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Response of rice fallow Blackgram to methods and time of sowing in rice field of various establishment methods with special reference to growth, yield attributes and yield

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Abstract
A field experiment was conducted on "Response of Rice fallow blackgram to Methods and Time of sowing in rice field of various Establishment methods with special reference to growth, yield attributes and yield" during September 2019-April 2020 at Agricultural College and Research Institute, Madurai (Tamil Nadu Agricultural University), Tamil Nadu, India. The experiment was laid out in Split-split plot design with three factor combination of nine treatments and was replicated thrice. The factors involve establishment methods of rice as main plot, methods of sowing of rice fallow blackgram as sub plot and time of sowing of rice fallow blackgram in sub-sub plot treatment. The soil of the experimental field was sandy clay loam. The results of study revealed that, sowing of rice fallow blackgram with rice fallow pulse planter at 10 days before rice harvest under rice establishment method of sowing by drum seeder registered highest values of growth attributes, root attributes, harvest index, yield and yield attributes. It might be due to higher residual moisture content which is known to enhance growth, yield and yield attributes as proven from above said combination.

Keywords: Rice fallow blackgram, methods of sowing, rice fallow pulse planter, time of sowing, rice establishment methods

Introduction
Pulses are the major source of dietary protein in vegetarian diet in India. Besides being a chief source of protein, they also uphold soil fertility through biological nitrogen fixation in soil and plays vital role in promoting sustainable agriculture (Sanjeev Gupta, 2016) [13]. Among global statistics, India is the largest producer (25%), consumer (27%) and importer (14%) of the pulses in the world. In India black gram extremely grown under south Indian states and also grown in some parts of northern states wherein semi-arid climate prevails. In Tamil Nadu, the production under pulses is 5.56 lakh tonnes attained from an area of 8.24 lakh hectares with productivity of 675 kg ha^{-1} during 2017-18. Whereas, the area covered by black gram is 4.26 lakh hectares with a production of 3.016 lakh tonnes and productivity of 707 kg ha^{-1} during 2019-2020 (Govt. of Tamil Nadu, 2020). Being a proteinaceous legume crop, its demand is getting enlarged due to ever growing population of India and also increasing demand due to its use of house hold tenacities for making variety of south Indian breakfast dishes. Hence it is also called as poor man's meat.
Intensification of existing agricultural systems is need of an hour to take care of rising demand of food grain production in the country (Kumar *et al.*, 2016) [4]. Pulses are cultivated under irrigated as well as rainfed conditions. They are also cultivated in another unique eco-system known as relay cropping or sequential cropping or rice fallow crop. Relay or sequential cropping system provides new dimension to crop production through soil fertility maintenance as compared to mono cropping. Ever since farmers started cultivation of rice, growing legumes in rice-fallows has also been under practice in wetland ecosystem. In this perspective, there is an enormous opportunity to increase the total cropping area through strategic research in rice-fallows (Kar and Kumar 2009) [3]. However, including the second crop in rice-fallows is a great challenge as post-rainy season often confront with series of abiotic and biotic stresses (Kumar *et al.*, 2018) [5].
The residual moisture left in the soil at the time of rice harvest will be sufficient to raise a short-season pulses (Pande, 2012) [9].

It can be used to grow an additional crop to utilise the moisture still retained in the soil in rice fallows. This unutilized area offers enormous opportunities to strengthen food and nutritional security. Introduction of pulses in the existing fallow area would enrich the fertility status of the soils by fixing atmospheric nitrogen and adding organic matter. (Mukesh Choudhary *et al.,* 2014) [7]. Rice fallows offers good scope for area expansion of these crops and crop intensification and their productive utilization can overcome many social and economic problems of the region like unemployment, labour migration and low income. Development and popularization of improved varieties of pulses suiting to rice fallows of different agro-ecological regions coupled with improved agro-technology will boost production, and thus improve income and livelihood security of farming community.

Sowing pulses under rice fallows, time of sowing is also utmost important agronomic factor for realizing yield potential of improved varieties in rice fallow pulses, which helps to achieving complete synchronization between vegetative and reproductive stages of crop and also obtaining high seed yields (Rathore *et al.,* 2010) [12]. In addition, methods of sowing were also one of the needy operations to get better revenue from agriculture. Broadcasting in rice fallow pulses causes many constraints like uneven distribution of seeds at shallow depth and loss of moisture after rice harvest which leads to poor contact between seeds and soil, low germination, more weed growth, unhealthy plant and lower yields.

