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Economic Feasibility of Ratoon Pigeon Pea under Different Levels of Irrigation, Fertilizers and Mulching

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ABSTRACT

Background: Ratooning in pigeon pea is one of the unexplored options for increasing the production and income through more number of crops per year under adequate supply of inputs. Dearth of knowledge on the ratooning, its yield and economics in pigeon pea on which the current study aimed at providing the basic idea of its suitability for cultivation.

Methods: The field experiment investigated during October 2020-February 2021 at University of Agricultural Sciences, GKVK, Bengaluru. The experiment was conducted with 2 levels of irrigation, 3 levels of fertigation and 2 levels of mulching under split-split plot design.

Result: The experimentation of ratoon pigeon pea with varied levels of inputs revealed that ratooning was found to be an economically feasible option with higher returns and lower cost of cultivation. The study comprehensively covers and states the adaptability of the practice in terms of yield and economics.

Key words: B:C ratio, Drip irrigation, Fertigation, Mulching, Pigeon pea, Ratooning.

INTRODUCTION

Pigeon pea (*Cajanus cajan*) is a legume crop, renowned for its adaptability to diverse agro-climatic conditions and its nutritional values. India is a dominant cultivator of pigeon pea with a contribution of 81% of the world's total area and 79% of production. Although India is a major producer, still it imports pigeon pea from other countries (Saxena and Kanwal, 2019). In order to meet the demand for pigeonpea increasing the production through horizontal as well as vertical expansion is needed. Ratooning of pigeon pea has remained as an unexplored path of horizontal expansion for increasing production. Ratooning of pigeon pea effectively reduces the crop durations in comparison to main crop hence; more crops per year can be taken. The major constraints for lower production of pigeonpea is attributable to its cultivation on sub-marginal lands with low energy inputs, poor soil fertility, inadequate fertilizer applications, cultivation by small holding farmers and majority of the area is under rainfed conditions. Apart from these, several intrinsic factors such as poor source to sink relationship, inefficient translocation of nutrients, flower dropping and long duration of the crop (Ware *et al*., 2018; Suresh *et al*., 2024).

The availability and supply of assured irrigation, fertilizers and mulching practice would have increased the pigeon pea yield which help to overcome the constraints for higher productivity. However, these additional inputs to enhance pigeonpea yield will result in increased cost of cultivation, that determines their practical implications under farmers' field. Drip irrigation combined with split drip fertigation had achieved higher productivity and profitability in pigeon pea cultivation (Gadade *et al*., 2022).

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Ratooning practice of pigeonpea cuts down the land preparation activities which accounts for 30% of the cost of production. Adaption of technologies such as drip irrigation, fertigation and mulching which have shown promising results in pigeonpea crop may help to boost the production of ratoon crop while, conserving the resources and minimizing the costs involved. The suitability of ratooning for cultivation depends on its yield and economics of production. Since, so far the ratooning of pigeon pea and its economic feasibility is unknown. With that objective, the following study was undertaken to check its economic suitability for cultivation.

MATERIALS AND METHODS

The experiment was conducted during October 2020 to February 2021 at Zonal Agriculture Research Station, GKVK, UAS, Bangalore. The research was formulated with two levels of irrigation (I_1: 0.50 CPE and I_2: 0.75 CPE), three levels of fertilizers (F_1: 100%, F_2: 75% and F_3: 50% recommended dose of fertilizers of pigeon pea) and two levels of mulching (M_0: without mulch and M_1: with mulch) under split-split plot design having 12 treatment combinations.

The previous crop was pruned to a uniform height of 45 cm above the ground level and in each plant three branches were retained for ratooning to avoid excessive vegetative growth. The irrigation water was applied in three days intervals up to a week before harvest through drip system on the basis of cumulative pan evaporation (CPE) values from the United States Weather Bureau (USWB) pan evaporimeter. The Recommended dose (25:50:25 kg N, P_2O_5 and K_2O ha^{-1}) of main crop applied to ratoon since no recommended dose of fertilizers (RDF) for rotoon crop. The fertilizers were applied in three splits at an interval of 30 days during *rabi* 2020 through drip fertigation. The source of nutrients were urea, di-ammonium phosphate and muriate of potash for nitrogen, phosphorous and potassium, respectively. The growth observations of the crop was recorded at 30, 60, 90 days after pruning (DAP) and at the harvest stage. The yield observations were recorded from tagged five plants and converted to hectare basis based on the number of plants per hectare. All the recorded experimental data was analyzed using a statistical

Table S1: Effect of irrigation, fertilizers and mulching on disease and mortality of ratoon pigeon pea.

