International Journal of Plant & Soil Science

Volume 36, Issue 12, Page 336-344, 2024; Article no.IJPSS.128080
ISSN: 2320-7035

Exploiting Possibilities of Short Duration Pigeonpea in Rice Fallows of Coastal Odisha, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i125207

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/128080

Original Research Article

Received: 09/10/2024
Accepted: 16/12/2024
Published: 19/12/2024

ABSTRACT

Aims: Need for horizontal expansion of pigeonpea encouraged for searching new niche. Out of 3.88 mha *kharif* rice area in Odisha 2.96 mha area estimated as rice fallow which should be exploited for growing pulses and oil seeds. Mild winter in coastal Odisha congenial for pigeonpea in winter and thus may be suitable for rice fallow situation after harvest of medium duration during November. A field experiment was conducted under rice fallow situation to evaluate the performance of promising short duration pigeonpea genotypes under partially irrigated medium land rice fallow situation of coastal Odisha.

Study Design: The trial was laid out in Randomized Block Design with four replications. The gross plot size was 5.4m X 4.2m and net plot size was 4.5m X 4m.

Place and Duration of Study: Nutri-Crops Research Station, OUAT, Berhampur, Odisha; Latitude: 19 deg. 18 min. Longitude: 84 deg. 54 min., Altitude: 34 m. above MSL.

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Cite as: *Panda, P. K., P.M. Mohapatra, I.O.P. Mishra, S. Behera, and A.A. Prusty. 2024. "Exploiting Possibilities of Short Duration Pigeonpea in Rice Fallows of Coastal Odisha, India". International Journal of Plant & Soil Science 36 (12):336-44. https://doi.org/10.9734/ijpss/2024/v36i125207.*

Climatic Zone: The eastern coastal region of India and East and South Eastern Coastal plain zone of the state. The soil was sandy loam in texture with 6.2 pH. The trials were conducted for two consecutive years during 2018-19 and 2019-20.

Methodology: Altogether thirteen short duration genotypes of pigeonpea were tested in RBD with four replications. The crop was sown in third week of November during both the years.

Results: Significant variation was observed among pigeonpea genotypes in growth, yield attributes and yield parameters during both the years. The pooled data revealed that pigeonpea genotype Pusa-991 sown during mid November under rice fallow condition with life saving irrigation recorded maximum grain yield (1317 kg/ha and 10.57 kg/ha/day) followed by Laxmi (1199 kg/ha and 9.15 kg/ha/day) and TJT-501 (1127 kg/ha and 8.6 kg/ha/day). PUSA-991 harvested in 125 days has also registered maximum pod/plant (64.0) and seed per pod (3.7). Among the super early genotypes PUSA ARHAR-16 harvested in 104 days and identified as well performer (1113 kg/ha) and recorded maximum yield per day (10.70 kg/ha/day). Maximum harvest index (39.3%) was recorded with Pusa Arhar-16 closely followed by Pusa-991(39.1%). Maximum gross return per hectare (Rs. 75541/-), net profit (Rs.42541/-), per day net return (Rs.342/ha/day) with B:C ratio (2.29) were obtained with PUSA-991. Strong positive association was found between grain yield and number of effective pods per plant (r=0.73) and plant stand (r=0.74) of pigeonpea.

Concluding Remarks: Considering the growing windows of the agro-ecological situation and availability of life saving irrigation, pigeonpea variety Pusa-991 (125days) may be selected for larger window and Pusa Arhar-16 (104days) for narrow window under rice fallow situation of coastal Odisha.

Keywords: Rice fallow; pigeonpea; correlation; harvest index; net return; B:C ratio.

