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Influence of Sowing Methods and Sowing Time on Growth, Growth Attributes and Yield of Black Gram *Vigna mungo* L. under Rice *Oryza sativa* L. Fallow Black Gram Cropping System

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Authors' contributions

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

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ABSTRACT

Aim: Blackgram is one of the most important pulse crops raised in several types of soil under well drained conditions. Currently, it is cultivated as monocrop , intercrop as well as rice fallow crop in southern India. When the rice fallow pulse systems are described as, the pulse crop is seeded before or after rice harvest without ploughing, the remaining soil moisture may be better used through conservation agriculture measures. It's also known as a relay crop, a no-till crop, or a residual crop.In general, the production and productivity of black gram is declining because of poor management practices . Thus, this study was undertaken rice establishment methods as a strategy to determine the availability of residual moisture on the establishment of rice fallow black gram system during the early growth stages.

Place and Duration of Study: A field investigation was carried out at Agricultural College and Research Institute, Madurai (Tamil Nadu Agricultural University9^{o}54' N Latitude, 78^{o}54' E Longitude with an altitude of 147 m above MSL), Tamil Nadu, India from September 2019 to April 2020

Methodology: To see how different seeding methods and time influence the rice fallow black gram, the factors include rice planting methods as the main plot, methods of sowing black gram on rice fallow black gram as sub plot, and time of sowing black gram on rice fallow black gram given out in sub-sub plot treatment.

Results: The treatments had the best growth qualities, growth analysis, and yield. It could be because the above-mentioned combinations had higher residual moisture content, which resulted in a higher germination percentage, better crop stand, and higher growth and yield of rice fallow black gram.

Conclusion: The best management strategy is to sowing black gram in rice fallow situations with a rice fallow pulse planter at 10 days before rice harvest, under the direct seeded of rice establishment technique with drum seeder.

Keywords: Method; time; sowing; establishment; black gram.

1. INTRODUCTION

Pulse crops have an integral role in human nutrition,considered as the chief source of proteins compared to other protein sources like meat and meat and its byproducts. The United Nations declared 2016 as "International Year of Pulses" (IYP) to reinforce public awareness of nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition [1]. Among the global statistics, India is the largest producer (25%), consumer (27%) and importer (14%) of the pulses in the world. In India black gram was grown majorly under south Indian states and also grown in some parts of northern states where in semi-arid climate prevails. In Tamil Nadu, the production under pulses is 0.55 million tonnes obtained from an area of 8.24 0.824 million hectares with productivity of 675 kg ha^{-1} during 2017-18. Whereas, under black gram the area is 4.26 0.426 million hectares with a production of 3.016 3.016 million tonnes and productivity of 707 kg ha^{-1} during 2019-2020 [2].

Being a proteinaceous legume crop, its demand is increasing as India's population grows and also increasing demand due to its use of house hold purposes for making variety of south Indian breakfast dishes. As a result, it's also known as "poverty meat". Since farmers started cultivation of rice, growing legumes in rice-fallows has also been under practice in wetland ecosystem [3].

Short-season pulses may be grown with the leftover moisture left in the soil after rice harvest (Pande, 2012). If planted in the existing fallow region, pulses would improve the soil fertility quality by fixing atmospheric nitrogen and supplying organic matter [4]. Relay cropping may aid in determining the optimum time of sowing for the following crop after rice, as well as favouring early ground cover to prevent evaporative loss [5,6]. Under relay cropping, rice fallow pulses contribute 40-50 per cent of total pulse production, of which major share by black gram. Practice of relay cropping decreases cost of production, as it need no land preparation and other field operations. Unlike other crops, rice fallow pulses do not require irrigation, weed and nutrient management excluding sowing and harvesting. In fact, rice fallow pulse is a boomerang to the wetland rice growers as they could able to fetch more income with less management and input cost [7].

Time of sowing is the utmost important agronomic factor for realizing yield potential of improved varieties in rice fallow pulses system; which helps in achieving complete synchronization between vegetative and reproductive stages of crop and also obtaining high seed yields [8]. In addition, methods of sowing were also one of the needy operations to get better revenue from agriculture. Broadcasting in rice fallow pulses cause 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 coventional 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. As sowing seeds at proper spacing by manual means in standing crop condition is technically not feasible and economically not viable in rice fallow pulse, machine sowing would offer a coping mechanism to accomplish the situation. Keeping in view, the study was undertaken in rice fallow pulse under different establishment methods of rice in combination with different methods and time of sowing.

