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Performance of *Rabi* Blackgram (*Vigna mungo*L.,) under Different Sowing Windows

K Reddemma [a++], M. Sreenivas Reddy [a#*] and M Kishan Tej [b†]

[a] *Department of Agronomy, Agricultural College, Mahanandi, ANGRAU, Andhra Prasesh, India.*
[b] *Department of Entomology, SMGR Agricultural College Udayagiri, ANGRAU, Andhra Prasesh, India.*

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

Field experiment was conducted at the College Farm, Agricultural College, Mahanandi of Acharya N.G. Ranga Agricultural University during the period from October, 2017 to January 2018 to evaluate the performance of *rabi*blackgram (*Vigna mungo* L.) under different sowing windows. The experimental site was sandy loam and it was neutral in reaction with a pH of 7.30, EC of 0.20 ds m^{-1}. The experiment comprised four blackgram varieties viz., TBG-104, LBG-787, GBG-1 and PU-31 and four sowing dates viz., 1st fort night of October, 2nd fort night of October, 1st fort night November and 2nd fort night November.The experiment was laid out in randomized block design with factorial concept (FRBD) having sixteen treatments and three replications. Results showed that varieties and dates of sowings significantly influenced all the parameters in the growth attributing experimentation

++M.Sc.;
Professor and Head (Agronomy);
† Assistant Professor;
*Corresponding author: E-mail: msreenivas1974@gmail.com;

characters such as plant height, dry weight, leaf area index, and yield attributing characters like number of pods plant^{-1}, number of seeds pod^{-1} and 1000 seed weight and seed yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index (%) and were found highest in PU-31and lowest in LBG-787. With regard to sowing windows, the higher as well as lower values of these parameters were observed with sowing 1st fort night of October and 2nd fort night of November, respectively. Sowing PU-31 on 1st fort night of October and 2nd fort night of November gave the highest seed yield (856.42 kg ha^{-1}) and haulm yield (2473.96 kg ha^{-1}) respectively. Overall the results proved that 1st FN of October seems to be the appropriate sowing date for getting higher yield of black gram during *rabi* season. Among different varieties PU-31 came out with higher yield followed by GBG-1, TBG-104 and LBG-787.

Keywords: Blackgram; vignamungo; legume; fabaceae.

1. INTRODUCTION

Pulses has great importance in Indian Agriculture as they are rich source of protein (17 to 25 %) compared to that of cereals (6 to 10 %) and their ability to fix atmospheric nitrogen and improve the soil fertility is of great importance. Among pulses, blackgram is one of the most important crops. Blackgram has originated from Indian sub-continent and found close resemblance between the chromosomes of *Vignamungo*and *Vigna radiata.*

Blackgram (*Vigna mungo* L.) belongs to family Fabaceae sub family papilionaceae, is being grown as one of the principle pulse crop. The most important states for pulses are Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Bihar which together account for 80% of total production. In India, it is cultivated in an area of 2.346 M ha with a production of 1.959 M t. In Andhra Pradesh, it occupies an area of 0.315 M ha with production of 0.298 M t. The average productivity of blackgram in Andhra Pradesh (946 kg ha^{-1}) is high as compared to India’s productivity (604 kg ha^{-1}).

The population of India is projected to grow from the current 1.40 billion (In 2021) to 1.68 billion by 2030. Accordingly, the projected pulse requirement for the year 2030 would be 32 million tonnes from the present level of 15 million tonnes with necessary growth rate of 4.2 per cent, where as the per capita availability of pulses decreasing from 69 g in 1961 to 37 g in 2016-17 in the country has been a serious concern. To alleviate protein energy malnutrition, a minimum of 50g pulses/capita/day should be available in addition to other sources of protein.

In this context, there is an urgent need to increase the production levels of pulses to meet the increasing demand by manipulating the production techniques. To fulfil our future requirement, it is must to follow the scientific production of pulses. Amongst all the factors of crop production, timely sowing is important in all crops and in all seasons as time of sowing will influence theyield and growth of the crops to the most and the date of sowing determine time of flowering and dry matter accumulation, seed set and seed yield. During *kharif* season, the major constraints are high humidity associated with luxurious vegetative growth, high insect-pest, diseases and less fruit setting etc. In order to save the crop from adverse effects of excess moisture during *kharif* season, cultivation of blackgram during *rabi* season or early summer may be beneficial where ever irrigation facilities are available.

Moreover, in recent years interest has been on the farmers for replacing many of traditional crops in late *kharif* and *rabi* with blackgram as the returns are more due to relatively more remunerative prices of blackgram compared to traditional cereal crops and also the duration of blackgram is smaller in nature. Since in recent years the crop has become susceptible to yellow mosaic virus, considerable number of tolerant varieties are released by Acharya N.G. Ranga Agricultural University and other State agricultural universities. Hence an experiment is conducted to find out the performance of different varieties of blackgram to different sowing widows in *rabi* 2017-18.

2. MATERIALS AND METHODS

Field experiments were conducted to study the performance of *rabi*blackgram [*Vigna mungo* (L.) Hepper] under different sowing windows during *rabi*, 2017-18at College Farm, Agricultural College, Mahanandi of AcharyaN.G. Ranga Agricultural University, which is geographically situated at 15^{0}.51' N latitude and 78^{0}.61' E longitude with an altitude of 233.48 meters above the mean sea level in Scarce Rainfall Zone of Andhra Pradesh and according to Troll's classification, it falls under Semi-Arid Tropics (SAT).Weather during the crop period recorded at meteorological observatory in Agricultural college farm, Mahanandi is presented in Table-1.

