

## Original Research Article

**Influence of sowing methods and sowing time on growth, yield and yield attributes of blackgram, *Vigna mungo* L. under rice *Oriza sativa* L. fallow blackgram cropping system**

**Comment [JW1]:** ... its ... ?????

**Comment [JW2]:** from

**Comment [JW3]:** Is this scientific name correct? It was the correct species investigated?

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**Comment [JW4]:** What is the correct: blackgram or black gram?

**Comment [JW5]:** In some place of the manuscript, the author need to clarify the scientific name and the variety

**Comment [JW6]:** The text requires an explanation about what is rice fallow blackgram crop system. Maybe here, or in Material and methods.

### **Abstract**

**Aim:** Black-gram is one of the most important pulse crops raised in ~~several~~ types of soil ~~underwith~~ well drained conditions ~~irrespective of season~~. ~~Currently, it~~ is cultivated as ~~monoculture~~ ~~pure crop~~, intercrop as well as rice fallow crop in southern India. In general, the production and productivity of blackgram is ~~getting declining ed because of owing to~~ poor management practices ~~that too in rice fallow blackgram~~. ~~Thus, this Hence the~~ study was undertaken ~~involving~~ rice establishment methods as ~~a one of the strategies to which~~ determine the availability of residual moisture ~~on essential for the~~ establishment of rice fallow blackgram ~~system~~ during ~~theits~~ early ~~growth~~ stages.

**Study design:** ~~The experiment was laid out in Split split plot design with three factors in combination of nine treatments and it was replicated thrice.~~

**Place and Duration of Study:** A field investigation was carried out at Agricultural College and Research Institute, Madurai (Tamil Nadu Agricultural University, ~~Latitude, Longitude and altitude~~), Tamil Nadu, India ~~from during~~ September 2019 ~~to~~ April 2020

**Methodology:** To evaluate the impact of methods and time of sowing on rice fallow blackgram. The factors involve establishment methods of rice as main plot, methods of sowing ~~blackgram on~~ rice fallow blackgram as sub plots, and time of sowing of rice fallow blackgram laid out in sub-sub plot treatment.

**Comment [JW7]:** Poor written. Is rice or blackgram in the sub sub plot

**Comment [JW8]:** Poor readability.

**Results:** ~~The above mentioned~~ treatments had the best growth qualities, growth analysis, and yield. It might be owing to increased residual moisture content in the above-mentioned combinations, which resulted in higher germination percentage, better crop stand, and higher growth and yield of rice fallow blackgram.

**Comment [JW9]:** ??? Poor readability.

**Conclusion:** Sowing blackgram in rice fallow situations with a rice fallow pulse planter 10 days before rice harvest underneath the rice establishment methodology of a drum seeder is the optimum management approach.

**Comment [JW10]:** ????? Poor readability.

**Key words:** Method, Time, Sowing, Establishment, Blackgram

## 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 products. 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 (Mohanty *et al.*, 2015). 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 5.56 lakh tonnes obtained from an area of 8.24 lakh hectares with productivity of 675 kg ha<sup>-1</sup> during 2017-18. Whereas, under blackgram the area is 4.26 lakh hectares with a production of 3.016 lakh tonnes and productivity of 707 kg ha<sup>-1</sup> during 2019-2020 (Govt. of Tamil Nadu, 2020).

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.

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. (Mukesh Choudhary *et al.*, 2014). 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. (Sharma *et al.*, 2014, Kumar *et al.*, 2019). 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 (Mahapatra, 1975).

Time of sowing is the utmost important agronomic factor for realizing yield potential of improved varieties in rice fallow pulse systems; which helps in achieving complete synchronization between vegetative and reproductive stages of crop and also obtaining high seed yields (Rathore *et al.*, 2010). 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. As sowing seeds at proper spacing by

**Comment [JW11]:** Write from pulses to scientific name and variety.

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**Comment [JW13]:** Byproducts.