The research findings available are very few in pulses, especially on methods and time of sowing which are vital as far as germination, emergence and establishment during its early stage and are found to be very poor in rice fallow black gram than normal system of cultivation. In order to effective utilization of residual moisture besides other resources like light, space and nutrients, placing the seeds at proper spacing and at optimum depth is vital as to enhance growth, development and yield of crop. It can be accomplished by having correct method and time of sowing combined with suitable rice establishment methods which cope up with rice fallow blackgram sowing in a feasible manner. Keeping in view, the study was undertaken on Response of Rice fallow blackgram to Methods and Time of sowing in rice field of various Establishment methods with special reference to growth, yield attributes and yield.

Materials and Methods

A field experiment was conducted at Agricultural College and Research Institute, Madurai (Tamil Nadu Agricultural University) Tamil Nadu, India, during September 2019-April 2020 to study the Response of Rice fallow blackgram to Methods and Time of sowing in rice field of various Establishment methods with special reference to growth, yield attributes and yield in wetland eco-system. The experiment was laid out in split-split plot design with three factors combination of nine treatments and was replicated thrice. The main plot (Establishment methods of rice) consists of M_1-Line planting by manual method, M_2-Sowing by drum seeder and M_3-Transplanting by machine, the sub plot (Methods of sowing of rice fallow blackgram) imposed with S_1-Sowing by rice fallow pulse planter, S_2-Random dibbling by manual method and S_3-Sowing by broadcasting (Farmer's practice) and Sub-sub plot (Time of sowing of rice fallow blackgram) were T_1-10 days before rice harvest, T_2-7 days before rice harvest and T_3-One day after rice harvest.

Black gram variety ADT 6 was chosen as test crop for the study. The seeds were sown as per the treatment schedule. Rice was hand harvested and their residues were allowed as a part of the continuous rice fallow black gram rotation experiment. Observations were recorded on growth attributes, root attributes, harvest index, yield and yield attributes. The data pertaining to critical difference were worked out at 5 per cent probability level $P \leq 0.05$ and non-significant values were denoted as NS.

Results and Discussion

Growth attributes

Of the various rice establishment methods, sowing by drum seeder (M_2) recorded distinctly highest plant height (32.26 cm), LAI (1.96) and DMP (1404 kg ha^{-1}) at 60 DAS in rice fallow black gram (Table. 1). While the lowest plant height (26.25 cm), LAI (1.79) and DMP (1397 kg ha^{-1}) were recorded in the rice establishment method of machine transplanting (M_3).

Under different methods of sowing of rice fallow blackgram (RFB), it gave significant impact on plant height, LAI and DMP. Sowing of rice fallow blackgram (RFB) with rice fallow pulse planter (S_1) recorded the highest plant height, LAI and DMP. Whereas, it was found to be lower under broadcasting method of sowing (S_3) of rice fallow blackgram (RFB).

With regard to different time of sowing of rice fallow blackgram (RFB), sowing rice fallow blackgram (RFB) at 10 days before harvesting of rice (T_1) recorded the highest plant height, LAI and DMP at 60 DAS Whereas, consistently lowest plant height, LAI and DMP produced in sowing rice fallow blackgram (RFB) at 1 day after harvesting rice (T_3). It was in close similarity with Sivakumar *et al.* (2018) [15] who reported increased growth attributes *viz.*, plant height (36.7 cm), LAI (4.1) and DMP (2228 kg ha^{-1}) at 60 DAS respectively with early sowing on June 28 than delayed sowing on July 14 in soybean. Gulab Singh Yadav *et al.* (2018) [2] reported that plant height, LAI and DMP were recorded highest in early sowing (25th November) compared with delayed sowing (15th December) of Lentil in rice fallow lands.

While studying the interaction effect, rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) recorded the highest plant height (45.44 cm), LAI (2.68) and DMP (1831 kg ha^{-1}). This was followed by rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2T_2S_1$) in recording Plant height and LAI. While it was at par with rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2T_2S_1$) in recording DMP. However, there were lowest plant height (19.75 cm), LAI (1.74) and DMP (732 kg ha^{-1}) noticed at 60 DAS in rice establishment method by machine transplanting in combination with rice fallow blackgram (RFB) sowing by broadcasting at 1 day after harvesting of rice ($M_3S_3T_3$).