2.1 Soil Characteristics of the Experimental Site

The initial soil samples were collected at random from 0-30 cm depth from the experimental field and the composite soil sample was analyzed for different physico-chemical properties. The results along with the methods employed for each of them are presented (Table -2). The results of physico-chemical properties revealed that soil was sandy loam in texture, medium in organiccarbon and nitrogen, high in phosphorus, potassium and sulphur, medium in calcium, low in magnesium and nearly optimum in zinc.

2.2 Experimental Details

2.2.1 Design and layout

The experiment was laid out in a Factorial randomized block design consisting of sixteen treatments with three replications. The lay out plan is furnished in the Fig.1.

Number of treatments: 16

List 1. Treatment details

Factor :1 Varieties (V)	Factor :II Dates of sowing (D)
V_1: TBG-104	D_1:1st FN of October
V_2: LBG- 787	D_2:2nd FN of October
V_3: GBG-1	D_3:1St FN of November
V_4: PU-31	D_4:2nd FN of November

List 2. Plot size and spacing

Season		*Rabi,* 2017-18
Design	:	Factorial Randomized Block Design
Gross	:	6.0 m x 5.0 m
Net	:	4.8 m x 4.6 m
Spacing	:	30.0 cm x 10.0 cm
Replications	:	Three

Varieties:

TBG-104: The variety TBG-104 is a photo insensitive variety suitable for cultivation in all the seasons under upland conditions. It is early maturing variety (75 days) with dark green foliage.

LBG-787 It is also photo insensitive suitable for cultivation in all the seasons including rice fallow situation. Duration of crop maturity is 75-80 days.
GBG-1: Bold seed variety is suitable for all seasons, tolerant to yellow mosaic with crop duration is 80-90 days.

PU-31: This variety matures in 85-90 days (medium) and is widely adaptive, popular and high yielding variety and resistant YMV disease. It is suitable for all seasons.

2.3 Biometric Observations Recorded

For recording the growth characters and yield attributes, five plants in net plot of each treatment were selected randomly and labelled with tags. Observations were recorded throughout the crop period. Destructive sample collected from border rows in sequence manner. Data on yield parameters were recorded at harvest.

2.4 Pre-Harvest Observations

Initial and final plant population: At 10 DAS in each plot, number of rows and in each row number of plants were counted and taken as initial plant population. Number of plants in each row was counted at harvest which represents the final plant population and both were expressed per m^2

Plant height: Plant height was measured from the base of the plant to the growing tip of the plants for five labelled plants at 30, 60 DAS and at harvest and the mean value was expressed in centimetres (cm).

Dry matter production: At 30, 60 DAS and at harvest five plants were uprooted from the destructive sampling area, leaving the extreme border rows. The plant samples were dried initially under sun and later dried in hot air oven at 70^{o}C to a constant weight. Dry matter production per hectare was worked out by taking the oven dry weight of all the five plants and expressed as kg ha^{-1}
Leaf area index: Leaf area from five destructive sampled plants was measured at 30, 60 DAS and at harvest using LI-COR Model LI-3100C leaf area meter with transparent conveyer belt having electronic display and expressed in cm^2. Leaf area index was calculated by dividing the total leaf area with the corresponding land area as suggested by Watson [1].

$$LAI = \frac{\text{Total Leaf area}}{\text{Unit land area}}$$

Harvest index: The relationship of economic yield to the total biological yield was expressed as harvest index.

$$\text{Harvest Index (\%)} = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

2.5 Statistical Analysis

The statistical analysis of data recorded for various characters studied in the investigation was followed by using statistical procedures appropriate to the Factorial Randomized Block Design (FRBD) as described by Panse and Sukhatme [2] and the differences were tested by F"test. Summary table for treatment mean has been prepared and furnished with standard error of mean (S.Em.) and co-efficient of variation (percent). Critical Difference (C.D.) at 5 percent level of probability has also been calculated where the treatment effects were found significant.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height at 30DAS: The significant variation in plant height of blackgram was recorded with different varieties and dates of sowing at 30DAS (Table 3).

Among the different varieties of black gram, the tallest plants (29.96 cm) were found in V_4 (PU-31), which were statistically similar (28.68 cm) with V_3 (GBG-1), while the shortest plant (27.86 cm) was recorded in V_2 (LBG-787), which was followed (28.36 cm) by V_1 TBG-104.
Data on different dates of sowing showed that the tallest plants (32.76 cm) were recorded in D_1 (Sowing on 1st fort night of October), which was followed (29.93 cm) by D_2 (Sowing on 2nd fort night of October) while the shortest plants (24.73 cm) were recorded from D_4 (Sowing on 2nd fort night of November) it was on par (27.45 cm) with D_3 (Sowing on 1st fort night of November). There results were in conformity with the findings of Jajgot Singh Gill. [3].

Plant height at 60DAS: The plant height of blackgram was found significant among different varieties and dates of sowing at 60DAS (Table 4)

Data pertaining to varieties, the tallest plants (41.61cm) were found in V_4 (PU-31) at 60DAS, which were statistically comparable with (40.84cm) V3 (GBG-1) while the shortest plants were recorded in (39.04 cm) V_2 (LBG-787) which was on par with V_1 (TBG-104) (39.45cm).

Among different sowing dates, the tallest plants (45.17cm) were recorded in D_1 (Sowing on 1st fort night of October), which was closely comparable with D_2 (43.51 cm) (Sowing on 2nd fort night of October) while the shortest plants (32.09 cm) were obtained from D_4 (Sowing on 2nd fort night of November), which was at par with (40.18 cm) D_3 (Sowing on 1st fort night of November) for same days after sowing.

Plant height at harvest: The significant variation was recorded for plant height of blackgram for different varieties and dates of sowing at harvest (Table 5).