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**Comment [JW16]:** Local expression

**Comment [JW17]:**

**Comment [JW18]:** Rice fallow and pulses: because pulses can be substituted by other crop.

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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.

## Materials and Methods

A field experiment was conducted at Agricultural College and Research Institute, Madurai (Tamil Nadu Agricultural University) Tamil Nadu, India, ~~from during~~ 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 ~~three times~~ ~~three~~. The main plot (Establishment methods of rice) consisted of  $M_1$  – Line planting by ~~the~~ ~~handyman~~ method,  $M_2$  – Sowing by drum seeder and  $M_3$  – Transplanting by machine; the sub plots (Methods of sowing of rice fallow blackgram) ~~were imposed with~~  $S_1$  – Sowing by rice fallow pulse planter,  $S_2$  – Random dibbling by ~~the~~ ~~handyman~~ method and  $S_3$  – ~~broadcast 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.

**Comment [JW23]:** Where is the yield attributes?

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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. ~~Data~~ ~~Observations~~ were recorded on soil moisture, growth attributes, growth analysis, 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.~~

**Comment [JW25]:** ??????????????

**Comment [JW26]:** How many growing periods of seasons?

**Comment [JW27]:** Please, attach in this place the model of variance analysis.

~~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  $P < 0.05$  and non-significant values were denoted as NS.~~

**Comment [JW28]:** Please, attach in this place the model of variance analysis.

## Results and Discussion

### Soil moisture (%)

In rice establishment methods, sowing by drum seeder ( $M_2$ ) registered distinctly highest soil moisture (36.77 %) at the time of sowing blackgram 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 (2009) reported that the rice fallow pulse relies entirely on moisture and nutrients left over from the previous rice crop to survive.

**Comment [JW29]:** The readability of the Tables does not make sense to readers.

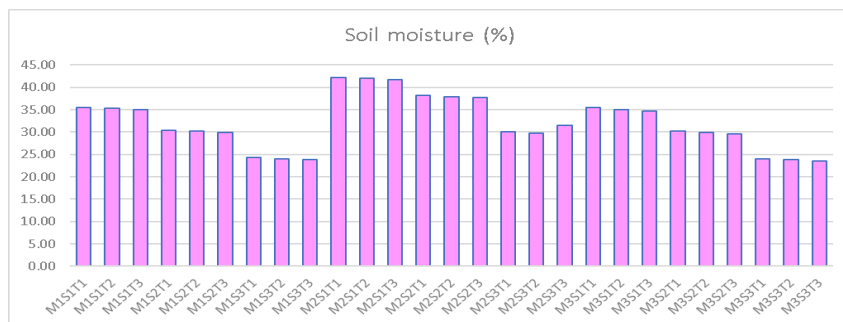
**Comment [JW30]:** Please attach in this section the Anova Table.

Under different methods of sowing, it gave significant impact on soil moisture at the time of sowing of blackgram 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 (Rao, 2011).

In case of different time of sowing of blackgram (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 blackgram**

**Comment [JW31]:** Poor designed.



### Germination percentage

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

The highest germination of 81.42 % was noted in sowing of blackgram with rice fallow pulse planter (S<sub>1</sub>) and lowest germination of 61.84 % in broadcasting (S<sub>3</sub>) method under different methods of sowing as rice fallow situations. Only 1.54 and 1.46 lakh plants ha<sup>-1</sup> were found in blackgram broadcasting beneath stubble mulch, respectively (Kavitha and Wahab, 2001). They have also reported that blackgram 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<sup>-1</sup>.