2. MATERIALS AND METHODS

A field experiment was conducted at Agricultural College and Research Institute, Madurai (Tamil Nadu Agricultural University) Tamil Nadu, India, from September 2019 to April 2020 to study the influence of methods and time of sowing on growth attributes, yield and yield attributes of Rice fallow Black gram under different rice establishment methods 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 method, M_2 – Sowing by drum seeder and M_3 – Transplanting by machine; the sub plot (Methods of sowing of rice fallow black gram) were S_1 – Sowing by rice fallow pulse planter, S_2 – Random dibbling by manual method and S_3 – broadcast sowing (Farmer's practice) and Sub-sub plot (Time of sowing of rice fallow black gram) were T_1 – 10 days before rice harvest, T_2 – 7 days before rice harvest and T_3 – One day after rice harvest.

Blackgram 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 blackgram rotation experiment. Data were recorded on soil moisture, growth attributes, growth analysis, yield and yield attributes. The data on various attributes studied during the course of investigation were statistically analyzed as suggested by Gomez et al. (2010).

The experiment design followed a split-split plot design with three factors, nine treatments and three replicates. 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.

3. RESULTS AND DISCUSSION

3.1 Soil Moisture (%)

In rice establishment methods, sowing by drum seeder (M_2) registered distinctly highest soil moisture (36.77%) at the time of sowing black gram under rice fallow conditions (Fig. 1). While the lowest soil moisture (29.55%) was observed in the rice establishment method of machine transplanting (M_3). Geetha and Velayutham [9] reported that the rice fallow pulse relies entirely on moisture and nutrients left over from the previous rice crop to survive.

Under different methods of sowing, it gave significant impact on soil moisture at the time of sowing of black gram with rice fallow pulse planter (S_1) recorded the highest soil moisture of 37.42%. Whereas, sowing by broadcasting (S_3) recorded the lowest soil moisture (26.08%) under fallows. The crop cultivated in the rice fallow systems thrives solely on the residual moisture and available soil nutrients left over [10].

In case of different time of sowing of black gram (RFB) and also in combination of three factors it gave non-significant impact on soil moisture.

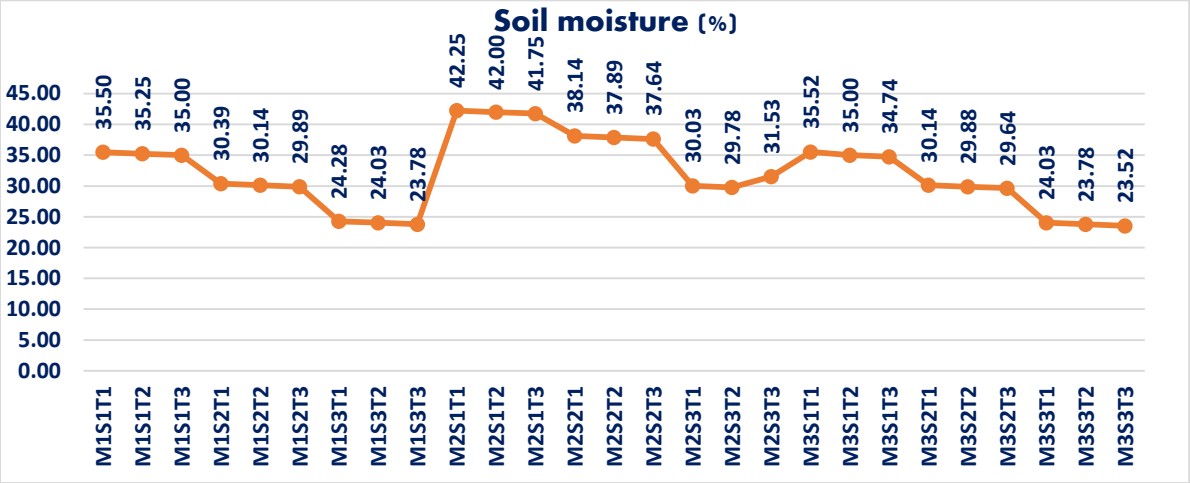

Fig. 1. Effect of methods and time of sowing and rice establishment methods on soil moisture (%) of rice fallow black gram

3.2 Germination Percentage

From Fig. 2, the rice establishment methods, sowing by drum seeder (M_2) recorded distinctly highest germination (79.81%). Whereas the lowest germination (68.00 %) were recorded in the manual transplanting of rice establishment method (M_2).