The tallest plants (43.85 cm) were found in V_4 (PU-31), which were statistically on par (42.89 cm) with V_3 (GBG-1) while the shortest plants were obtained (41.34cm) in V_2 (LBG-787) which was at par with V_1 (TBG-104) (42.18cm).

With regard to dates of sowing, the tallest plant (46.93 cm) was recorded in D_1 (Sowing on 1st fort night of October), which were (45.12 cm) comparable with D_2 (Sowing on 2nd fort night of October) while the shortest plants (33.99 cm) were obtained from D_4 (Sowing on 2nd fort night of November), which were on par (44.22 cm) with D_3 (Sowing on 1st fort night of November).

The highest plant height at 30, 60 and harvest was observed with V_4 (PU-31) and D_1 (Sowing on 1st fort night of October) over other varieties and dates of sowing. This might be due to early sowing of blackgram during October that enhanced the accumulation of more photosynthates due to high temperatures occurred than later dates of sowing and blackgram variety PU-31 due to its genetical potential helped in producing more no of leaves that resulted in more accumulation of photosynthates and also favoured the plant height. These results were in line with the findings of Rehman *et.al* [4] Sharma *et.al.* [5] and Kundu *et.al.* [6]

The interaction between varieties and dates of sowing were found to be non significant at all stages of (30, 60 DAS and at harvest) of crop growth during experimentation.

3.2 Dry Matter Accumulation

Dry matter recorded at 30, 60 DAS and at harvest was significantly influenced by varieties and dates of sowing of blackgram.

Dry matter accumulation at 30DAS: The significant difference wasobserved in dry matter accumulation of blackgram for different varieties and dates of sowing at 30DAS (Table 6)

Among different varieties, the highest dry matter accumulation (572.46 kg ha^{-1}) was found in V_4 (PU-31), which was statistically on par (548.96 kg ha^{-1}) with V_3 (GBG-1), while the lowest dry matter accumulation was recorded (531.40 kg ha^{-1}) in V_2 (LBG-787) which was on par (534.54 kg ha^{-1}) with V_1 (TBG-104).

Dry matter accumulation of blackgram varied significantly for different sowing dates. The highest dry matter accumulation (687.27 kg ha^{-1}) was obtained in D_1 (Sowing on 1^{st} fort night of October) which was followed (596.04 kg ha^{-1}) by D_2 (Sowing on 2^{nd} fort night of October) and the lowest dry matter accumulation was obtained (409.67 kg ha^{-1}) in D_4 (Sowing on 2^{nd} fort night of November) which was on par (500.39 kg ha^{-1}) with D_3 (Sowing on 1^{nd} fort night of November). Similar results were found by Jajgot Singh gill [3].

Dry matter accumulation at 60DAS (kg ha^{-1}): The significantdifferences were recorded for dry matter accumulation of blackgram with varieties and dates of sowing at 60DAS (Table 7).With regard to different varieties, the highest dry matter accumulation(2355 kg ha^{-1}) was found in V_4 (PU-31), which was statistically comparable (2322 kg ha^{-1}) with V_3 (GBG-1) and the lowest dry matter accumulation was recorded (2212 kg ha^{-1}) in V_2 (LBG-787) which was on par with (2281 kg ha^{-1}) in V_1 (TBG-104).

Dry matter accumulation of blackgram was significantly varied due to different sowing dates. The highest dry matter accumulation (2509 kg ha^{-1}) was obtained in D_1 (Sowing on 1^{st} fort night of October), which was followed (2374 kg ha^{-1}) by D_2 (Sowing on 2^{nd} fort night of October) and the lowest dry matter accumulation in plant (2054 kg ha^{-1}) was obtained from D_4 (Sowing on 2^{nd} fort night of November), which was on par (2233 kg ha^{-1}) with D_3 (Sowing on 1^{nd} fort night of November). These results are in confirmatory with findings of Monem *et.al.* [7]

Dry matter accumulation at harvest (kg ha^{-1}): The significantvariation was recorded for dry matter accumulation of blackgram with different varieties and sowing dates at harvest (Table 8).With regard to varieties, the highest dry matter accumulation in plant(4003 kg ha^{-1}) was found in V_4 (PU-31), which was statistically comparable (3952 kg ha^{-1}) with V_3 (GBG-1), while the lowest dry matter (3833 kg ha^{-1}) was obtained in V_2 (LBG-787) which was on par with (3912 kg ha^{-1}) V_1 (TBG-104).

Dry matter accumulation of blackgram varied significantly for different sowing dates at harvest. The highest dry matter accumulation in plant (4546 kg ha^{-1}) was obtained in D_1 (Sowing on 1^{st} fort night of October), which was (4392 kg ha^{-1}) statistically followed by D_2 (Sowing on 2^{nd} fort night of October) and the lowest dry matter accumulation(3111 kg ha^{-1}) was obtained from D_4 (Sowing on 2^{nd} fort night of November), which was on par (3651 kg ha^{-1}) with D_3 (Sowing on 1^{nd} fort night of November).

The highest dry matter was observed with the variety PU-31 (V_4) and D_1 (Sowing on 1^{st} fort night of October) at all the growth stages of crop over other dates of sowing and varieties might be attributed to genetic makeup of variety and effective utilization resources such as water, nutrient, light and space in a conductive crop environment. Moreover, during early stages of crop growth the allocation of dry matter was towards to the vegetative plant parts. These results are in consistent with Gangwar*et.al.* [8] Jagjot Singh Gil. [3] Jadhav[9] and Kumar *et.al.* [10].