Treatments	Diseased plants (%)			Mortality (%)		
	Mulching (M)		Mean	Mulching (M)		Mean
Irrigation (I)	M_0	M_1		M_0	M_1	
I_1: 0.50 CPE	3.00	5.77	4.39	25.09	20.81	22.95
I_2: 0.75 CPE	6.29	8.48	7.39	18.72	13.51	16.12
Mean	4.65	7.13		21.91	17.16	
	F-test	S.Em ±	CD (P=0.05)	F-test	S.Em ±	CD (P=0.05)
I	*	0.30	1.80	*	0.78	4.76
M	*	0.08	0.26	*	0.24	0.74
I × M	*	0.12	0.36	NS	0.34	-
Fertigation (F)	**Mulching (M)**			**Mulching (M)**		
F_1: 100% RDF	7.70	10.44	9.07	20.38	17.18	18.78
F_2: 75% RDF	4.68	7.82	6.25	21.94	15.61	18.78
F_3: 50% RDF	1.56	3.12	2.34	23.40	18.69	21.05
Mean	4.65	7.13		21.91	17.16	
	F-test	S.Em ±	CD (P=0.05)	F-test	S.Em ±	CD (P=0.05)
F	*	0.21	0.69	*	0.48	1.55
F × M	*	0.14	0.44	*	0.42	1.28
Fertigation (F)	**Irrigation (I)**			**Irrigation (I)**		
	I_1	I_2		I_1	I_2	
F_1: 100% RDF	6.93	11.20	9.07	20.40	17.15	18.78
F_2: 75% RDF	4.67	7.83	6.25	21.96	15.60	18.78
F_3: 50% RDF	1.56	3.12	2.34	26.50	15.60	21.05
Mean	4.39	7.39		22.95	16.12	
I × F	F-test	S.Em ±	CD (P=0.05)	F-test	S.Em ±	CD (P=0.05)
	*	0.30	0.97	*	0.67	2.19
	Mulching (M)			**Mulching (M)**		
	M_0	M_1		M_0	M_1	
I_1F_1	5.88	7.98		22.05	18.76	
I_1F_2	3.12	6.21		25.14	18.77	
I_1F_3	0.00	3.12		28.08	24.91	
I_2F_1	9.51	12.90		18.70	15.60	
I_2F_2	6.25	9.42		18.74	12.46	
I_2F_3	3.12	3.12		18.72	12.48	
I × F × M	F-test	S.Em ±	CD (P=0.05)	F-test	S.Em ±	CD (P=0.05)
	*	0.12	0.36	NS	0.34	-

I: Irrigation, F: Fertilizers, M: Mulching, I_1: 0.50 Crop Pan Evaporation (CPE), I_2: 0.75 CPE, F_1: 100% Recommended dose of fertilizers (RDF), F_2: 75% RDF, F_3: 50% RDF, M_0: Without mulch, M_1: With mulch.

Table 1: Effect of irrigation, fertilizers and mulch on growth attributes of ratoon pigeon pea.

Irrigation (I)		Plant height (cm)				Number of branches per plant				Leaf area (cm^2 $plant^{-1}$)				Dry matter accumulation (g $plant^{-1}$)			
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
I_1		16.42	51.21	67.74	76.27	7.81	8.98	9.98	10.24	678	2490	3601	2637	9.16	34.18	85.26	96.52
I_2		27.10	73.07	93.77	99.51	9.48	11.05	12.02	11.85	802	4693	6273	4327	15.38	85.07	139.77	152.61
CD		6.04	12.84	19.51	16.37	1.50	2.05	1.94	1.52	114	680	1209	849	2.35	14.39	22.77	34.25
Fertilizers (F)																	
F_1		24.47	70.75	88.15	95.70	9.41	10.94	11.75	11.94	857	4129	5685	4186	15.00	70.07	132.69	146.05
F_2		22.01	59.21	80.48	86.33	8.41	9.80	10.96	11.00	726	3733	4801	3362	12.12	59.79	110.78	122.54
F_3		18.80	56.46	73.63	81.63	8.13	9.32	10.29	10.20	637	2913	4325	2898	9.69	49.01	94.08	105.09
CD		2.04	4.70	5.71	5.96	0.70	1.09	1.01	0.80	52	419	488	413	1.37	5.06	8.64	7.89
Mulching (M)																	
M_0		19.46	59.62	77.58	85.95	8.42	9.60	10.53	10.64	675	3394	4749	3309	11.25	56.31	106.40	116.63
M_1		24.06	64.66	83.92	89.83	8.88	10.44	11.47	11.45	805	3789	5125	3655	13.29	62.94	118.63	132.49
CD		1.02	2.71	3.57	3.65	0.36	0.51	0.47	0.56	30	139	219	142	1.12	2.59	5.23	5.86
Interaction (I × F)																	
I_1	F_1	18.10	57.00	75.03	84.99	8.36	9.94	10.87	11.21	757	2742	4086	3144	9.72	42.38	98.98	112.05
	F_2	16.14	47.58	63.77	70.37	7.59	8.55	9.81	9.95	689	2609	3276	2325	9.16	32.78	86.52	95.20
	F_3	15.01	49.05	64.41	73.45	7.50	8.47	9.26	9.57	588	2119	3441	2443	8.62	27.39	70.29	82.31
I_2	F_1	30.83	84.50	101.26	106.41	10.46	11.94	12.63	12.66	958	5516	7284	5227	20.29	97.77	166.41	180.04
	F_2	27.87	70.84	97.19	102.30	9.23	11.05	12.12	12.05	763	4857	6325	4400	15.09	86.81	135.03	149.89
	F_3	22.59	63.88	82.85	89.81	8.76	10.17	11.31	10.84	685	3707	5209	3353	10.75	70.64	117.87	127.88
CD		2.89	6.65	8.08	8.43	NS	NS	NS	NS	73	593	690	585	1.94	7.15	12.21	11.15

