RESEARCH ARTICLE

# ENVIRONMENTAL EFFECT ON PHENOLOGY AND GROWTH PARAMETERS OF RICE CROP IN CHHATTISGARH PLAIN REGION

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**Abstract:** The results of phenological studies revealed that the days taken from sowing to seedling, tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity varied with different varieties. The results of growth characters revealed that plant height, number of filled grains per panicle, test weight, number of panicle per $m^2$, grain yield and harvest index at maturity were recorded maximum in Mahamaya as compared to Karma Mahsuri and MTU-1010. Whereas, the length of panicle and sterility percentage were recorded maximum in Karma Mahsuri while straw yield is maximum in MTU-1010. The results of dry matter accumulation, crop growth rate and relative growth rate showed that these were maximum in Karma Mahsuri, Mahamaya and MTU-1010.

**Keywords:** Environment, Phenology, Growth parameter, Rice crop

## INTRODUCTION

Chhattisgarh popularly known as "Rice Bowl of India" occupies an area around 3610.47 thousand hectares with the production of 5.48 Mt and productivity of 1517 kg $ha^{-1}$ (Anonymous, 2010). The major causes of low productivity of rice in Chhattisgarh are inappropriate adoption of agronomical practices, limited irrigation (28.0%), lack of improved varieties suitable to different ecosystems and lack of extension services. Chhattisgarh farmers are mainly depends on climate for rice cultivation. The ultimate source of all the energy for physical and biological processes occurring on the earth is radiation received from the sun that is why it is commonly called solar radiation. Agriculture is the exploitation of solar energy under adequate supply of nutrients and water by maintaining plant growth.

Crop growth is a result of many physical and physiological processes, each of which is affected by environmental factors. The main factors which have strong influence on crop growth and yield are air temperature, duration and quantity of light, radiation from the sun, cloudiness and precipitation**.** In Chhattisgarh, rice is mainly grown under rainfed condition. Rice is also grown under tube well and canal irrigation.

Anonymous (1997) reported that the total dry matter accumulation above ground ($g/m^2$) had significant influence at all the stages of irrigated ecosystem over rainfed ecosystem. Dry matter accumulation above the ground was recorded significantly higher under July 15 as compared to 25 July and August 4 planting. Kumar and Subramaniam (1991) found that transplanting done during June-July produced taller plants at harvest in comparison to delay transplanting. However, delay in planting from mid June caused considerable reduction in plant height.

Om *et al*., (1996) reported that dry matter production was highest in July 25 transplanting up to 60 and 40 DAT in 1993 and 1994, respectively. At later growing stages, this trend was observed in June 25 planting. At the last two crop growth stages non significant differences were observed between June 25 and July 5; and June 15 July 5 in 1993, while dry matter production varied significantly with each date of transplanting in 1994.

## MATERIAL AND METHOD

### Crop growth rate (g/ $m^2$ /days)

Crop growth rate represents the dry matter accumulation by a unit area of crop per unit time (Leosold and Kriedemann 1975) and is computed with the following formula:

$$CGR = \frac{W2 - W1}{t2 - t1} = g/\ m2\ /day$$

Where,

W2-W1- Difference in over dry biomass at the time interval (t2-t1)

t2-t1- time interval in days

### Relative growth rate (g/g/day)

Relative growth rate is an index of the amount of growing material per unit dry weight of plant per unit time (Leosold and Kriedemann 1975). The relative growth rate was computed by using following formula:

$$RGR = \frac{\ln W2 - \ln W1}{t2 - t1} = g/g/\ day$$

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Where,
Ln- is the logarithm at base e (natural log)
W2-W1- Difference in over dry biomass at the time interval (t2-t1)
t2-t1- time interval in days

**Statistical analysis**

All the data were tabulated and analysed statistically as per the procedure suggested by Panse and Sukhatme (1967) and Chandel (1984). The F test was used for judging the significance of the treatment mean at 5% level. Whenever F test showed significant difference the differences between treatment means were further tested by using critical difference (CD) value. To compare different mean value of treatments, critical difference (CD) values were calculated as follows:

$$SEm \pm = \sqrt{\frac{Ems}{n}}$$

Where,
Sem ± Standard error of mean
Ems = Error mean square
n = Number of observations on which the mean values is based
(ii) CD (5%) = Sem x√ 2 x t at 5 % for Error d.f. (2.02).