The interaction between varieties and dates of sowing in dry matter accumulation was found to be non significant at all stages of (30, 60 DAS and at harvest) of crop growth during experimentation

3.3 Leaf Area Index (LAI)

Leaf area index in blackgram was significantly influenced by varieties and dates of sowing at 30, 60 DAS and at harvest. The leaf area index increased progressively from 30 to 60 DAS but declined as the crop reached harvest stage due to loss of chlorophyll and senescence of lower leaves at maturity stage

Leaf Area Index at 30DAS: The significant variation was observed inleaf area index of blackgram for different varieties and dates of sowing at 30DAS (Table 9).

The highest leaf area index (0.52) was found in V_4 (PU-31) which was statistically identical (0.51) with V3 (GBG-1) and the lowest leaf area index

(0.48) was found in V_2 (LBG-787) which was on par (0.49) with in V_1 (TBG-104).

Due to different sowing dates, the highest leaf area index (0.64) was recorded in D_1 (Sowing on 1st fort night of October), which was (0.54) comparable with D_2 (Sowing on 2nd fort night of October) and the lowest leaf area index (0.33) was observed in D_4 (Sowing on 2nd fort night of November), which was on par with (0.49) D_3 (Sowing on 1st fort night of November).

Leaf Area Index at 60DAS: The significant variation was recorded inleaf area index of blackgram for different varieties and dates of sowing at 60DAS. (Table 10)

The highest leaf area index (0.73) was found in V_4 (PU-31), which was statistically comparable (0.68) with V_3 (GBG-1) and the low leaf area index (0.65) was recorded in V_2 (LBG-787) which was on par (0.66) with V_1 (TBG-104) for same DAS.

Leaf area index of blackgram due to different sowing dates, the highest leaf area index (0.84) was recorded in D_1 (Sowing on 1st fort night of October), which was (0.76) comparable with D_2 (Sowing on 2nd fort night of October) and the lowest leaf area index (0.44) was observed in D_4 (Sowing on 2nd fort night of November), which was on par with (0.69) D_3 (Sowing on 1st fort night of November.

Leaf Area Index at harvest: The significant variation was recorded inleaf area index of blackgram with different varieties and dates of sowing at harvest (Table 11).
The highest leaf area index (0.72) was found in V_4 (PU-31) which was statistically followed (0.69) by V_3 (GBG-1) and the low leaf area index (0.63) was recorded in V_2 (LBG-787) which was on par (0.67) with V_1 (TBG-104) at harvest.

Due to different sowing dates, the highest leaf area index (0.83) was recorded in D_1 (Sowing on 1st fort night of October), which was followed (0.79) by D_2 (Sowing on 2nd fort night of October) and the lowest leaf area index (0.39) was obtained in D_4 (Sowing on 2nd fort night of November), which was on par (0.69) with D_3 (Sowing on1st fort night of November).

The highest leaf area index was found with V_4 (PU-31) and D_1 (Sowing on 1st fort night of October) over other varieties and dates of sowing might be due to higher number of leaves and ultimately high leaf area which resulted in increased transfer of photosynthates to sink. Similar results were reported by Sharma *et.al.* [5] Mondal *et.al.* [11] Wilson *et.al.* [12] Jadhav *et.al.* [9] and Khot *et.al.* [13].

The interaction between varieties and dates of sowing in leaf area index was found to be non significant at all stages of (30, 60 DAS and at harvest) of crop growth during the study.

3.4 Yield Attributes

3.4.1 Number of pods per plant

Number of pods per plant in blackgram was significantly influenced by different varieties and dates of sowing at harvest (Table 12).

The more number of pods plant^{-1} (23.42) were found in V_4 (PU-31) at all dates of sowing studied in experimentation, which was statistically comparable (22.97) with V_3 (GBG-1) and the lowest pods per plant (21.66) was obtained in V_2 (LBG-787) which was on par (21.88) with V_1 (TBG-104)

Number of pods per plant of blackgram at harvest varied significantly due to sowing dates. More number of pods per plant (25.70) was recorded in D_1 (Sowing on 1st fort night of October), which was followed (22.88) by D_2 (Sowing on 2nd fort night of October) and the lowest pods per plant (19.89) was obtained from D_4 (Sowing on 2nd fort night of November), which was on par (21.42) with D_3 (Sowing on 1st fort night of November).
The more number of pods plant^{-1} were found in V_4 (PU-31) at all dates of sowing studied in experimentation might be attributed to genetic makeup of variety that has helped in improving photosynthetic activity due to increased source capacity and efficient translocation of photosynthates to the sink. Similar reports were also by Patra *et.al.* [14] Yadahalli*et.al.* [15] Ghosh *et.al.* [16] and Imran *et.al.* [17].

Statistically non significant differences were recorded in number of pods per plant due to the interaction effect of variety and sowing dates for number of pods per plant at harvest.

3.4.2 Number of seeds pod^{-1}

Number of seeds per pod was significantly varied with different varieties and sowing dates at harvest (Table 13).

More number of seeds per pod (5.38) was found in V_4 (PU-31) at all dates of sowing studied, which were statistically comparable (5.15) with V_3 (GBG-1) and the lowest number seeds per pod (4.79) were obtained in V_2 (LBG-787) which was on par (4.88) with V_1 (TBG-104).

Number of seeds per pod of blackgram at harvest varied significantly due to sowing date. More number of seeds per pod (7.48) was recorded in D_1 (Sowing on 1st fort night of October), which was (6.54) followed by D_2 (Sowing on 2nd fort night of October) and the lowest seeds per pod (5.29) was recorded in D_4 (Sowing on 2nd fort night of November), which was on par (6.17) with D_3 (sowing on 1st fort night of November).

