean**	**C_0 (Control)**	**C_1 (Intercrop)**	**Mean**	**C_0 (Control)**	**C_1 (Intercrop)**	**Mean**
P_1: *Vigna radiata* L.	49.05	59.45	54.25	64.48	52.35	58.41	8.03	4.98	6.50
P_2: *Vigna sinensis* L.	41.50	51.09	46.30	60.99	51.15	56.07	6.60	4.65	5.63
P_3: *Vigna mungo* L.	47.60	63.18	55.39	69.95	57.65	63.80	9.08	5.23	7.15
P_4:*Dolichos lablab* L.	57.53	67.00	62.26	72.80	60.83	66.81	10.90	6.80	8.85
P_5: *Cajanas cajan* L.	74.13	95.95	85.04	112.65	94.33	103.49	17.15	11.30	14.23
Mean	53.96	67.33		76.17	63.26		10.35	6.59	
	P	C	PXC	P	C	PXC	P	C	PXC
S. Em ±	1.445	0.914	2.043	1.858	1.175	2.627	0.266	0.169	0.377
CD @ 5 %	4.19	2.65	5.93	5.39	3.41	NS	0.77	0.49	1.09
CV %	6.74			7.54			8.90		

Table 2: Effect of growing condition on yield parameters of pulse crops

Treatments	Number of Pods per plant			Number of Grains per pod			Grain Yield (g/plant)		
	C_0 (Control)	**C_1 (Intercrop)**	**Mean**	**C_0 (Control)**	**C_1 (Intercrop)**	**Mean**	**C_0 (Control)**	**C_1 (Intercrop)**	**Mean**
P_1: *Vigna radiata* L.	17.06	12.02	14.54	13.25	11.78	12.52	6.85	5.88	6.36
P_2: *Vigna sinensis* L.	13.53	11.45	12.49	9.53	6.79	8.16	5.12	4.59	4.85
P_3: *Vigna mungo* L.	15.42	13.57	14.49	19.86	14.88	17.37	7.56	6.71	7.13
P_4:*Dolichos lablab* L.	16.71	13.19	14.95	4.79	3.72	4.26	7.11	5.18	6.15
P_5: *Cajanas cajan* L.	19.43	18.38	18.91	4.84	3.72	4.28	7.66	6.44	7.05
Mean	16.43	13.72		10.45	8.18		6.86	5.76	
	P	C	PXC	P	C	CXP	P	C	PXC
S. Em ±	0.478	0.302	0.676	0.302	0.191	0.427	0.158	0.100	0.224
CD @ 5 %	1.39	0.88	1.96	0.88	0.55	1.24	0.46	0.29	0.65
CV %	8.96			9.17			7.09		

Table 3: Effect of growing condition on yield parameters of pulse crops

Treatments	Grain Yield (g/plot)			Grain Yield (kg/ha)		
	C_0 (Control)	**C_1 (Intercrop)**	**Mean**	**C_0 (Control)**	**C_1 (Intercrop)**	**Mean**
P_1: *Vigna radiata* L.	1085.23	887.35	986.29	1248.06	1106.46	1177.26
P_2: *Vigna sinensis* L.	796.05	674.43	735.24	1078.25	999.24	1038.74
P_3: *Vigna mungo* L.	767.98	667.75	717.86	1137.53	989.27	1063.40
P_4:*Dolichos lablab* L.	533.05	391.46	462.26	689.69	579.95	634.82
P_5: *Cajanas cajan* L.	385.73	337.80	361.76	571.53	480.81	526.17
Mean	713.61	591.76		945.01	831.15	
	P	C	PXC	P	C	PXC
S. Em ±	16.466	10.414	23.286	23.394	15.428	34.498
CD @ 5 %	47.77	30.21	67.56	70.77	44.76	100.09
CV %	7.14			7.14		

Table 4: Effect of different pulse crops on yield parameters of Jatropha

Treatments	Number of Fruits per plant	Seed yield (g/plant)	Seed yield (kg/plot)	Seed yield (kg/ha)
P_1:*Vigna radiata* L.	9.88	27.32	1.07	43.70
P_2:*Vigna sinensis* L.	11.13	30.65	1.20	49.05
P_3:*Vigna mungo* L.	10.65	30.05	1.15	48.09
P_4:*Dolichos lablab* L.	12.25	33.92	1.32	54.28
P_5:*Cajanas cajan* L.	11.71	32.12	1.25	51.38
S. Em ±	0.484	1.224	0.050	1.959
CD @ 5 %	1.49	3.77	0.16	6.03
CV %	8.69	7.95	8.03	7.95

Table 5: Economics of pulse crops as influence by different treatments

Treatment	Grain yield (kg/ha)	Jatropha Seed Yield (kg/ha)	Cost of seed material (Rs.)	Sowing labour cost (Rs.)	Fixed cost (Rs/ha)	Total cost (Rs/ha)	Gross Realization (Rs/ha)		Total Gross Realization (Rs/ha)	Net Realization (Rs/ha)	CBR
							Pulse Crops	Jatropha			
P_1C_0	1248.06	0	1400	1400	8398.54	11198.54	62403.00	0	62403.00	51204.46	4.57
P_2C_0	1078.25	0	1600	1400	8521.74	11521.74	59303.75	0	59303.75	47782.01	4.15
P_3C_0	1137.74	0	1200	1400	8398.54	10998.54	47785.11	0	47785.11	36786.57	3.34
P_4C_0	689.70	0	1800	1400	8583.34	11783.34	41382.22	0	41382.22	29598.88	2.51
P_5C_0	571.44	0	2000	1400	8706.54	12106.54	29715.11	0	29715.11	17608.57	1.45
P_1C_1	1106.46	43.70	1400	1400	8398.54	11198.54	55323.00	874.00	56197.00	44998.46	4.02
P_2C_1	999.24	49.05	1600	1400	8521.74	11521.74	54958.43	981.00	55939.43	44417.69	3.86
P_3C_1	989.26	48.09	1200	1400	8398.54	10998.54	41548.89	962.00	42510.89	31512.35	2.87
P_4C_1	579.94	54.28	1800	1400	8583.34	11783.34	34796.67	1086.00	35882.67	24099.33	2.05
P_5C_1	500.44	51.38	2000	1400	8706.54	12106.54	26023.11	1028.00	27051.11	14944.57	1.23

Market price of

Greengram = Rs.50/kg	Labour wages =Rs.100/day
Cowpea = Rs.55/kg	Jatropha Seed = Rs. 20/kg
Black gram = Rs.42/kg	Indian bean = Rs. 60/kg
Pigeon pea = Rs. 52/kg	

Conclusion

From the above findings, it is concluded that the growing of pulse crop in open condition resulted significant increase in fresh weight of plant, number of branches per plant, number of pods per plant, number of grains per pod and yield of pulse crops per plot and hectare over intercropping with Jatropha. Moreover, maximum number of fruits per plant, seed yield per plant, seed yield per plot and per hectare of Jatropha was recorded in Cowpea. From the economic point of view, Greengram, Cowpea, Blackgram, Indian bean and Pigeon pea grown as a sole crop found more profitable than grown as intercrop with Jatropha. The maximum CBR (Cost Benefit Ratio) was found in P_1C_0 i.e. Greengram grown in open condition. However, Jatropha found more suitable with Indian bean.

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