I: Irrigation, F: Fertilizers, M - Mulching, CD: Critical difference, I_1: 0.50 Crop Pan Evaporation (CPE), I_2: 0.75 CPE, F_1: 100% Recommended dose of fertilizers (RDF), F_2: 75% RDF, F_3: 50% RDF, M_0: Without mulch, M_1: With mulch.

F test (P=0.05) at 5% level of significance. Wherever the F test is found to be significant the critical difference (CD) was calculated and non significant data is not mentioned.

RESULTS AND DISCUSSION

Growth attributes

The treatments had significant effect on the growth parameters of ratoon pigeonpea (Table 1). Among the different treatments higher amount of growth parameters such as plant height, number of branches, leaf area and dry matter accumulation was observed in higher irrigation level (0.75 CPE), fertilizer (100% RDF) and plants with mulching throughout the growth period. Among all the interactions, irrigation and fertilizers interaction significantly affected the growth parameters where higher plant height, leaf area and dry matter accumulation were recorded at 0.75 CPE irrigation level with 100% RDF.

Better growth parameters at higher irrigation level is because of better availability of moisture in the root zone which maintains better turgor pressure in the leaf leading to better cell division and expansion (Nagaraj *et al*., 2019) similar results found by Jadav *et al.* (2022) and Kumar *et al*., (2024). Higher availability of primary nutrients such as N, P and K in soil led to more uptake of nutrients as well as positively influenced the absorption of other nutrients under drip irrigation (Kakade *et al*., 2018). Mulching the crop with black polyethylene sheet maintained better moisture content, nutrient availability by virtue of reducing evaporation and soil thermal regime improved the growth (Savani *et al*., 2017). The complementary effect of better availability of moisture and split fertigation of nutrients enhances the uptake and contributes to the better plant growth (Praharaj and Kumar, 2012) meanwhile, reducing the deep percolation losses.

Yield and yield attributes

Irrigation, fertilizers and mulching had significant influence on the yield and yield attributes of ratoon pigeonpea (Table 2). Days to 50% flowering, number of pods per plant, number of seeds per pod, stalk yield of ratoon pigeon pea were found higher at 0.75 CPE irrigation level, 100% RDF and plants with mulchihg. Meanwhile, higher seed yield and harvest index was recorded at same irrigation and mulching levels but at 50% RDF. Among irrigation and fertilizers interactions, irrigation at 0.75 CPE with 50% RDF was observed with a higher number of pods, seed yield, and harvest index. Meanwhile, a higher amount of stalk (2490 kg ha^{-1}) was recorded at 0.75 CPE irrigation level with 100% RDF fertilizer level.

Drip irrigation provides optimum moisture conditions which improved the yield due to better crop growth and air-soil-water proportion maintained at 0.75 CPE throughout the crop growth stage (Jadhav *et al*., 2018; Kumbhar *et al*., 2015). Mulching with black polythene sheet effectively improves the storage of water in the rhizosphere and reduces evaporation

Table 2: Effect of irrigation, fertilizers and mulch on yield and yield attributes of ratoon pigeon pea.