Number of seeds per pod was higher with V_4 (PU-31) at all dates of sowing studied due to higher growth and physiological attributes. These results are similar with the results of Biswas *et.al.* [18] and Monem *et.al.* [7].

Statistically non significant differences were recorded due to the interaction effect of varieties and sowing dates for number of seeds per pods during the study.

3.4.3 Test weight

Statistically significant differences were observed in test weight of blackgram with different varieties and sowing dates (Table 14).

The highest test weight (41.36 g) was found in V_4 (PU-31), which was comparable (40.80 g) with V_3 (GBG-1) while the lowest weight of 1000 seeds (39.08) was found in V_2 (LBG-787) which was on par (39.85) with V_1 (TBG-104). Patra *et.al* (2001) found that varieties also had significant effect on test weight of blackgram and reported that variety PU-19 recorded test weight which was at par with PU-30.

Test weight of blackgram differs significantly due to sowing dates. The higher test weight (42.45 g) was recorded in D_1 (Sowing on 1st fort night of October), which was statistically followed (40.75g) by D_2 (Sowing on 2nd fort night of October) and the lowest weight of 1000 seeds (38.36g) was obtained in D_4 (Sowing on 2nd fort night of November) which was on par (39.53 g) with D_3 (sowing on1st fort night of November).

The highest test weight was found in V_4 (PU-31) and D_1 (Sowing on 1st fort night of October) which attributed to short vegetative period of growth and comparatively long reproductive and grain filling period that significantly raised the test weight of blackgram.

Statistically non significant test weight was recorded due to interaction effect of varieties and sowing dates in the experimentation.

3.5 Yield

3.5.1 Seed yield (kg ha^{-1})

Significant and progressive difference was observed in seed yield of blackgram due to different varieties and dates of sowing (Table 15)

The highest seed yield (845 kg ha^{-1}) was obtained in V_4 (PU-31), which was statistically followed (829 kg ha^{-1}) by V_3 (GBG-1) and the lowest seed yield (778 kg ha^{-1}) was found in V_2 (LBG-787) which was on par (790 kg ha^{-1}) with V_1 (TBG-104).

Seed yield of blackgram at harvest varied significant due to sowing dates. The highest seed yield (856 kg ha^{-1}) was recorded in D_1 (sowing on 1st fort night of October), which was statistically followed (835 kg ha^{-1}) by D_2 (sowing on 2nd fort night of October) and the lowest seed yield (741 kg ha^{-1}) was found in D_4 (sowing on 2nd fort night of November) which was on par (809 kg ha^{-1}) with D_3 (sowing on1st fort night of November).

Interaction effect of varieties and sowing dates showed statistically significant difference for seed yield under the present trial. The highest seed yield (891kg ha^{-1}) was recorded from V_4D_1 (PU-31 and Sowing on 1st fort night October) and the lowest seed yield (727 kg ha^{-1}) was found from V_2D_4 (LBG-787 and Sowing on 2nd fort night November). Singh (2009) reported thathigher seed yield (17.45q ha^{-1}) was obtained with 20th October sowing crop than other sowing dates (27th October, 3th November, 10th November).

The higher seed yield (kg ha^{-1}) was obtained in V_4D_1 (PU-31 and Sowing on 1st fort night October) due to its inherited genetic makeup as evidence by higher vegetative growth, yield attributing characters. It may be the result of increased translocation of photosynthates towards grain formation. Moreover early sowing of the crop resulted in higher accumulation of photosynthates dueto high temperatures that later dates of sowing. These results are in line with the findings of Inderjit *et.al.*[19] Monem *et.al.* [7] and Pantora*et.al.*[20].

Table 1. Standard week wise meteorological data during the crop growth period (03.10.2017 to 29.01.2018)

Standard week	Date and Month	Temperature (°C)		Mean relative	Rainfall (mm)	Number of
		Maximum	Minimum	Humidity (%)		rainy days
40	3 OCT– 7 OCT	30.5	23.8	85.5	5	1
41	8 OCT– 14 OCT	30.4	23.9	86.2	17	1
42	15 OCT – 21OCT	31.3	23.1	82.2	10	1
43	22 OCT – 28 OCT	32.4	22.7	74.3	0	0
44	29 OCT– 4 NOV	31.2	19.6	74.8	0	0
45	5 NOV– 11 NOV	30.7	21.3	74.6	0	0
46	12 NOV – 18 NOV	31.7	19.9	78.7	0	0
47	19NOV – 25 NOV	32.5	21.0	74.5	0	0
48	26NOV – 2 DEC	31.3	19.7	73.5	0	0
49	3 DEC – 9 DEC	31.3	19.3	76.5	0	0
50	10 DEC –16 DEC	31.6	16.9	69.5	0	0
51	17 DEC – 23DEC	30.4	15.4	68.4	0	0
52	24 DEC – 30 DEC	30.7	16.0	67.5	0	0
53	31 DEC – 6 JAN	30.4	16.8	64.2	0	0
1	7 JAN – 13 JAN	30.3	17.4	67	0	0
2	14JAN – 20 JAN	31.4	16.6	65.5	0	0
3	21JAN – 27JAN	31.1	16.3	64.3	0	0
4	28JAN – 29 JAN	31.5	17	59.7	0	0
	Total	560.7	387.9	1233.4	32	3
	Mean	31.15	21.55	68.5		