## RESULT AND DISCUSSION

**Phenological studies**

The data regarding different rice varieties sown on three different dates (10 days interval) are shown in Table 1. The data showed that Karma Mahsuri ($V_1$) sown on 10th June ($D_1$) required 50 days for tillering, 72 days for panicle initiation, 86 days for booting, 97 days for panicle emergence, 105 days for 50 percent flowering, 113 days for milking, 122 days for dough and 138 days for maturity. Whereas, the duration taken by the same variety sown on 20th June ($D_2$) were 49 days for tillering, 71 days for panicle initiation, 86 days for booting, 96 days for panicle emergence, 102 days for 50 percent flowering, 109 days for milking, 118 days for dough and 134 days for maturity and for crop sown on 30th June ($D_3$) the duration were 48 days for tillering, 68 days for panicle initiation, 84 days for booting, 92 days for panicle emergence, 99 days for 50 percent flowering, 106 days for milking, 115 days for dough and 130 days for maturity. Thus, timely sowing on 10th June ($D_1$) Karma Mahsuri variety took 8 days more to mature as compared to delayed sowing on 30th June.
Similarly, Mahamaya ($V_2$) sown on 10th June ($D_1$) required 44, 65, 79, 89, 96, 104, 113 and 129 days for tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity respectively. The same variety sown on 20th June ($D_2$) required 42, 63, 78, 88, 95, 102, 110 and 126 days to complete for tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity respectively. The same variety sown 30th June ($D_3$) required 41, 63, 76, 85, 91, 98, 106 and 122 days to complete for tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity respectively. Hence, Mahamaya sown on 10th June took 7 days more to mature as compared to delayed sowing crop on 30th June.
Among the variety MTU-1010 ($V_3$) sown on 10th June ($D_1$) required 40, 59, 71, 81, 88, 95, 103 and 120 days the days to complete for tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity respectively. Similarly, the variety sowing on 20th June ($D_2$) 38, 56, 68, 78, 85, 91, 98 and 116 days required tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity respectively, and for MTU-1010 ($V_3$) sown on 30th June ($D_3$) 37, 54, 66, 76, 83, 88, 95 and 113 days required for tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity respectively. Thus MTU-1010 sowing on 10th June took 7 days to mature as compared to delayed sowing on 30th June. This might be due to the early sowing of crop that was sown in optimum temperature which took more number of days for 50 per cent flowering and maturity as compared to late sown crop. Apart from these phenophase other phenological events also decreased by 5 to 8 days under delayed sown condition. These statements agree with the finding of Dakhore (2003).

**Plant height (cm)**

The plant height was taken at 15 days intervals from 20 days after transplanting (DAT) to maturity. The initial plant height at 20 DAT was highest in MTU-1010 (46.3cm) followed by Mahamaya (44.9 cm) and Karma Mahsuri (42.6 cm) as shown in Table 2, Fig 1. It was observed that the plant height increased rapidly from 20 DAT to 80 DAT that is till the crop entered at reproductive stage. Thereafter the increase in height was marginal. At maturity Mahamaya attained highest plant height of 118.7 cm, followed by MTU-1010 (114.4 cm) whereas; Karma Mahsuri attended the lowest height of (107.7 cm).
Regarding the effect of different date of sowing the plant height at 20 DAT was highest 48.1 cm with 10th June sown, followed by 20th June 43.3 cm and lowest height 30th June 42.3 cm. It was observed that the plant height increased rapidly from 20 DAT to 80 DAT that till the crop entered reproductive stage. Thereafter the increase in height was marginal. At maturity the crop sown on 10th June attended maximum height of 115.9 cm, followed by 20th June 113.1 cm whereas, 30th June attended the lowest height of 111.9 cm. It was observed that the plant height increased with advancement in crop age and reached to maximum at maturity. The increase in plant height taken place slowly after 80 days after transplanting. Maximum rate of increased in plant

height was observed between 50 to 80 days after transplanting when the varieties are in panicle emergence stage. In general, highest plant height was observed with Mahamaya as compared to MTU-1010 and Karma Mahsuri. It was observed that the average plant height varied among the varieties because of the genotypic characters of these varieties.