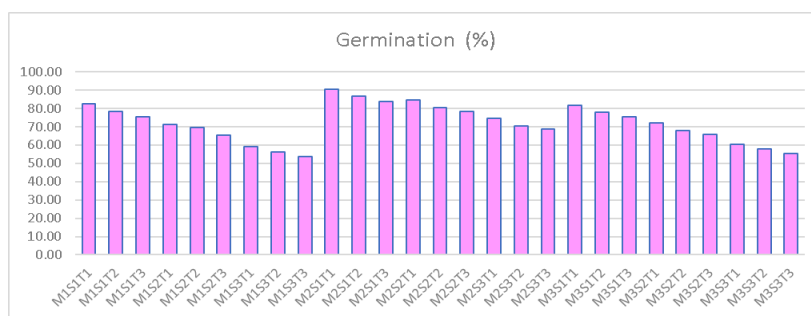
As for different timing, it gave significant impact on germination (%). At 10 days before harvesting of rice (T<sub>1</sub>) recorded the maximum germination (75.22 %), whereas consistently lowest germination (69.19 %) was recorded at 1 day after harvesting rice (T<sub>3</sub>).

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

**Comment [JW32]:** Table of the split plot analyses.

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

**Comment [JW33]:** It does not make sense.



### 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 ( $1686.20 \text{ kg ha}^{-1}$ ) at harvest stage. (Table.1). 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 blackgram 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.* (2001) reported that dibbling of green gram seeds with mulch produced significantly higher LAI of 3.94.

With regard to different time of sowing, sowing blackgram (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 blackgram (RFB) at 1 day after harvesting rice ( $T_3$ ). Similar results were also detected by Maruthupandi *et al.* (2016) and Dasharath Prasad *et al.* (2012) in LAI of rice fallow blackgram sowing at 10 days before harvesting of rice. Gulab Singh Yadav *et al.* (2018) described plant height, LAI and DMP were observed highest in early sowing (25<sup>th</sup> November) compared with delayed sowing (15<sup>th</sup> December) of Lentil in rice fallow lands.

Although studying the interaction effect, rice establishment method of sowing by drum seeder in combination with blackgram 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 ( $2236.90 \text{ kg ha}^{-1}$ ). It was followed by rice establishment method of sowing by drum seeder in combination with blackgram 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 ( $731.78 \text{ kg ha}^{-1}$ ) at harvest stage was noticed in rice establishment method by machine transplanting in combination with sowing of blackgram 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. (Kabir *et al.*, 2009).

UNDER PEER REVIEW

**Table 1.** Effect of methods and time of sowing and rice establishment methods on plant height (cm), LAI and DMP (kg ha<sup>-1</sup>) of rice fallow blackgram (RFB) at harvest

**Comment [JW34]:** Only in this Table is possible to understand that rice was sowed too.

Establishment method of Rice	Method of sowing RFB	Time of sowing			Mean	Time of sowing			Mean	Time of sowing			Mean
		RFB on Plant height at Harvest				RFB on LAI at Harvest				RFB on DMP at Harvest			
		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	
M <sub>1</sub>	S <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	38.74	38.94	39.42	39.03	1.47	1.42	1.40	1.43	1264.20	1362.12	856.02	1160.78
<b>Mean</b>		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 <sub>2</sub>	S <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	39.25	39.38	35.50	38.04	1.59	1.49	1.38	1.49	1391.48	1525.97	1255.55	1391.00
<b>Mean</b>		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 <sub>3</sub>	S <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	38.68	37.97	30.80	35.81	1.44	1.30	1.12	1.28	1106.08	1208.09	731.78	1015.32
<b>Mean</b>		42.47	36.72	32.75	37.31	1.57	1.35	1.22	1.38	1305.65	1365.31	1024.98	1231.98
		<b>SEd</b>		<b>CD (P=0.05)</b>		<b>SEd</b>		<b>CD (P=0.05)</b>		<b>SEd</b>		<b>CD (P=0.05)</b>	

<b>M</b>	0.48	0.98	0.016	0.033	48.40	134.39
<b>S</b>	0.55	1.21	0.027	0.060	20.58	44.85
<b>T</b>	1.19	3.03	0.039	0.098	30.73	62.33
<b>MS</b>	1.26	3.20	0.050	0.121	56.48	147.86
<b>MT</b>	0.84	1.70	0.028	0.057	65.05	158.89
<b>ST</b>	1.45	2.95	0.056	0.118	48.09	98.87
<b>MST</b>	0.98	2.72	0.031	0.087	80.71	165.29

UNDER PEER REVIEW

## Growth analysis

Comment [JW35]: Poor reading paragraphs.