Table 2. Physico-chemical properties of the soil of the experimental field

Particulars	Value	Method
I.Physical characteristics		
Sand (%)	68.36	Bouyoucos Hydrometer
Silt (%)	20.91	(Piper, 1950)
Clay (%)	10.73	
Soil texture	Sandy loam	
II.Chemical characteristics		
Soil pH (1 : 2.5 soil water suspension)	7.3	Glass electrode pH meter (Jackson, 1973)
Electrical conductivity ($dS\ m^{-1}$)	0.20	Conductivity bridge (Jackson, 1973)
Organic carbon (%)	0.57	Wet digestion method (Walkley and Black, 1934)
Available N ($kg\ ha^{-1}$)	297	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 ($kg\ ha^{-1}$)	44	Olsen's method (Olsen et al., 1954)
Available K_2O ($kg\ ha^{-1}$)	392	Flame photometry (Jackson, 1973)
Exchangeable Ca [C mol. (P^+) kg^{-1}]	2.2	EDTA Titration method(Cheng and Bray, 1951)
Exchangeable Mg [C mol. (P^+) kg^{-1}]	0.9	
Available S (ppm)	27	$CaCl_2$ turbidimetry method (Chesnin and Yien, 1950)
Available Zn (ppm)	0.61	DTPA extractant by AAS method (Lindsay and Norwell, 1978)

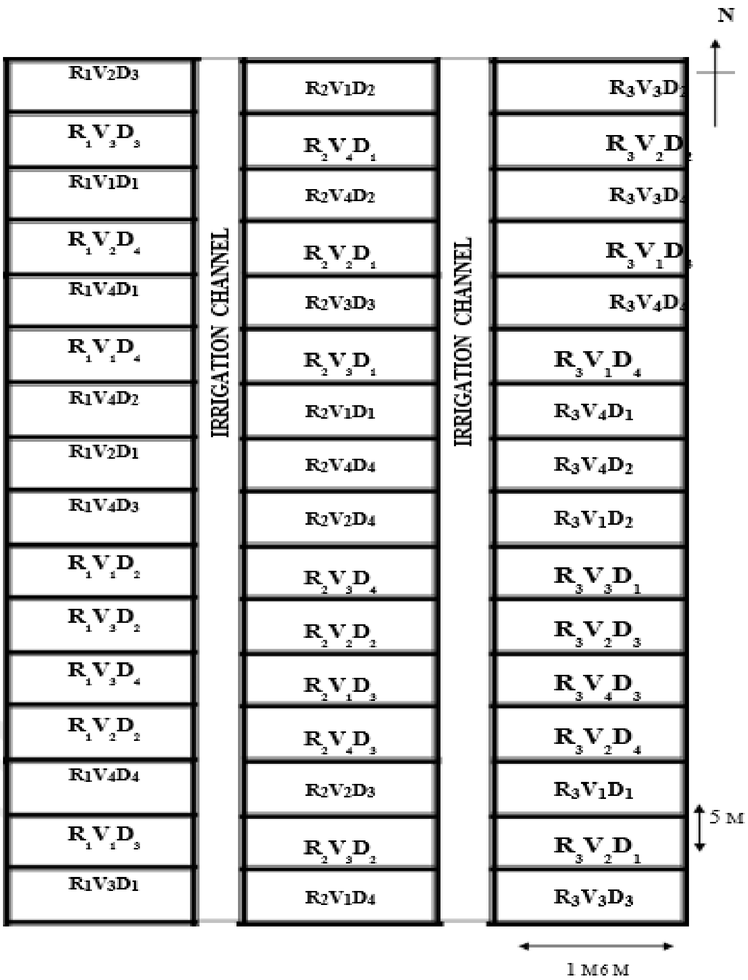

Fig. 1. Layout plan of the experimental field

Table 3. Plant height (cm) of blackgram at 30 DAS as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	31.84	31.21	33.43	34.54	32.76
D2: (October 2nd FN)	29.50	28.47	29.90	31.87	29.93
D3: (November 1st FN)	27.13	26.47	28.07	28.13	27.45
D4: (November 2nd FN)	24.17	25.30	23.33	25.30	24.72
Mean	28.36	27.86	28.68	29.96	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.42		1.21		
Dates of sowing (D)	0.42		1.21		
Interaction (VXD)	0.84		NS		

Table 4. Plant height (cm) of blackgram at 60 DAS as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	44.47	42.27	46.93	47.00	45.17
D2: (October 2nd FN)	42.10	43.80	44.13	44.00	43.51
D3: (November 1st FN)	39.86	40.30	40.22	40.35	40.18
D4: (November 2nd FN)	31.40	29.80	32.07	35.10	32.09
Mean	39.45	39.04	40.84	41.61	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.53		1.53		
Dates of sowing (D)	0.53		1.53		
Interaction (VXD)	1.06		NS		

Table 5. Plant height (cm) of blackgram at harvest as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	46.27	45.33	47.87	48.27	46.93
D2: (October 2nd FN)	45.17	43.90	45.40	46.00	45.12
D3: (November 1st FN)	43.60	42.36	45.07	45.90	44.22
D4: (November 2nd FN)	33.69	33.83	33.21	35.23	33.99
Mean	42.18	41.34	42.89	43.85	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.48		1.37		
Dates of sowing (D)	0.48		1.37		
Interaction (VXD)	0.95		NS		

Table 6. Dry weight (kg ha-1) of blackgram at 30 DAS as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	649.20	658.02	705.73	712.10	687.27
D2: (October 2nd FN)	603.87	581.12	570.47	628.70	596.04
D3: (November 1st FN)	483.53	497.80	495.21	525.01	500.39
D4: (November 2nd FN)	401.55	388.64	424.45	424.03	409.67
Mean	534.54	531.40	548.96	572.46	
	SEm±		**CD (P=0.05)**		
Varieties (V)	6.96		20.09		
Dates of sowing (D)	6.96		20.09		
Interaction (VXD)	13.91		NS		