The plant height increased at faster rate up to 35 days after transplanting. The plant height again increased rapidly further from 35 to 80 days after transplanting. Thereafter increase in plant height was only marginal. Finally at maturity the plant height of 115.9 cm was obtained in 10th June sowing, while 111.9 cm was obtained in 30th June sowing in general plant height was highest in $D_1$ as compared to $D_2$ and $D_3$ in all the observations. Similar results were found by Kumar and Subramanian (1991).

**Number of tillers/hill**

The number of tillers per hill of different varieties at 15 days intervals from 20 DAT to maturity was showed in Table 3. It was found that the number of tillers per hill 20 and 35 days after transplanting was statistically similar in all the varieties. However, Karma Mahsuri are produced highest number of tillers as compared to rest two varieties at 35 days after transplanting. It also observed that the number of tillers per hill increased gradually from 20 DAT and reached at its maximum at 65 DAT that is the crop till entered in elongation stage. Thereafter the number of tillers per hill decreased at 80 DAT and at maturity. Karma Mahsuri attained highest number of tillers/hill (8.3) followed by (7.3) with MTU-1010, Lowest number of tillers/hill attainded by was Mahamaya (7.1).

Among the different dates of sowing the number of tillers/hill at 20 DAT was highest on 20th June (6.3) followed by 10th June (5.5) and lowest number of tillers/hill observed at 30th June which was (4.9). With 10th June sown attained maximum tillers/hill 8.4 followed by 20th June (7.3) and 30th June (7.0). It was observed that the number of tillers/hill increased with advancement in crop growth and reached to maximum at 65 DAT. Maximum rate of increase in a number of tillers/hill was observed between 35 to 50 days after transplanting. In general, highest number of tillers/hill was observed in variety Karma Mahsuri and MTU-1010 on 10th June sown as compared to 20th June and 30th June sown. The lowest number of tillers/hill was recorded in variety Mahamaya. It also observed that the average number of tillers/hill was varied among the varieties because of the genotypic characters of these varieties. Similar results were also observed by Singh and Singh (1999).

**Dry matter production (g/m$^2$)**

The dry matter production is the best measure and index of the total performance of the varieties to weather conditions. The performance of different varieties to different sowing dates was given in Table 4. The dry matter production of the different varieties at 15 days interval from 20 DAT to maturity is shown through Fig 2. It can be seen that the initial dry matter production at 20 DAT was highest with Mahamaya (46.2 g/m$^2$) followed by MTU-1010 that is (44.2 g/m$^2$) and Karma Mahsuri (40.1 g/m$^2$). The dry matter production increased rapidly from 20 DAT to 110 DAT that is the crop till entered dough stage. Thereafter increase in dry matter was marginal. At maturity Karma Mahsuri attainded highest dry matter of (1550.3 g/m$^2$) followed by Mahamaya (1432.7 g/m$^2$) and the lowest dry matter was with MTU-1010 that is (1383.8 g/m$^2$). Under different dates of sowing dry matter production at 20 DAT in 10th June sowing was (46.8 g/m$^2$) followed by 20th June sowing (44.1 g/m$^2$) and the lowest dry matter was in 30th June sowing (39.6 g/m$^2$). It was observed that the dry matter production increased gradually from 20 DAT to 50 DAT and 110 DAT that is the crop till entered dough stage. Thereafter, the increased in dry matter was marginal. At maturity the crop sown on 10th June produced highest dry matter (1514.9 g/m$^2$) followed by 20th June (1461.1 g/m$^2$) and 30th June (1390.8 g/m$^2$). The rate of increase in dry matter production was highest during 35 to 110 DAT due to highest photosynthesis and active vegetative phase of the crop.