### 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 blackgram (Table.2). While, lowest CGR was obtained in the rice establishment method of machine transplanting ( $M_3$ ).

Sowing blackgram 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.

### Relative growth rate (RGR)

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

Under different methods of sowing of blackgram, it gave significant impact on RGR. Meanwhile, sowing blackgram 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 blackgram (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 blackgram (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 blackgram 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 blackgram 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 CGR, RGR of rice fallow blackgram (RFB) at 60 DAS - Harvest**

Treatment	CGR at 60 DAS - Harvest	RGR at 60 DAS - Harvest
<b>Main - Establishment method of Rice</b>		
$M_1$ - 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
<b>SEd</b>	0.0092	0.00005
<b>CD (P=0.05)</b>	0.025	NS
<b>Sub - Method of sowing RFB</b>		
$S_1$ - Sowing by rice fallow pulse planter	0.603	0.0035

Comment [JW36]: ????????????

S <sub>2</sub> - Random dibbling by manual method	0.554	0.0034
S <sub>3</sub> - Sowing by broadcasting (Farmer's practice)	0.542	0.0044
<b>SEd</b>	0.0096	0.00004
<b>CD (P=0.05)</b>	0.021	0.00010
<b>Sub-sub - Time of sowing of RFB</b>		
T <sub>1</sub> - 10 days before rice harvest	0.590	0.0034
T <sub>2</sub> -7 days before rice harvest	0.571	0.0037
T <sub>3</sub> - One day after rice harvest	0.538	0.0042
<b>SEd</b>	0.010	0.00006
<b>CD (P=0.05)</b>	0.217	0.00012
<b>Interaction (SEd)</b>	0.029	0.00019
<b>Interaction CD (P=0.05)</b>	NS	0.00033

Comment [JW37]: ????

### Yield parameters

As for rice establishment methods, sowing rice by drum seeder (M<sub>2</sub>) recorded distinctly highest seed and haulm yield (421.07 and 1471.22 kg ha<sup>-1</sup> respectively). While, lowest seed and haulm yield (279.32 and 1102.00 kg ha<sup>-1</sup> respectively) was observed in rice establishment method by machine transplanting (M<sub>3</sub>) (Table.3).

Comment [JW38]:

Comment [JW39]: Dry matter yield or ... (percentage of humidity)? Go back to Material and methods. Clarify it!

As such, sowing of blackgram with rice fallow pulse planter (S<sub>1</sub>) recorded the highest seed and haulm yield. Whereas, sowing by broadcasting (S<sub>3</sub>) recorded the lowest seed and haulm yield. Similar results were also reported by Sasikala *et al.*, (2014) who obtained higher seed yield of 1207 kg ha<sup>-1</sup> rice fallow blackgram in sowing by line dibbling compared to sowing by broadcasting (247 kg ha<sup>-1</sup>).

In the case of time of sowing, blackgram sowing at 10 days before rice harvest (T<sub>1</sub>) recorded the highest seed and haulm yield. Whereas, these were consistently lower at 1 day after rice harvest (T<sub>3</sub>). Similar results were made by Rakesh Kumar *et al.* (2015) who reported that the seed yield increased with early sowing (5<sup>th</sup> 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 sowing by rice fallow pulse planter at 10 days before harvesting of rice (M<sub>2</sub>S<sub>1</sub>T<sub>1</sub>) produced the highest seed and haulm yield (714.90 and 1802.33 kg ha<sup>-1</sup> respectively). It was followed by rice establishment method of sowing by drum seeder in combination with rice fallow blackgram sowing by rice fallow pulse planter at 7 days before harvesting of rice (M<sub>2</sub>T<sub>2</sub>S<sub>1</sub>). However, the lowest seed and haulm yield (121.02 and 697.33 kg ha<sup>-1</sup> 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<sub>3</sub>S<sub>3</sub>T<sub>3</sub>).

