*Original Research Article*

# 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


## 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 University$9^{o}54'$ 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.



**Key words:** Method, Time, Sowing, Establishment, Black gram

## 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 (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 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 (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 (Kar and Kumar 2009).

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 pulses system; 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 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.

## 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.

## Results and Discussion

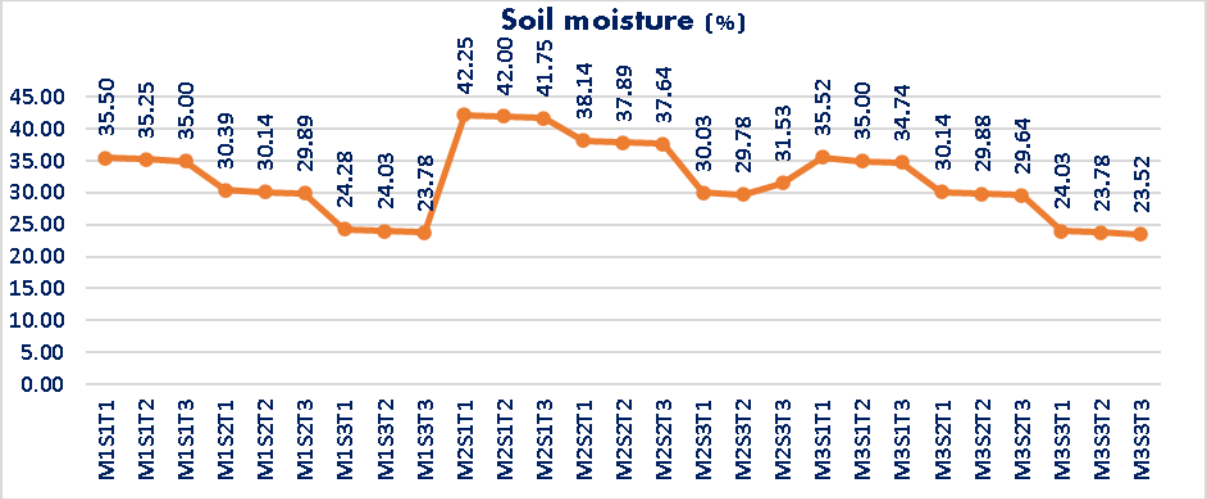
### Soil moisture (%)

In rice establishment methods, sowing by drum seeder ($M_2$) registered distinctly highest soil moisture (36.77 %) at the time of sowing 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 (2009) 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 (Rao, 2011).

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**




**Germination percentage**

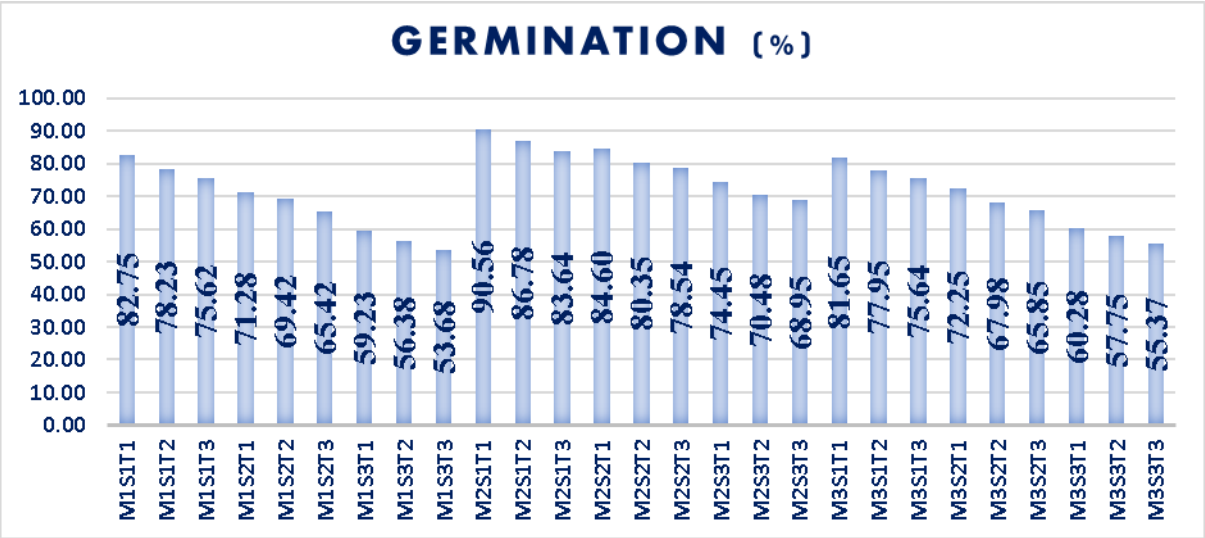
From Fig. 2, the rice establishment methods, sowing by drum seeder ($M_2$) recorded distinctly highest germination (79.81 %). Whereas the lowest germination (68.00 %) were recorded in the manual transplanting of rice establishment method ($M_2$).

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 (Kavitha and Wahab, 2001). 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**




**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. (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 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.* (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 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.* (2016) and Dasharath Prasad *et al.* (2012) in LAI of rice fallow black gram 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$^{th}$ November) compared with delayed sowing (15$^{th}$ 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. (Kabir *et al.*, 2009).

**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 | | | 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 | | | |
| | | $T_1$ | $T_2$ | $T_3$ | | $T_1$ | $T_2$ | $T_3$ | | $T_1$ | $T_2$ | $T_3$ | |
| $M_1$ | $S_1$ | 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 |

**Growth analysis**

**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.

**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 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 |

**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*., (2014) 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*. (2015) who reported that the seed yield increased with early sowing ($5^{th}$ 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 ($M_3S_3T_3$).

**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 | | | Mean | Time of sowing | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | | RFB on seed yield | | | | RFB on haulm yield | | | |
| | | $T_1$ | $T_2$ | $T_3$ | | $T_1$ | $T_2$ | $T_3$ | |
| $M_1$ | $S_1$ | 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 |

**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 ($M_3$).

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.* (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) (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 |

## 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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