1. INTRODUCTION

Rice fallow is a typical mono cropped rice based system existing in India, particularly in rainfed areas since a long time. Vast fallows in the dry season are an issue of serious concern in agriculture production system of Odisha and other parts of eastern India. With rainfed rice based mono-cropping system the resource poor, small and marginal farmers are forced to dwell in the vicious circle of poverty (Mohapatra et al.,2022; Mohapatra,2020). Hence the issue of rice fallow is among the top agenda for the policy makers and also for agri-scientists for implementing strategies and critically analysing the sustainable, eco-friendly agricultural system for poverty reduction and food and nutrient security (Mohapatra, 2021; Mohapatra, et al.,2022). Productivity in rice fallow is quite low due to moisture stress during crop season, terminal drought, poor plant stand, non-suitable variety, weed menace, poor crop management practice, biotic stress and so on. Sustainable intensification from single crop to double cropping could improve the food supply and enhance the livelihood of poor people directly or indirectly involved in agriculture sector (Pretty et al.,2018). The Govt. of India looking for a leap forward in agriculture productivity for doubling farmers income by utilizing rice fallow areas. There is an enormous possibility to further intensify a considerable total of potential rice fallow area using improved technology (Chandana and Mandal 2020; Venugopal and Rao, 1999). It is estimated that about 11.7mha in India remains fallow after rice harvest of which about 82% lies in the eastern India. Out of 3.88 mha *kharif* rice area in Odisha 2.96 mha area estimated as rice fallow (Operational Guide line of TRFA ,2016) which should be exploited for growing pulses and oil seeds. Pulses are important for both soil and human health due to its inherent BNF capability with richness in protein and micro nutrients. The rapid strides in population growth further aggravate the deficit situation coupled with decrease in arable land available for pulses. Pigeonpea fits very well in various production niches. Pigeonpea [*Cajanus cajan* (L.) Millsp.] always face challenges from natural calamities, aberrant weather condition, severe attack of pod borer complex and competitive remunerative rainfed crops during *kharif* season. Need for horizontal expansion of pigeonpea encouraged for searching new niche. Pigeonpea can be grown as *rabi* crop in areas with mild and short winter (Roy Sharma,1980; Puste and Jana,1990; Panda et al.,2003). Panda et.al. (2003) studied on the effect of NK fertilization on performance of yambean-pigeonpea intercropping system during pre-*rabi* and its residual effect on succeeding mung in West Bengal. Babu and Kalra (1989) standardized nutrient management of *rabi* pigeonpea in Maharastra. Kanwar (1981) indicated the importance of early maturing pigeonpea for post-monsoon sowing. Mahalakshmi *et. al.* (2011) reported the positive response of *rabi* pigeonpea to drip irrigation. Panda et al. (2018) reported that mid -September is the proper time of sowing for pre-*rabi* pigeonpea under upland condition. In irrigated *rabi* situation pigeonpea can be grown (mid-November sowing) profitably with vegetables (Panda et al.,2022, 2017). Laxmi (ICPL 85063), Manak , CORG9701 and TJT501 performed well under November sowing during *rabi* (Panda et al.,2019). Considering the scope of pulses cultivation in rice fallows in eastern states of India, a sub scheme on Targeting Rice Fallow Areas (TRFA) was implemented under RKVY during 2016-17 for bringing one million hectare land under crop intensification. In the XXIV meeting of ICAR regional committee No-II held at IMAGE, Bhubaneswar, Odisha under chairmanship of Dr. Trilochan Mohapatra, Secy. DARE & DG, ICAR during June-2018, it was decided to exploit possibilities of short duration pigeonpea in rice fallows of Odisha for increasing pulse production of the state utilizing rice fallows. Generally pigeonpea shows reduced growth and duration during *rabi* as compared to *kharif* sowing (Panda et al.,2019). Short duration (early and super early) pigeonpea genotypes with life saving irrigation may be tested for the purpose in medium land after harvest of medium paddy(120-130) days. Effort has therefore been made to test the feasibility of early and super early genotypes of pigeonpea in rice fallow condition at Centre for Pulses Researh, OUAT, Berhampur, Odisha.