Table 1: Effect of methods and time of sowing and rice establishment methods on Plant height (cm), LAI and DMP (kg ha^{-1}) of rice fallow blackgram (RFB) at 60 DAS

Establishment method of Rice	Method of sowing RFB	Time of sowing RFB on Plant height at 60 DAS			Mean	Time of sowing RFB on LAI at 60 DAS			Mean	Time of sowing RFB on DMP at 60 DAS			Mean
		T_1	T_2	T_3		T_1	T_2	T_3		T_1	T_2	T_3	
M_1	S_1	31.66	32.45	28.00	30.70	1.91	2.13	1.93	1.99	1181	1175	1164	1173
	S_2	29.18	32.65	33.06	31.63	2.00	2.04	2.15	2.06	1296	1221	1075	1197
	S_3	27.85	28.30	28.37	28.17	1.90	1.94	1.85	1.89	1024	1121	724	956
Mean		29.56	31.13	29.81	30.17	1.93	2.03	1.97	1.98	1167	1172	987	1109
M_2	S_1	45.44	38.29	33.43	39.05	2.68	2.22	2.00	2.30	1831	1741	1358	1643
	S_2	34.23	26.98	30.94	30.71	2.08	1.66	1.90	1.88	1681	1381	1161	1408
	S_3	27.82	28.59	24.60	27.00	1.75	1.82	1.57	1.71	1177	1318	988	1161
Mean		35.83	31.29	29.66	32.26	2.17	1.90	1.82	1.96	1536	1480	1169	1404
M_3	S_1	34.86	21.94	23.48	26.76	1.95	1.73	1.69	1.79	1332	1190	965	1162
	S_2	32.53	26.99	22.23	27.25	2.17	1.77	1.63	1.85	968	1229	913	1036
	S_3	27.02	27.46	19.75	24.74	1.88	1.85	1.49	1.74	881	958	732	857
Mean		31.47	25.46	21.82	26.25	2.00	1.78	1.60	1.79	1060	1125	870	1018
	SEd	CD (P=0.05)			SEd	CD (P=0.05)			SEd	CD (P=0.05)			
M	0.25	0.70			0.04	0.11			12.28	34.10			
S	0.53	1.09			0.04	0.09			25.08	54.65			
T	0.66	1.43			0.03	0.07			23.60	47.88			
MS	0.80	1.69			0.07	0.17			37.53	84.19			
MT	0.96	2.14			0.06	0.15			35.57	75.32			
ST	0.93	1.89			0.06	0.14			41.75	86.96			
MST	1.61	3.36			0.11	0.22			67.83	140.38			

Root attributes

Of the various rice establishment methods, sowing by drum seeder (M_2) recorded distinctly highest root biomass (0.68 kg ha^{-1}), root length (19.14 cm) and root spread (8.01 cm) at harvest in rice fallow black gram (Table. 2). While the lowest root biomass (0.58 kg ha^{-1}), root length (14.85 cm) and root spread (7.08 cm) at harvest were recorded in the rice establishment method of machine transplanting (M_3).

Under different methods of sowing of rice fallow blackgram (RFB), it gave significant impact on root biomass, root length and root spread. Sowing of rice fallow blackgram (RFB) with rice fallow pulse planter (S_1) recorded the highest root biomass, root length and root spread. Whereas, it was found to be lower under broadcasting method of sowing (S_3) of rice fallow blackgram (RFB).

With regard to different time of sowing of rice fallow blackgram (RFB), sowing rice fallow blackgram (RFB) at 10 days before harvesting of rice (T_1) recorded higher in root biomass, root length and root spread at harvest. Whereas root biomass, root length and root spread were consistently lower in sowing rice fallow blackgram (RFB) at 1 day after harvesting rice (T_3). Similar results were made by Gulab Singh Yadav *et al.* (2018) [2] who reported that the root length were recorded highest in early sowing (25th November) compared with delayed sowing (15th December) of Lentil in rice fallow lands.

While studying the interaction effect, rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) recorded the highest root biomass (0.77 kg ha^{-1}), root length (26.52 cm) and root spread (9.93 cm) at harvest. However, it was at par with rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 7 days before harvesting of rice (M2T2S1). The lowest root biomass (0.58 kg ha^{-1}), root length (9.66 cm) and root spread (6.37 cm) at harvest was noticed in rice establishment method by machine transplanting in combination with rice fallow blackgram (RFB) sowing by broadcasting at 1 day after harvesting of rice ($M_3S_3T_3$).