Table 7. Dry weight (kg ha-1) of blackgram at 60 DAS as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	2517.90	2349.30	2558.15	2614.00	2509.84
D2: (October 2nd FN)	2302.10	2418.13	2369.40	2406.90	2374.13
D3: (November 1st FN)	2259.63	2119.15	2330.53	2225.34	2233.07
D4: (November 2nd FN)	2048.13	1962.59	2033.07	2175.17	2054.74
Mean	2281.94	2212.29	2322.79	2355.35	
	SEm±		**CD (P=0.05)**		
Varieties (V)	25.42		73.79		
Dates of sowing (D)	25.42		73.79		
Interaction (VXD)	50.83		NS		

Table 8. Dry weight (kg ha-1) of blackgram at harvest as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	4382.00	4521.30	4611.82	4670.70	4546.46
D2: (October 2nd FN)	4316.10	4344.47	4368.35	4539.80	4392.18
D3: (November 1st FN)	3720.73	3554.37	3651.27	3680.89	3651.81
D4: (November 2nd FN)	3230.37	2911.90	3180.41	3123.57	3111.56
Mean	3912.30	3833.01	3952.96	4003.74	
	SEm±		**CD (P=0.05)**		
Varieties (V)	41.48		119.78		
Dates of sowing (D)	41.48		119.78		
Interaction (VXD)	82.97		NS		

Table 9. Leaf Area Index of blackgram at 30 DAS as influenced by varieties and dates of sowing

Varieties					
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	0.62	0.60	0.66	0.67	0.64
D2: (October 2nd FN)	0.54	0.53	0.54	0.56	0.54
D3: (November 1st FN)	0.47	0.46	0.51	0.51	0.49
D4: (November 2nd FN)	0.33	0.32	0.33	0.34	0.33
Mean	0.49	0.48	0.51	0.52	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.01		0.02		
Dates of sowing (D)	0.01		0.02		
Interaction (VXD)	0.01		NS		

Table 10. Leaf Area Index of blackgram at 60 DAS as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	0.82	0.80	0.86	0.87	0.84
D2: (October 2nd FN)	0.74	0.74	0.72	0.83	0.76
D3: (November 1st FN)	0.67	0.65	0.69	0.76	0.69
D4: (November 2nd FN)	0.43	0.39	0.45	0.47	0.44
Mean	0.66	0.65	0.68	0.73	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.03		0.09		
Dates of sowing (D)	0.03		0.09		
Interaction (VXD)	0.06		NS		

Table 11. Leaf Area Index of blackgram at harvest as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	0.82	0.80	0.83	0.88	0.83
D2: (October 2nd FN)	0.79	0.74	0.81	0.84	0.79
D3: (November 1st FN)	0.69	0.64	0.69	0.72	0.69
D4: (November 2nd FN)	0.33	0.30	0.42	0.44	0.39
Mean	0.67	0.63	0.69	0.72	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.01		0.03		
Dates of sowing (D)	0.01		0.03		
Interaction (VXD)	0.01		NS		

Table 12. Number of pods plant-1 of blackgram as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	26.00	24.27	26.00	26.53	25.70
D2: (October 2nd FN)	23.27	22.27	22.80	23.20	22.88
D3: (November 1st FN)	19.80	20.40	22.93	22.53	21.42
D4: (November 2nd FN)	18.47	19.53	20.13	21.43	19.89
Mean	21.88	21.62	22.97	23.42	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.95		NS		
Dates of sowing (D)	0.95		2.73		
Interaction (VXD)	1.89		NS		

Table 13. Number of seeds pod-1 of blackgramas influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	7.00	7.17	7.60	8.17	7.48
D2: (October 2nd FN)	6.50	6.00	6.33	7.33	6.54
D3: (November 1st FN)	6.00	6.00	6.67	6.00	6.17
D4: (November 2nd FN)	5.17	5.00	5.00	6.00	5.29
Mean	4.88	4.79	5.15	5.38	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.27		NS		
Dates of sowing (D)	0.27		0.77		
Interaction (VXD)	0.53		NS		

Table 14. Test weight (g) of blackgram as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	40.28	40.51	44.00	45.02	42.45
D2: (October 2nd FN)	39.12	39.57	41.71	42.58	40.75
D3: (November 1st FN)	40.30	38.68	39.56	39.57	39.53
D4: (November 2nd FN)	39.69	37.54	37.92	38.29	38.36
Mean	39.85	39.08	40.80	41.36	
	SEm±		**CD (P=0.05)**		
Varieties (V)	0.51		1.48		
Dates of sowing (D)	0.51		1.48		
Interaction (VXD)	1.02		NS		

Table 15. Seed yield (kg ha-1) of blackgram as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	830	827	879	891	856
D2: (October 2nd FN)	816	797	856	871	835
D3: (November 1st FN)	778	762	835	862	809
D4: (November 2nd FN)	734	727	746	756	741
Mean	790	778	829	845	

	SEm±	CD (P=0.05)
Varieties (V)	3.58	10.32
Dates of sowing (D)	3.58	10.32
Interaction (VXD)	7.15	20.65

Table 16. Haulm yield (kg ha-1) of blackgram as influenced by varieties and dates of sowing

	Varieties				
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	2350	2207	2665	2674	2474
D2: (October 2nd FN)	2059	2164	2287	2339	2212
D3: (November 1st FN)	2038	1972	2038	2081	2032
D4: (November 2nd FN)	1927	1940	2000	2053	1930
Mean	2093	2021	2248	2287	

	SEm±	CD (P=0.05)
Varieties (V)	41.27	119.15
Dates of sowing (D)	41.27	119.15
Interaction (VXD)	82.53	NS