2. MATERIALS AND METHODS

A field experiment was conducted under rice fallow during 2018-19 & 2019-20 under AICRP on Pigeonpea at the Centre for Pulses Research, OUAT, Berhampur(O) located at latitude 19^0 18’ and longitude 84^0 54’ with an altitude of 34 m above MSL, in the East and South Eastern Coastal Plain Zone of Odisha. Altogether 13 genotypes of Pigeonpea such as UPAS-120, PA-291, AL-882, AL-201, PAU-881, Pusa-991, Pusa-992, Pusa Arhar-16, ICPL-20338,ICPL-11255, Laxmi (ICPL 85063), CORG-9701 and TJT-501 were taken in Randomized Block Design with four replications. The crop was sown on 16^{th} of November during both the years at 45 X 10cm spacing in gross plot size 5.4m X 4m (12lines of 4m) after harvest of *khaif* rice in medium land in RBD with four replications. The net plot size 4.5 m X 3.8 m (17.1m^2) was taken into consideration and conversion factor (0.5848) for transforming net plot yield (g) to yield per hectare (kg) was computed. The soil was sandy loam with pH 5.8, low Organic Carbon (0.41 %), medium available Phosphorus (21.38kg/ha) and medium potassium (132.7kg/ha). The crop has received 38 mm &11.9 mm rainfall (4 & 2 rainy days) during the cropping season of 2018-19 &2019-20, respectively. Three number of irrigations (two for super early) were given at critical stages of growth during both the years. Recommended package of practice for *kharif* crop was followed. Observations on days to 50% and 100% flowering was recorded on the basis of percentage of plants in a plot initiated flowering. At the time of harvest plant height(cm), number of primary fruiting branches per plant, yield attributes (number of effective pods per plant, number of seeds per pod), grain yield (kg/ha), *bhusa* or husk yield (kg/ha) and stick yield(kg/ha) were taken at harvest and analysed as per statistical procedure described by Panse and Sukhatme(1985) Venugopal & Rao (1999). Total dry matter production (TDMP), harvest index (%) and duration of the crop were also calculated. Economics including gross return, net return, per day productivity, per day gross return, per day net return and benefit-cost ratio were calculated and compared for economic feasibility. The correlation study was also made between yield and yield attributes for identification of strength of relation among variables.

3. RESULTS AND DISCUSSION

3.1 Plant Stand, Days to Flowering, Duration

Number of effective plants (having pod) in the net plot was counted at maturity and plant stand was computed as percentage of calculated population (10 row X 38 plant= 380plant per net plot). Grain yield was found to be highly correlated with plant stand (r=0.74) ie. plots having higher plant stand gave more yield. It is essential to maintain the number of plants per unit area for obtaining higher yield. In rice fallow condition availability of soil moisture is the single most limiting factor for raising a crop and hence duration of the crop and per day productivity has immense importance for selection of suitable variety. Genotypes having less duration also initiate flowering early. Days to 50% flowering was recorded when approximately 50% of plant in the plot initiated flowering. The span of reproductive phase has positive impact on grain yield. Super early genotypes matured in 104 days may be considered more suitable as require less irrigation and vacate the land early than early genotypes (120-131 days).

3.2 Plant Height

In general plant height of pigeonpea during rice fallow situation found to be shorter than that of the *kharif* crop (agronomic dwarfing). Significant variation was observed in plant height of pigeonpea genotypes during rice fallow situation. Data depicted in Table-1 revealed that maximum plant height of 96.9 cm was recorded with pigeonpea genotype Pusa991 followed by CORG9701(94.8 cm) and Laxmi (94.1 cm). Supper early genotypes recorded lower plant height and the most dwarf plants were found with ICPL 11255 (33.3 cm) and ICPL20338 (34.1 cm).

3.3 Yield Attributes

Various yield attributes of pigeonpea genotypes were taken at harvest and placed in Table 1. Variation of number of primary fruiting branches per plant due to different genotypes found insignificant. The highest number of fruiting branches per plant (6.39) was recorded with Pusa-991 followed by Laxmi (6.31) and Pusa Arhar16 (6.27). Significant variation on the number of effective pod/plant was also observed among the pigeonpea genotypes. The maximum number of pod /plant (64.0) was obtained from Pusa-991 followed by Laxmi (56.9). Variation in number of seed/pod due to genotype difference was found statistically insignificant. However the maximum seed/ pod (3.7) was obtained from Pusa-991 (Table 1).