The highest germination of 81.42% was noted in sowing of black gram with rice fallow pulse planter (S_1) and lowest germination of 61.84% in broadcasting (S_3) method under different methods of sowing as rice fallow situations. Only 1.54 and 1.46 lakh plants ha^{-1} were found in black gram broadcasting beneath stubble mulch, respectively [11]. They have also reported that black gram dibbling in rice with intact stubbles and stubble mulch greatly aided germination and resulted in a higher population of 217 and 213 lakh plants ha^{-1}.

As for different timing, it gave significant impact on germination (%). At 10 days before harvesting of rice (T_1) recorded the maximum germination (75.22%), whereas consistently lowest germination (69.19%) was recorded at 1 day after harvesting rice (T_3).

There was no interaction effect in between the treatments on germination (%) of black gram.

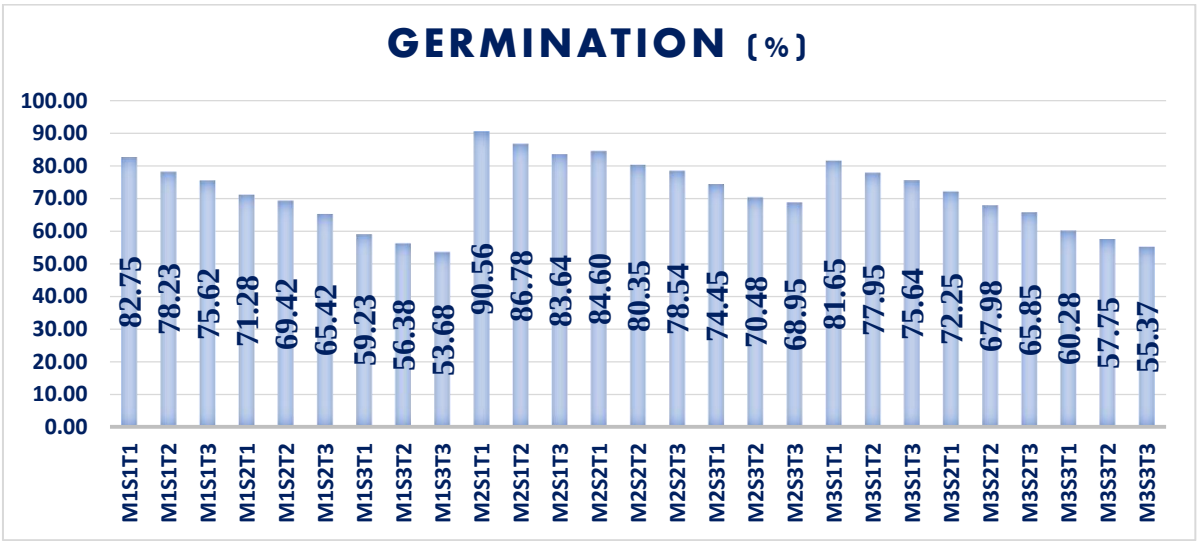

Fig. 2. Effect of methods and time of sowing and rice establishment methods on germination (%) of rice fallow black gram

3.3 Growth Attributes

Of the various rice establishment methods, sowing by drum seeder (M_2) reached distinctly highest plant height (43.24 cm), LAI (1.63) and DMP (1686.20 kg ha^{-1}) at harvest stage (Table1). While the lowest plant height (37.31), LAI (1.38) and DMP (1231.98) were obtained in the rice establishment method of machine transplanting (M_3).

Sowing of black gram with rice fallow pulse planter (S_1) achieved maximum plant height, LAI and DMP. Whereas, it was found to be lower under broadcasting method of sowing (S_3) in various methods of sowing. Pandian et al*.* [12] reported that dibbling of green gram seeds with mulch produced significantly higher LAI of 3.94.