Table 2: Effect of methods and time of sowing and rice establishment methods on Root biomass (kg ha^{-1}), Root length (cm) and Root spread (cm) of rice fallow blackgram (RFB) at Harvest

Establishment method of Rice	Method of sowing RFB	Time of sowing RFB on Root biomass			Mean	Time of sowing RFB on Root length			Mean	Time of sowing RFB on Root spread			Mean
		T_1	T_2	T_3		T_1	T_2	T_3		T_1	T_2	T_3	
M_1	S_1	0.62	0.51	0.51	0.55	22.46	17.44	15.83	18.57	8.43	7.44	7.39	7.75
	S_2	0.70	0.59	0.55	0.61	17.50	16.61	14.60	16.24	8.37	6.74	7.87	7.66
	S_3	0.70	0.68	0.59	0.65	15.05	12.56	12.16	13.25	8.21	6.44	7.93	7.52
Mean		0.67	0.59	0.55	0.60	18.34	15.53	14.19	16.02	8.34	6.87	7.73	7.65
M_2	S_1	0.77	0.73	0.56	0.69	26.52	19.43	17.82	21.25	9.93	9.02	8.27	9.07
	S_2	0.68	0.67	0.55	0.63	24.53	18.63	16.62	19.92	7.09	7.05	8.55	7.56
	S_3	0.66	0.85	0.54	0.68	18.05	15.56	15.16	16.25	7.14	6.56	8.49	7.40
Mean		0.70	0.75	0.55	0.67	23.03	17.87	16.53	19.14	8.05	7.54	8.44	8.01
M_3	S_1	0.62	0.54	0.64	0.60	23.49	16.40	14.79	18.22	7.68	6.83	8.13	7.54
	S_2	0.61	0.56	0.53	0.56	16.54	15.65	13.63	15.27	6.75	6.64	7.95	7.11
	S_3	0.61	0.64	0.49	0.58	12.55	10.93	9.66	11.04	6.98	6.44	6.37	6.60
Mean		0.61	0.58	0.55	0.58	17.52	14.32	12.69	14.85	7.13	6.64	7.48	7.08
	SEd	CD (P=0.05)			SEd	CD (P=0.05)			SEd	CD (P=0.05)			
M	0.012	0.034			0.284	0.789			0.066	0.185			

S	0.009	0.019	0.285	0.621	0.145	0.295
T	0.009	0.018	0.277	0.563	0.076	0.167
MS	0.017	0.044	0.493	1.173	0.216	0.454
MT	0.018	0.043	0.484	1.108	0.127	0.298
ST	0.015	0.032	0.485	1.010	0.251	0.511
MST	0.025	0.053	0.791	1.635	0.372	0.760

Yield attributes

Among different rice establishment methods, sowing by drum seeder (M_2) recorded distinctly highest pods per plant (20.73) and seeds per pod (4.51) in rice fallow black gram (Table.3). While the lowest pods per plant (19.53) and seeds per pod (4.07) were observed in rice establishment method by machine planting (M_3).

Under different methods of sowing of rice fallow blackgram (RFB), it gave significant impact on highest pods per plant and seeds per pod. Sowing of rice fallow blackgram (RFB) with rice fallow pulse planter (S_1) recorded the highest pods per plant and seeds per pod. However, sowing of rice fallow blackgram (RFB) by broadcasting (S_3) recorded the lowest highest pods per plant and seeds per pod.

In the case of different time of sowing of rice fallow blackgram (RFB), sowing rice fallow blackgram (RFB) at 10 days before harvesting of rice (T_1) recorded the highest pods per plant and seeds per pod, whereas sowing rice fallow blackgram (RFB) at 1 day after harvesting rice (T_3) consistently produced the lowest highest pods per plant and seeds per pod. Similar results are also obtained by Ramesh Naidu *et al.* (2017) [11] who found that earliest sown crop during 16th September resulted in significantly a greater number of pods per plant and number of seeds per pod. While, in delayed sown crop during 1st October, there was significant decrease in number of pods per plant and number of seeds per pod in soybean.