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**Table 3. Effect of methods and time of sowing and rice establishment methods on Seed and Haulm yield (kg ha<sup>-1</sup>) of rice fallow blackgram (RFB)**

Establishment method of Rice	Method of sowing RFB	Time of sowing			Mean	Time of sowing			Mean
		RFB on seed yield				RFB on haulm yield			
		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>		T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	
M <sub>1</sub>	S <sub>1</sub>	386.16	353.69	324.16	354.67	1190.66	1193.66	1219.66	1201.33
	S <sub>2</sub>	462.91	440.63	309.41	404.32	1222.66	1223.66	1213.33	1219.88
	S <sub>3</sub>	271.03	336.78	172.28	260.03	1145.66	1191.66	786.33	1041.22
<b>Mean</b>		373.37	377.03	268.62	339.67	1186.33	1203.00	1073.11	1154.14
M <sub>2</sub>	S <sub>1</sub>	714.90	622.84	349.12	562.29	1802.33	1716.66	1423.66	1647.55
	S <sub>2</sub>	574.54	496.99	278.01	449.85	1654.00	1469.33	1258.00	1460.44
	S <sub>3</sub>	258.96	321.75	172.55	251.08	1299.00	1388.00	1230.00	1305.66
<b>Mean</b>		516.13	480.53	266.56	421.07	1585.11	1524.66	1303.88	1471.22
M <sub>3</sub>	S <sub>1</sub>	524.10	361.74	238.02	374.62	1239.66	1217.00	1123.66	1193.44
	S <sub>2</sub>	244.20	429.10	195.09	289.46	1149.66	1236.00	1066.00	1150.55
	S <sub>3</sub>	178.72	221.92	121.02	173.89	1058.33	1130.33	697.33	962.00
<b>Mean</b>		315.67	337.58	184.71	279.32	1149.22	1194.44	962.33	1041.22
	<b>SEd</b>	<b>CD (P=0.05)</b>			<b>SEd</b>	<b>CD (P=0.05)</b>			
<b>M</b>	8.05	22.36			21.38	59.38			
<b>S</b>	6.37	12.93			29.21	50.57			
<b>T</b>	8.57	18.67			15.94	32.34			
<b>MS</b>	12.09	28.54			39.17	92.33			
<b>MT</b>	14.55	34.37			31.07	74.04			
<b>ST</b>	11.04	22.40			32.36	68.14			
<b>MST</b>	19.77	41.22			51.02	106.66			

### 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 blackgram (Table.4). While, lowest N, P and K was obtained in the rice establishment method of machine transplanting ( $M_3$ ).

Sowing blackgram 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.* (2012) 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.

**Table 4. Effect of methods and time of sowing and rice establishment methods on available nutrients (NPK) ( $\text{kg ha}^{-1}$ ) of rice fallow blackgram (RFB)**

Treatment	N	P	K
<b>Main - Establishment method of Rice</b>			
$M_1$ - 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
<b>Sub - Method of sowing RFB</b>			
$S_1$ - 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
<b>Sub-sub - Time of sowing of RFB</b>			
$T_1$ - 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

## Conclusion

From this investigation, it could be concluded that sowing rice fallow blackgram with rice fallow pulse planter at 10 days before rice harvesting under the rice establishment method of drum seeder is the best management practice to get better growth, yield and yield attributes besides growth analysis in rice fallow blackgram.

Comment [JW41]: Who is it?

Comment [JW42]: From which one?

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