With regard to different time of sowing, sowing black gram (RFB) at 10 days before harvesting of rice (T_1) produced the highest plant height, LAI and DMP at harvest. Whereas, consistently lowest plant height, LAI and DMP produced in sowing rice fallow black gram (RFB) at 1 day after harvesting rice (T_3). Similar results were also detected by Maruthupandi et al*.* [13] and Dasharath Prasad et al*.* [14] in LAI of rice fallow black gram sowing at 10 days before harvesting of rice. Gulab Singh Yadav et al*.* [15] described plant height, LAI and DMP were observed highest in early sowing (25th November) compared with delayed sowing (15th December) of Lentil in rice fallow lands.

Although studying the interaction effect, rice establishment method of sowing by drum seeder in combination with black gram sowing by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) recorded the highest plant height (55.52 cm), LAI (2.13) and DMP (2236.90 kg ha^{-1}). It was followed by rice establishment method of sowing by drum seeder in combination with black gram sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2T_2S_1$). However, the lowest plant height (30.80 cm), LAI (1.12) and DMP (731.78 kg ha^{-1}) at harvest stage was noticed in rice establishment method by machine transplanting in combination with sowing of black gram broadcasting at 1 day after harvesting of rice ($M_3S_3T_3$). Chickpea seeded on December 1 produced the highest plant height. Sowing on December 20 gave a lower value. This might be due to improved source and sink relationships as well as higher growth attributes [16].

3.4 Growth Analysis

3.4.1 Crop growth rate (CGR)

Among the rice establishment methods, sowing by drum seeder (M_2) registered numerically more in CGR at 60 DAS - harvest in black gram (Table.2). While, lowest CGR was obtained in the rice establishment method of machine transplanting (M_3).

Sowing black gram with rice fallow pulse planter (S_1) recorded the highest CGR. While in broadcasting (S_3) it obtained lowest CGR under several method of sowing.

In the case of different time of sowing, sowing at 10 days before harvesting of rice (T_1) produced the highest CGR at 60 DAS – harvest. Whereas, consistently lowest CGR recorded at 1 day after harvesting rice (T_3).

There was no interaction between the treatments on CGR at 60 DAS - harvest.

3.4.2 Relative growth rate (RGR)

There was no significant difference between the treatments of rice establishment methods on RGR at 60 DAS - harvest in black gram in fallows (Table 3).

Under different methods of sowing of black gram, it gave significant impact on RGR. Meanwhile, sowing black gram with rice fallow pulse planter (S_1) reached the highest RGR. Whereas, in broadcasting (S_3) method recorded the lowest RGR at 60 DAS - harvest.

Sowing black gram (RFB) at 10 days before harvesting of rice (T_1) reached the highest RGR at 60 DAS – harvest. Whereas, consistently lowest RGR in sowing rice fallow black gram (RFB) at 1 day after harvesting rice (T_3) under time of sowing.

While studying the interaction effect, rice establishment method of sowing by drum seeder in combination with black gram sowing in rice fallows by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) recorded the highest RGR. However, the lowest RGR at 60 DAS-harvest stage was noticed in rice establishment method by machine transplanting in combination with sowing of black gram 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 black gram (RFB) at harvest

Establishment method of Rice	Method of sowing RFB	Time of sowing RFB on Plant height at Harvest			Mean	Time of sowing RFB on LAI at Harvest			Mean	Time of sowing RFB on DMP at Harvest			Mean
		T_1	T_2	T_3		T_1	T_2	T_3		T_1	T_2	T_3	
M_1	S_1	44.46	43.09	38.91	42.45	1.64	1.68	1.57	1.63	1403.48	1378.73	1376.49	1386.23
	S_2	39.34	44.31	43.95	42.53	1.54	1.58	1.53	1.55	1498.62	1480.14	1358.27	1445.67
	S_3	38.74	38.94	39.42	39.03	1.47	1.42	1.40	1.43	1264.20	1362.12	856.02	1160.78
Mean		40.84	42.11	40.76	41.24	1.55	1.56	1.50	1.53	1388.77	1406.99	1196.93	1330.90
M_2	S_1	55.52	48.80	44.83	49.71	2.13	1.69	1.59	1.80	2236.90	2080.67	1581.26	1966.27
	S_2	45.69	38.57	41.66	41.97	1.77	1.54	1.55	1.62	1982.70	1750.00	1371.30	1701.33
	S_3	39.25	39.38	35.50	38.04	1.59	1.49	1.38	1.49	1391.48	1525.97	1255.55	1391.00
Mean		46.82	42.25	40.66	43.24	1.83	1.57	1.51	1.63	1870.36	1785.54	1402.70	1968.20
M_3	S_1	45.66	34.41	34.24	38.10	1.66	1.40	1.34	1.47	1566.31	1406.50	1216.00	1396.27
	S_2	43.08	37.78	33.22	38.02	1.60	1.36	1.21	1.39	1244.57	1481.34	1127.16	1284.35
	S_3	38.68	37.97	30.80	35.81	1.44	1.30	1.12	1.28	1106.08	1208.09	731.78	1015.32
Mean		42.47	36.72	32.75	37.31	1.57	1.35	1.22	1.38	1305.65	1365.31	1024.98	1231.98
	SEd		**CD (P=0.05)**			**SEd**		**CD (P=0.05)**		**SEd**		**CD (P=0.05)**	
M	0.48		0.98			0.016		0.033		48.40		134.39	
S	0.55		1.21			0.027		0.060		20.58		44.85	
T	1.19		3.03			0.039		0.098		30.73		62.33	
MS	1.26		3.20			0.050		0.121		56.48		147.86	
MT	0.84		1.70			0.028		0.057		65.05		158.89	
ST	1.45		2.95			0.056		0.118		48.09		98.87	
MST	0.98		2.72			0.031		0.087		80.71		165.29	