Treatments	Days to 50% fowering	Number of pods per plant	Number of seeds per pod	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (%)
Irrigation (I)						
I_1	83.78	93.84	3.29	357	1604	18.23
I_2	91.67	125.11	3.83	611	2250	21.49
CD	7.80	27.10	0.47	118	432	2.50
Fertilizers (F)						
F_1	90.08	112.13	3.70	457	2108	17.93
F_2	87.11	105.64	3.59	482	1927	19.63
F_3	85.98	110.20	3.39	515	1746	22.02
CD	3.06	5.37	0.18	45	109	1.78
Mulching (M)						
M_0	87.47	106.57	3.54	468	1866	19.81
M_1	87.97	112.38	3.59	500	1988	19.91
CD	NS	5.17	NS	22	80	NS
Interaction (I × F)						
I_1 F_1	84.66	107.09	3.56	395	1726	18.62
F_2	83.88	91.09	3.25	355	1689	17.33
F_3	82.78	83.33	3.05	322	1398	18.74
I_2 F_1	95.49	118.09	3.84	518	2490	17.24
F_2	90.33	120.18	3.93	608	2166	21.93
F_3	89.18	137.07	3.73	708	2094	25.30
CD	NS	7.60	0.25	64	155	2.52

I: Irrigation, F: Fertilizers, M: Mulching, CD: Critical difference, I_1: 0.50 Crop Pan Evaporation (CPE), I_2: 0.75 CPE, F: 100% Recommended dose of fertilizers (RDF), F_2: 75% RDF, F_3: 50% RDF, M_0: Without mulch, M_1: With mulch.

Table 3: Effect of irrigation, fertilizers and mulch on economics of ratoon pigeon pea.

Treatments	Yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
$I_1F_1M_0$	377	21858	17600	4258	1.24
$I_1F_1M_1$	413	24774	17600	7174	1.41
$I_1F_2M_0$	343	20574	16746	3828	1.23
$I_1F_2M_1$	367	21999	16746	5253	1.31
$I_1F_3M_0$	307	18433	15893	2540	1.16
$I_1F_3M_1$	337	20202	15893	4309	1.27
$I_2F_1M_0$	507	30419	17600	12819	1.73
$I_2F_1M_1$	529	31761	17600	14161	1.80
$I_2F_2M_0$	586	35183	16746	18437	2.10
$I_2F_2M_1$	630	37826	16746	21080	2.26
$I_2F_3M_0$	689	41342	15893	25449	2.60
$I_2F_3M_1$	727	43591	15893	27698	2.74

I: Irrigation, F: Fertilizers, M: Mulching, I_1: 0.50 Crop Pan Evaporation (CPE), I_2: 0.75 CPE, F_1: 100% Recommended dose of fertilizers (RDF), F_2: 75% RDF, F_3: 50% RDF, M_0: Without mulch, M_1: With mulch.

(Dhillon, 2020) similar results were recorded by Swathi *et al*. (2017) and Kumar *et al*. (2022) in which improved the leaf area of the crop and increased the photosynthates production and their accumulation in grains under mulching.

The yield of the crop at different fertilizer level is greatly influenced by its interaction with irrigation levels. The lower yield at 100% RDF fertilizer level along with 0.75 CPE is because of higher diseased (pigeonpea sterility mosaic) and dead plants (non-ratooned crop) which is mainly because of the luxuriant plant growth which attracted more insects in the main crop and ratoon crop leading to lower yields (Table S1). The another probable reason for lower yield at 100% RDF at 0.75 CPE is higher vegetative growth and flower dropping which imbalances the source to sink relationship because of which lower number of pods per plants recorded resulting in lower yield (Gangana Gowdra *et al*., 2024).

Economics

Among all the twelve combinations of irrigation, fertilizers and mulching; $I_2F_3M_1$ (Irrigation at 0.75 CPE, fertilizers at 50% RDF and with mulching) recorded lower cost of cultivation, higher gross returns (Rs. 43,591 ha^{-1}), net returns (Rs. 27,698 ha^{-1}) and BC ratio (2.74) followed by $I_2F_2M_1$ (Table 3)

The economics of the crop was mainly influenced by the yield of crop and cost of cultivation involved in it. The higher gross income and net income were recorded in $I_2F_3M_1$ (Irrigation at 0.75 CPE + 50% RDF + with mulching) because of higher yields which is in line with the results of (Savani *et al*., 2017). Another strong factor that influences the income and B:C ratio is the cost of production which was found lower in the treatment that has recorded higher yield.

CONCLUSION

Under the changing climatic situation, it is necessary to evaluate the alternate methods of cultivation to meet the needs of the growing population. Ratooning of pigeon pea in *rabi* under different irrigation, fertilizers and mulching revealed that, higher irrigation (0.75 CPE), fertilizer (100% RDF) and mulching improved the growth attributes. Meanwhile, higher irrigation (0.75 CPE) with lower fertilizer (50% RDF) and mulching found suitable for receiving higher ratoon pigeon pea yield. Cultivating ratoon pigeon pea with 50% RDF at 0.75 CPE irrigation level and mulching found to be more economically feasible than the other treatment combination. The combination of treatment found with higher net returns (Rs. 27,698 ha^{-1}), BC ratio (2.74) and lower cost of cultivation (Rs. 15,893 ha^{-1}) with save of 50% fertilizer dosage.

Conflict of interest

Authors do not have any conflict to disclose regarding the publication of article.

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