While studying the interaction effect of rice establishment methods, sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) recorded the highest pods per plant (26.12), seeds per pod (6.46). In the case of pods per plant, it was followed by rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2T_2S_1$). As for seeds per pod, it was at par with rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2T_2S_1$). However, the lowest pods per plant (17.40) and seeds per pod (3.33) was noticed in rice establishment method by machine transplanting in combination with rice fallow blackgram (RFB) sowing by broadcasting at 1 day after harvesting of rice ($M_3S_3T_3$). These results are in conformation with the finding of Mutnal *et al.* (1995) [8] who reported that the number of pods per plant is higher in blackgram (24.71 plant^{-1}) and cowpea (21.32 plant^{-1}) under rice fallow condition due to residual soil moisture. Mishra *et al.* (2016) [6] concluded that the pods per plant and seeds per pod were recorded significantly higher in utera cropping (sowing crops in standing rice 10 days before rice harvest) as compared to zero tillage (ZT) and ZT with straw mulch in lathyrus and chickpea crop.

Table 3: Effect of methods and time of sowing and rice establishment methods on number of pods plant^{-1} and number of seeds per pod^{-1} of rice fallow blackgram (RFB)

Establishment method of Rice	Method of sowing RFB	Time of sowing RFB on No. of pods per plant			Mean	Time of sowing RFB on No. of seeds per pod			Mean
		T_1	T_2	T_3		T_1	T_2	T_3	
M_1	S_1	21.02	21.48	19.75	20.75	5.00	4.66	4.00	4.55
	S_2	25.40	19.82	19.90	21.70	5.00	4.00	4.33	4.44
	S_3	24.58	17.69	16.99	19.75	5.00	4.66	4.00	4.55
Mean		23.67	19.67	18.89	20.73	5.00	4.44	4.11	4.51
M_2	S_1	26.12	25.87	21.22	24.40	6.46	5.78	4.67	5.63
	S_2	23.27	23.79	19.00	22.02	5.00	4.66	5.53	5.06
	S_3	23.56	24.14	16.84	21.51	4.33	5.00	5.00	4.77
Mean		24.40	22.02	21.51	22.64	5.26	5.14	5.06	5.15
M_3	S_1	22.76	19.44	24.97	22.39	5.00	5.31	4.00	4.77
	S_2	20.83	15.85	19.75	18.81	4.00	3.67	3.00	3.55
	S_3	20.84	16.52	14.86	17.40	3.66	4.66	3.33	3.89
Mean		22.39	18.81	17.40	19.53	4.22	4.54	3.44	4.07
	SEd	CD (P=0.05)			SEd	CD (P=0.05)			
M	0.46	1.28			0.052	0.145			
S	0.32	0.71			0.093	0.203			
T	0.35	0.71			0.087	0.178			
MS	0.65	1.62			0.141	0.320			
MT	0.68	1.62			0.134	0.289			
ST	0.59	1.24			0.155	0.323			
MST	0.98	2.03			0.252	0.522			

Yield

As for rice establishment methods, sowing rice by drum seeder (M_2) recorded distinctly highest pod and haulm yield (441.54 and 1154.14 kg ha^{-1} respectively). While, lowest pod and haulm yield (299.79 and 1102.00 kg ha^{-1} respectively) was observed in rice establishment method by machine transplanting (M_3) (Table. 4).

Significant impact on both seed and haulm yield was noticed

under different methods of sowing of rice fallow blackgram (RFB). As such, sowing of rice fallow blackgram (RFB) with rice fallow pulse planter (S_1) recorded the highest pod and haulm yield. Whereas, sowing rice fallow blackgram (RFB) by broadcasting (S_3) recorded the lowest pod and haulm yield. The higher pod yield of rice fallow blackgram in sowing by line dibbling compared to sowing by broadcasting (Sasikala *et al*., 2014) [14].

In the case of time of sowing of rice fallow blackgram (RFB), sowing of rice fallow blackgram (RFB) at 10 days before rice harvest (T_1) recorded the highest pod and haulm yield. Whereas, these were consistently lower at 1 day after rice harvest (T_3). Similar results were made by Rakesh Kumar *et al.* (2015) [10] who reported that the pod and haulm yield increased with early sowing (5th April) of green gram. While, yield decreased with late sowing (April 15).

As for as interaction effect of treatments, the rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) recorded the highest pod and haulm yield (744.90 and 1802.33 kg ha^{-1} respectively). It was followed by rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2S_1T_2$). However, the lowest pod and haulm yield (140.097 and 697 kg ha^{-1} respectively) were observed in rice establishment method by machine transplanting in combination with rice fallow blackgram (RFB) sowing by broadcasting at 1 day after harvesting of rice ($M_3S_3T_3$).