Table 2. Effect of methods and time of sowing and rice establishment methods on CGR, RGR of rice fallow black gram (RFB) at 60 DAS – Harvest

Treatment	CGR at 60 DAS - Harvest	RGR at 60 DAS - Harvest
Main plot- Establishment method of Rice		
M_1- Line planting by manual method	0.579	0.0037
M_2- Sowing by drum seeder	0.609	0.0038
M_3- Transplanting by machine	0.512	0.0038
SEd	0.0092	0.00005
CD (P=0.05)	0.025	NS
Sub plot- Method of sowing RFB		
S_1- Sowing by rice fallow pulse planter	0.603	0.0035
S_2- Random dibbling by manual method	0.554	0.0034
S_3- Sowing by broadcasting (Farmer's practice)	0.542	00044
SEd	0.0096	0.00004
CD (P=0.05)	0.021	0.00010
Sub-sub plot- Time of sowing of RFB		
T_1- 10 days before rice harvest	0.590	0.0034
T_2-7 days before rice harvest	0.571	0.0037
T_3- One day after rice harvest	0.538	0.0042
SEd	0.010	0.00006
CD (P=0.05)	0.217	0.00012
Interaction (SEd)	0.029	0.00019
Interaction CD (P=0.05)	NS	0.00033

3.5 Yield

As for rice establishment methods, sowing rice by drum seeder (M_2) recorded distinctly highest seed and haulm yield (421.07 and 1471.22 kg ha^{-1} respectively). While, lowest seed and haulm yield (279.32 and 1102.00 kg ha^{-1} respectively) was observed in rice establishment method by machine transplanting (M_3) (Table.3). Whereas, haulm yield is calculated as after picking of the pods, the plants were cut at ground level, sun dried and dry weight was recorded and expressed in kg per hectare.

As such, sowing of black gram with rice fallow pulse planter (S_1) recorded the highest seed and haulm yield. Whereas, sowing by broadcasting (S_3) recorded the lowest seed and haulm yield. Similar results were also reported by Sasikala et al., [17] who obtained higher seed yield of 1207 kg ha^{-1} rice fallow black gram in sowing by line dibbling compared to sowing by broadcasting (247 kg ha^{-1}).

In the case of time of sowing, black gram sowing at 10 days before rice harvest (T_1) recorded the highest seed 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. [18] who reported that the seed 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 black gram sowing by rice fallow pulse planter at 10 days before harvesting of rice ($M_2S_1T_1$) produced the highest seed and haulm yield (714.90 and 1802.33 kg ha^{-1} respectively). It was followed by rice establishment method of sowing by drum seeder in combination with rice fallow black gram sowing by rice fallow pulse planter at 7 days before harvesting of rice ($M_2T_2S_1$). However, the lowest seed and haulm yield (121.02 and 697.33 kg ha^{-1} respectively) were observed in rice establishment method by machine transplanting in combination with rice fallow black gram (RFB) sowing by broadcasting at 1 day after harvesting of rice ($M_3S_3T_3$).