3.4 Yield

Conspicuous variation in pigeonpea grain yield was observed with different genotypes of pigeonpea in rice fallow situation (Table 2). Maximum grain yield per net plot was recorded from pigeonpea genotype Pusa-991(2251g/17.1m^2, pooled). Pusa-991 registered maximum grain yield per hectare during both the years of experimentation (1435 and 1198kg/ha respectively) and the significantly highest grain yield (1317 kg/ha,pooled), followed by Laxmi (1199 kg/ha). Bhusa and stick yield followed the same trend. Maximum total dry matter production was registered with Pusa-991 (3365kg/ha). Grain yield per hectare per day was also computed and the maximum value (10.7kg/ha/day) was recorded with Pusa arhar-16 followed by Pusa-991(10.57 kg/ha/day) that emphasized the suitability of super early genotype under rice fallow situation.

3.5 Harvest Index (HI)

Harvest Index was calculated on proportion of grain yield to biological yield ie, total dry matter production of above ground parts to find out the photosynthate (dry matter) partitioning to grain or the reproductive efficiency of crop as influenced by varying genotypes of pigeonpea in rice fallow situation (Table 2). Maximum harvest index (39.3%) was recorded with Pusa arhar-16 followed by Pusa-991 (39.1%), which indicates better photosynthate partitioning from source to sink (grain) in super early genotypes in rice fallow situation. Low vegetative growth of pigeonpea during rice fallow (dwarfing) as compared to *kharif* crops leads to lower stick yield and lower biological yield *i.e*. total dry matter production or above ground biomass. However the grain yield has not been reduced proportionately resulting higher harvest index. Higher plant density compensated the lower pod number per plant, but failed to compensate the profuse vegetative growth of crop during *kharif* indicating higher biological efficiency of crop in rice fallow situation.

3.6 Economics

Economics for each genotypes was computed and presented in Table-3. The gross return was calculated on genotype basis by multiplying average grain yield of both the years with average minimum support price (MSP) for both years [Rs.56.75 /kg(2018-19); Rs.58.00/kg (2019-20) and mean Rs. 57.38/kg] and cost of cultivation was computed as Rs 33,000/ha for early genotypes and Rs 31,000/ha for super early genotypes (due to one irrigation less) . The highest gross return (Rs. 75,541/ha), net return (Rs 42,541/ha), per day net return (Rs.342/-) and B:C ratio (2.29) was obtained from PUSA 991 followed by Laxmi (58,799/ha, 35,799/ha & 2.08 respectively). Super early genotype Pusa Arhar 16 recorded maximum per day productivity (10.7 kg/ha) and per day gross return (Rs.614/-) with an appreciable per day net return (Rs.316/-) and B:C ratio of 2.06. With short growing window and limited availability of irrigation Pusa Arhar 16 may be a better choice in rice fallow situation. This indicate that the short duration (early and super early) pigeonpea genotypes are economically suitable and compatible with various crops in rice based cropping sequence.

Table 1. Growth and yield attributes of short duration pigeonpea genotypes in rice fallows situation (two year pooled)

Sl. No.	Entries	Plant stand/ plot	Days to Flowering		Maturity Days (mean)	Plant Height (cm)	Primary branch/ plant	Pod/ Plant	Seed/ pod
			50%	100%					
V1	UPAS-120	89%	62.5	74.5	120	84.1	6.13	41.3	3.3
V2	PA-291	87%	61.0	73.0	120	81.5	6.16	48.5	3.5
V3	AL-882	92%	51.0	61.0	104	48.2	5.34	37.0	3.4
V4	AL-201	91%	54.0	66.5	108	75.9	5.35	39.6	3.4
V5	PAU-881	91%	61.0	73.5	125	86.9	4.81	39.6	3.5
V6	PUSA-991	93%	62.0	74.5	125	96.9	6.39	64.0	3.7
V7	PUSA-992	92%	62.0	75.0	125	90.3	6.21	56.2	3.3
V8	PUSA ARHAR-16	90%	51.0	62.5	104	44.1	6.27	41.0	3.4
V9	ICPL-20338	89%	50.0	60.0	104	34.1	4.07	30.7	3.3
V10	ICPL-11255	87%	50.0	60.0	104	33.3	3.68	26.0	3.2
V11	LAXMI	92%	64.5	77.0	131	94.1	6.31	56.9	3.4
V12	CORG-9701	90%	64.5	77.0	131	94.8	4.95	46.8	3.4
V13	TJT-501	92%	64.5	77.0	131	91.8	5.37	51.2	3.5
	SEm(±)					4.46	NS	3.14	NS
	CD(P=.05)					12.79		9.01	
	CV(%)					9.26		14.52	