Table 4: Effect of methods and time of sowing and rice establishment methods on Pod and Haulm yield (kg ha^{-1}) of rice fallow blackgram (RFB)

Establishment method of Rice	Method of sowing RFB	Time of sowing RFB on Pod yield			Mean	Time of sowing RFB on Haulm yield			Mean
		T_1	T_2	T_3		T_1	T_2	T_3	
M_1	S_1	416.16	379.54	349.81	381.83	1190.66	1193.66	1219.66	1201.33
	S_2	483.36	442.88	329.56	418.60	1222.66	1223.66	1213.33	1219.88
	S_3	291.08	356.78	192.13	279.99	1145.66	1191.66	786.33	1041.22
Mean		396.86	393.06	290.50	360.14	1186.33	1203.00	1073.11	1154.14
M_2	S_1	744.90	648.69	374.77	589.45	1802.33	1716.66	1423.66	1647.55
	S_2	594.99	499.24	298.16	464.13	1654.00	1469.33	1258.00	1460.44
	S_3	279.01	341.75	192.39	271.05	1299.00	1388.00	1230.00	1305.66
Mean		539.63	496.56	288.44	441.54	1585.11	1524.66	1303.88	1471.22
M_3	S_1	554.10	387.59	263.66	401.78	1239.66	1217.00	1123.66	1193.44
	S_2	264.65	431.35	215.24	303.74	1149.66	1236.00	1066.00	1150.55
	S_3	198.77	241.91	140.97	193.85	1058.33	1130.33	697.33	962.00
Mean		339.17	353.62	206.59	299.79	1149.22	1194.44	962.33	1102.00
	SEd	CD (P=0.05)			SEd	CD (P=0.05)			
M	5.19	14.42			21.38	59.38			
S	5.40	11.76			23.21	50.57			
T	6.74	13.68			15.94	32.34			
MS	9.23	21.87			39.17	92.33			
MT	10.86	23.89			31.07	74.04			
ST	10.96	22.63			32.36	68.14			
MST	18.20	37.40			51.02	106.66			

Harvest index

Among different rice establishment methods, sowing by drum seeder (M_2) recorded distinctly higher harvest index (0.22) (Table. 5). While the least harvest index (0.19) was observed in rice establishment method by machine planting (M_3).

Under different methods of sowing of rice fallow blackgram (RFB), it gave significant impact on harvest index. Sowing of rice fallow blackgram (RFB) with rice fallow pulse planter (S_1) recorded the higher harvest index. However, sowing of rice fallow blackgram (RFB) by broadcasting (S_3) recorded the lower harvest index.

In the case of different time of sowing of rice fallow blackgram (RFB), the results showed that sowing rice fallow blackgram (RFB) at 10 days before harvesting of rice (T_1) recorded the higher harvest index, whereas sowing rice fallow blackgram (RFB) at 1 day after harvesting rice (T_3) consistently produced the lower harvest index.

While studying the interaction effect of rice establishment methods, sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) recorded the higher harvest index (0.28). However, it was at par with rice establishment method of sowing by drum seeder in combination with rice fallow blackgram (RFB) sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2T_2S_1$). However, the lower harvest index (0.14) was noticed in rice establishment method by machine transplanting in combination with rice fallow blackgram (RFB) sowing by broadcasting at 1 day after harvesting of rice ($M_3S_3T_3$).

Table 5: Effect of methods and time of sowing and rice establishment methods on Harvest index (HI) of rice fallow blackgram (RFB)

Establishment method of Rice	Method of sowing RFB	Time of sowing RFB			Mean
		Harvest index (HI)			
		T_1	T_2	T_3	
M_1	S_1	0.24	0.23	0.21	0.22
	S_2	0.27	0.26	0.20	0.24
	S_3	0.19	0.22	0.18	0.19
Mean		0.24	0.23	0.19	0.21
M_2	S_1	0.28	0.27	0.20	0.25
	S_2	0.26	0.25	0.18	0.23
	S_3	0.16	0.19	0.12	0.16
Mean		0.24	0.23	0.16	0.22
M_3	S_1	0.29	0.22	0.18	0.23
	S_2	0.17	0.25	0.15	0.19
	S_3	0.15	0.16	0.14	0.15
Mean		0.20	0.21	0.16	0.19
		SEd			CD (P=0.05)
M		0.005			0.016
S		0.003			0.008
T		0.004			0.008
MS		0.007			0.019
MT		0.008			0.019
ST		0.006			0.014
MST		0.011			0.023

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