3.6 Available Nutrients (NPK) in Post-Harvest Soil

Among the rice establishment methods, sowing by drum seeder (M_2) registered highest N, P and K in black gram (Table 4). While, lowest N, P and K was obtained in the rice establishment method of machine transplanting (M_3).

Table 3. Effect of methods and time of sowing and rice establishment methods on Seed and Haulm yield (kg ha^{-1}) of rice fallow black gram (RFB)

Establishment method of Rice	Method of sowing RFB	Time of sowing RFB on seed 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	386.16	353.69	324.16	354.67	1190.66	1193.66	1219.66	1201.33
	S_2	462.91	440.63	309.41	404.32	1222.66	1223.66	1213.33	1219.88
	S_3	271.03	336.78	172.28	260.03	1145.66	1191.66	786.33	1041.22
Mean		373.37	377.03	268.62	339.67	1186.33	1203.00	1073.11	1154.14
M_2	S_1	714.90	622.84	349.12	562.29	1802.33	1716.66	1423.66	1647.55
	S_2	574.54	496.99	278.01	449.85	1654.00	1469.33	1258.00	1460.44
	S_3	258.96	321.75	172.55	251.08	1299.00	1388.00	1230.00	1305.66
Mean		516.13	480.53	266.56	421.07	1585.11	1524.66	1303.88	1471.22
M_3	S_1	524.10	361.74	238.02	374.62	1239.66	1217.00	1123.66	1193.44
	S_2	244.20	429.10	195.09	289.46	1149.66	1236.00	1066.00	1150.55
	S_3	178.72	221.92	121.02	173.89	1058.33	1130.33	697.33	962.00
Mean		315.67	337.58	184.71	279.32	1149.22	1194.44	962.33	1041.22
	SEd	**CD (P=0.05)**			**SEd**	**CD (P=0.05)**			
M	8.05	22.36			21.38	59.38			
S	6.37	12.93			29.21	50.57			
T	8.57	18.67			15.94	32.34			
MS	12.09	28.54			39.17	92.33			
MT	14.55	34.37			31.07	74.04			
ST	11.04	22.40			32.36	68.14			
MST	19.77	41.22			51.02	106.66			

Table 4. Effect of methods and time of sowing and rice establishment methods on available nutrients (NPK) (kg ha^{-1}) of rice fallow black gram (RFB)

Treatment	N	P	K
Main - Establishment method of Rice			
M_1- Line planting by manual method	216.25	11.55	147.11
M_2- Sowing by drum seeder	221.22	11.74	159.03
M_3- Transplanting by machine	212.84	11.50	143.94
SEd	0.05	0.002	0.14
CD (P=0.05)	0.16	0.005	0.39
Sub - Method of sowing RFB			
S_1- Sowing by rice fallow pulse planter	225.03	12.04	154.34
S_2- Random dibbling by manual method	218.14	11.67	149.50
S_3- Sowing by broadcasting (Farmer's practice)	207.13	11.08	146.23
SEd	1.68	0.07	0.37
CD (P=0.05)	3.66	0.17	0.82
Sub-sub - Time of sowing of RFB			
T_1- 10 days before rice harvest	222.13	12.23	153.99
T_2-7 days before rice harvest	215.99	11.73	149.90
T_3- One day after rice harvest	212.19	10.82	146.19
SEd	1.41	0.07	1.01
CD (P=0.05)	2.87	0.15	2.04
Interaction (SEd)	4.20	0.21	2.53
Interaction CD (P=0.05)	NS	NS	NS

Sowing black gram with rice fallow pulse planter (S_1) recorded the highest N, P and K. While in broadcasting (S_3) it obtained lowest N, P and K under several method of sowing.

In the case of different time of sowing, sowing at 10 days before harvesting of rice (T_1) produced the highest N, P and K. Whereas, consistently lowest N, P and K recorded at 1 day after harvesting rice (T_3). Archana Kumari et al. [19] studied that early sowing on October 10 resulted in a considerable increase in N, P and K absorption compared to sowing on October 30.

There was no interaction between the treatments on N, P and K in post-harvest soil.

4. CONCLUSION

According to the findings of this study, sowing rice fallow black gram with a rice fallow pulse planter (seed drill) is the best method for achieving higher growth and better crop establishment in rice fallow black gram, and sowing 10 days before rice harvest is the best time for achieving higher growth and better crop establishment in rice fallow black gram under direct-seeded rice with drum seeder in rice fallow conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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