Table 2. Yield and harvest index(HI) of short duration pigeonpea genotypes in rice fallows situation .

Sl. No.	Entries	Grain Yield (g/net plot)	Grain Yield (kg/ha)			Grain Yield (kg/ha/ day)	Stick yield (kg/ha)	Bhusa yield (kg/ha)	TDMP (kg/ha)	HI (%)
			2018-19	2019-20	Pooled					
V1	UPAS-120	1403	857	784	821	6.84	1391	492	2704	30.3
V2	PA-291	1424	853	812	833	6.94	1307	488	2628	31.7
V3	AL-882	1673	1033	924	979	9.42	1147	538	2664	36.7
V4	AL-201	1607	994	886	940	8.75	1263	517	2720	34.6
V5	PAU-881	1478	823	906	865	6.94	1254	495	2613	33.1
V6	PUSA-991	2251	1435	1198	1317	10.57	1394	654	3365	39.1
V7	PUSA-992	1731	1033	992	1013	8.13	1468	567	3048	33.2
V8	PA-16	1903	1132	1094	1113	10.70	1124	598	2835	39.3
V9	ICPL-20338	1587	1042	814	928	8.94	986	492	2406	38.6
V10	ICPL-11255	1389	748	876	812	7.81	977	476	2265	35.8

Sl. No.	Entries	Grain Yield (g/net plot)	Grain Yield (kg/ha)			Grain Yield (kg/ha/ day)	Stick yield (kg/ha)	Bhusa yield (kg/ha)	TDMP (kg/ha)	HI (%)
			2018-19	2019-20	Pooled					
V11	LAXMI	2050	1244	1154	1199	9.15	1369	629	3197	37.5
V12	CORG-9701	1843	1140	1016	1078	8.22	1342	597	3017	35.7
V13	TJT-501	1927	1190	1064	1127	8.60	1334	620	3081	36.6
	SEm(±)	134.1	84.7	73.3	78.9		98.3	36.2	193.1	
	CD(P=.05)	384.8	243.1	210.2	226.4		282.1	103.8	554.1	
	CV(%)	15.67	16.12	13.98	15.68		13.26	9.84	11.87	

Table 3. Yield and economics of short duration pigeonpea genotypes in rice fallows situation .

Sl. No.	Entries	Maturity Days (mean)	Grain Yield (kg/ha)	Gross return (Rs/ha)	Gross return (Rs/day)	Cost of production (Rs/ha)	Net return (Rs/ha)	Net return (Rs/day)	B: C ratio
V1	UPAS-120	120	821	47080	392.34	33000	14080	117.34	1.43
V2	PA-291	120	833	47769	398.07	33000	14769	123.07	1.45
V3	AL-882	104	979	56146	539.87	31000	25146	241.79	1.81
V4	AL-201	108	940	53937	499.42	31000	22937	212.38	1.74
V5	PAU-881	124.5	865	49605	398.43	33000	16605	133.37	1.50
V6	PUSA-991	124.5	1317	75541	606.75	33000	42541	341.69	2.29
V7	PUSA-992	124.5	1013	58097	466.64	33000	25097	201.58	1.76
V8	PA-16	104	1113	63864	614.08	31000	32864	316.00	2.06
V9	ICPL-20338	104	928	53249	512.01	31000	22249	213.93	1.72
V10	ICPL-11255	104	812	46593	448.01	31000	15593	149.93	1.50
V11	LAXMI	131	1199	68799	525.18	33000	35799	273.27	2.08
V12	CORG-9701	131	1078	61856	472.18	33000	28856	220.27	1.87
V13	TJT-501	131	1127	64667	493.64	33000	31667	241.73	1.96