Table 17. Harvest index (%) of blackgram as influenced by varieties and dates of sowing

Varieties					
Dates of sowing	**V1 (TBG-104)**	**V2 (LBG-787)**	**V3 (GBG-1)**	**V4 (PU-31)**	**Mean**
D1: (October 1st FN)	25.20	23.63	26.09	26.40	25.33
D2: (October 2nd FN)	22.61	20.38	23.56	24.85	22.85
D3: (November 1st FN)	22.44	18.85	22.50	22.07	21.47
D4: (November 2nd FN)	20.53	17.21	20.34	19.50	19.40
Mean	22.70	20.02	23.12	23.21	

	SEm±	CD (P=0.05)
Varieties (V)	0.44	1.27
Dates of sowing (D)	0.44	1.27
Interaction (VXD)	0.88	NS

3.5.2 Haulm Yield (kg ha^{-1})

Statistically significant variation was recorded for haulm yield of blackgram due to varieties and different dates of sowing (Table 16).

Among the different varieties tried in experimentation, V_4 (PU-31) recorded the highest haulm yield (2287 kg ha^{-1}), which was on par (2248 kg ha^{-1}) with V_3 (GBG-1) while the lowest haulm yield was recorded (2021 kg ha^{-1}) in V_2 (LBG-787) which was on par (2093 kg ha^{-1}) with V_1 (TBG-104).

Due to different sowing dates, the highest haulm yield (2474 kg ha^{-1}) was recorded in D_1 (Sowing on 1st fort night of October), which was comparable (2212 kg ha^{-1}) with D_2 (Sowing on 2nd fort night of October) while the lowest haulm yield (1930 kg ha^{-1}) was found in D_4 (Sowing on 2nd fort night of November) which was on par (2032 kg ha^{-1}) with D_3 (Sowing on1st fort night of November).

The highest haulm yield was obtained with V_4 (PU-31) and D_1 (Sowing on 1st fort night of October) that other varieties and dates of sowing might be due to accumulation of more dry matter, production efficiency and higher biomass potential. The results obtained are in concurrence with Turk *et.al.*[21] Monem *et.al.* [7] and Pantora*et.al.*[20]

Statistically non significant differences for haulm yield was recorded due to interaction of varieties and sowing dates.

3.5.3 Harvest Index (%)

Statistically significant variation was recorded for harvest index of blackgram due to different varieties and dates of sowing (Table 17).
Data pertaining to varieties, the highest harvest index (23.21) was recorded in V_4 (PU-31) which was on par (23.12) with V_3 (GBG-1), while the lowestharvest index (20.02) was recorded in V_2 (LBG-787) which was followed (22.70) by V_1 (TBG-104).

Different sowing dates recorded significantly varied harvest index of blackgram. The highest harvest index (25.33) was recorded in D_1 (Sowing on 1st fort night of October), which was statistically followed (22.85) by D_2 (Sowing on 2nd fort night of October) while the lowest harvest index (19.40) was recorded from D_4 (Sowing on 2nd fort night of November) which was on par (21.47) with D_3 (Sowing on1st fort night of November).

Higher harvest index was observed with V_4 (PU-31) and D_1 (Sowing on 1st fort night of October) might be attributed to high assimilate use efficiency due to increased sink capacity. These results were in confirmatory with the results of Moosavi *et.al.*[22].

Statistically non significant harvest index was recorded due to interaction effect of varieties and sowing dates in the experimentation.

4. SUMMARY AND CONCLUSION

Observations were recorded on growth parameters *VIZ*., plant height, dry matter accumulation. physiological parameters *VIZ*., Leaf Area Index (LAI), and yield attributes *VIZ*., number of pods plant^{-1}, seeds pod^{-1}, test weight, seed yield, haulm yield and harvest index during the study.

With respect to different varieties at 30, 60 DAS and harvest, the tallest plants (29.96cm, 41.61cm, and 43.85 cm) was observed in V_4 (PU-31) while the shortest plant (27.86 cm, 39.04 cm, and 41.34 cm) were found in V_2 (LBG-787). The highest dry matter accumulation (572.46, 2355.35 and 4003.74 kg ha^{-1}) was observed in V_4 and the lowest (531.40, 2212.29 and 3833.01 kg ha^{-1}) was found in V_2. The highest Leaf Area Index (0.52, 0.73 and 0.72) was observed in V_4 and the lowest LAI (0.48, 0.65 and 0.63) was found in V_2.

Data on yield attributes revealed that the highest number of pods per plant (23.42) was observed in V_4 while the lowest (21.62) was found in V_2. The highest number seeds per pod (5.38) were observed in V_4 while the lowest (4.79) was found in V_2. The highest test weight (41.36g) was observed in V_4 and the lowest (39.08g) was found in V_2.

The highest seed yield (845 kg ha^{-1}) was obtained in V_4 and the lowest (778 kg ha^{-1}) was recorded in V_2. The highest haulm yield (2287 kg ha^{-1}) was recorded in V_4 while the lowest (2021 kg ha^{-1}) in V_2. The highest harvest index (23.21%) was recorded in V_4 while the lowest (20.02%) in V_2Considering the results of the present experiment, it can be concluded thatThe varieties *VIZ.,* PU-31 and GBG-1 was gives higher yield than other two varieties *i.e.* TBG-104, LBG-787 during the study.

October 1st Fort night sowing date was best for sowing *RABI*blackgram and also recorded higher yields than remaining dates of sowing.

Sowing of blackgram varieties *VIZ.,* PU-31 and GBG-1 on 1st fort night of October resulted in higher returns.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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