Table 4. Correlation study among growth and yield attributing characters with grain yield of pigeonpea genotypes in rice fallows situation

Characters	Grain yield (kg/ha)	Duration (day)	Plant Height (cm)	Fruiting branch/plant	Effective pod/ plant	Seed/ pod	Plant stand(%)	50% flowering
Grain yield(kg/ha)	1.00							
Duration(day)	0.41	1.00						
Plant height(cm)	0.39	0.92	1.00					
Fruiting branch/plant	0.48	0.40	0.57	1.00				
Effective pod/plant	0.73	0.76	0.82	0.78	1.00			
Seed/pod	0.58	0.45	0.55	0.47	0.66	1.00		
Plant stand(%)	0.74	0.40	0.48	0.42	0.62	0.50	1.00	
50% flowering	0.34	0.98	0.95	0.50	0.77	0.44	0.34	1.00

3.7 Correlation Study

Correlation refers to measure the strength and direction of linear relationship between two variables. Correlation among grain yield and growth & yield attributing characters such as plant height, primary fruiting branches per plant, effective pods per plant, seeds per pod along with duration (day) of the genotype, plant stand (%) and 50% flowering were computed and the coefficient values placed in Table 4. The data revealed that there was strong positive association (r=0.73) between effective pod/plant and grain yield of pigeonpea in rice fallow situation. Plant stand also play an important role for enhancing grain yield (r=0.74). Low to moderate positive associations of grain yield were found with duration of the genotype (r=0.41), plant height (0.39), primary branch /plant (0.48), flowering time (0.34) and seed/pod (0.58) . Genotypes with more duration has more plant height(r=0.92), more effective pods (r=0.76) and delayed flowering (r=0.98). More pods per plant obtained from taller plants having more vegetative growth (r=0.82) and more primary fruiting branch per plant(r=0.78). The results corroborate with the findings of Panda et al. (2019). Plant stand and effective pod per plant has been identified as the most determining factor for enhancing grain yield.

4. CONCLUSION

Agronomic dwarfing (dwarfed plant height with delayed sowing towards shorter day length), shortening of maturity period and synchronous maturity were noticed with sowing of pigeonpea in rice fallow situation (mid-November sowing) irrespective of genotypes. The maximum values of growth and yield attributing factors and ultimately maximum grain yield, TDMP and harvest index were registered with genotype PUSA991 followed by Laxmi, & Pusa Arhar16. Maximum gross return, per day gross return, net return, per day net return and B:C ratio was also obtained from same genotype (PUSA991). However maximum per day productivity and harvest index was recorded with super early genotype Pusa Arhar-16. Thus it can be concluded that after harvest of medium duration *kharif* paddy (120-130 days) in medium land with limited irrigation facility(for life saving irrigation) in coastal Odisha , growing pigeonpea genotype Pusa-991and Laxmi may be recommended to farmers for higher profitability and soil health .With smaller growing window and limited availability of irrigation super early genotype Pusa Arhar- 16 may be a good option for rice fallow situation. The study confirms the feasibility of pigeonpea under medium land rice fallow situation.

CERTIFICATE

This is to certify that the study has not been published before or is not under consideration for publication elsewhere. Its publication is permitted by all authors and after accepted for publication it will not be submitted for publication anywhere else in English or ii any other language without the written approval of the author.

DISCLAIMER (ARTIFICIAL INTELLIGENCE

Authors hereby declare that NO generative AI technologies and text-to-image generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENT

The authors acknowledge the financial help from AICRP on Pigeonpea and logistic support from OUAT, Bhubaneswar.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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