The dry matter production and its partitioning to different plant organs decreased considerably in delayed sown crop 30th June as compared to the crop 10th June. The biomass increased continuously right from sowing to maturity, whereas the leaf biomass increased up to 96 days after transplanting i.e. milking stage / dough stage and slightly towards maturity. However the rate of leaf dry matter accumulation was maximum between 35-50 days after transplanting. Similarly the decrease in leaf dry matter at maturity may be due to the senescence of older leaves and translocation of older leaves and translocation of food material from leaf to grain. The stem dry weight was increased up to maturity as the stem dry matter was taken including the panicle. It is well known that after the gram filling the weight of panicles increased and this may be the reason of increasing stem dry matter up to maturity. Apart from this the food materials also moved from source to sink at the time of maturity. On the other hand the total dry matter increased up to maturity. The increase in total dry matter was also reported by Anon (1997), similar result were obtained by Om *et al.*, (1996).

**Crop growth rate**

The data presented in Table 5 showed crop growth rate of different varieties and the values of crop growth rate were fluctuating during different stages. The highest crop growth rate were observed 80-95 days in Karma Mahsuri (23.43) followed by MTU-1010 (20.31) and Mahamaya (17.98) during panicle emergence stage. Among the different sowing dates crop growth rate was found highest in 10th June sowing as compared to 30th June sowing in all observations between 50 to 65 days after

transplanting. The crop growth was increased with advancement of crop growth and reached at in maximum between 80-95 days after transplanting. Highest crop growth rate associated with timely sowing was mainly due to highest leaf area index. This accumulated dry matter at a faster rate per unit time and thereby reducing tiller mortality and senescence of older leaf

**Relative growth rate**

The values of relative growth rate (RGR) were highest for the crop sown on 10$^{th}$ June as compared to the crop sown on 30$^{th}$ June. In 10$^{th}$ June sowing the relative growth rate was negligible up to 20-50 days after transplanting, thereafter, increased sharply up to 50-65 days after transplanting. It was slightly decreased in relative growth rate during 65 to 110 days after transplanting and reached in maximum of (0.192 g/g/day) during 0-20 days after transplanting. In 20$^{th}$ June sowing the RGR was showed fluctuated trend during in different growth stages the relative growth rate was maximum of (0.189 g/g/day) in between 0 to 20 days after transplanting. In 30$^{th}$ June sowing the relative growth rate was minimum (0.184 g/g/day) in between 0 to 20 days after transplanting, shows Table 6.

## CONCLUSION

It was found that timely sown crop took more number of days from sowing to maturity as compared to delayed sowing. Days to attain maturity with all the variety Karma mahsuri, Mahamaya and MTU-1010 were maximum under first date of sowing (138 days, 129 days and 120 days respectively) followed by second date of sowing (134 days, 126 days and 116 days respectively) and late sowing (130 day, 122 day and 113 days respectively). The duration of the late sown rice was shortened by 8 days due to delayed sowing in both Karma mahsuri and Mahamaya whereas, it was shortened by 7 days in MTU-1010. The highest plant height was observed in timely sowing Mahamaya followed by Karma mahsuri and MTU-1010. Higher number of tillers/hill was recorded with Karma mahsuri as compared to Mahamaya and MTU-1010. Among the different dates of sowing higher plant height and number of tillers/hill were observed under 10 June sowing which was dominant over 20 and 30 June sowing. Finally, sowing done on 10 June attained the higher plant height and number of tillers/hill as compared to 20 and 30 June sowing. The dry matter accumulation was maximum with Karma mahsuri as compared to Mahamaya and MTU-1010. Under different dates of sowing the dry matter accumulation was recorded higher with 10 June sowing at 65-85 days after transplanting over 20 and 30 June sowing. The crop growth rate and relative growth rate was higher with MTU-1010 as compared to Karma mahsuri and Mahamaya while under dates of sowing it was recorded maximum under 10 June sowing at 95-110 days after transplanting over 20 and 30 June sowing.

**Table 1.** Effect of different date of sowing on phenology of rice varieties

| Sowing Dates | Crop growth stages | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Seedling | Tillering | Panicle Initiation | Booting Stage | Panicle Emergence | 50% Flow. | Milking | Dough | Maturity |
| **$V_1$-Karma mahsuri** | | | | | | | | | |
| $D_1$-10 June | 25 | 50 | 72 | 86 | 97 | 105 | 113 | 122 | 138 |
| $D_2$-20 June | 25 | 49 | 71 | 86 | 96 | 102 | 109 | 118 | 134 |
| $D_3$-30 June | 25 | 48 | 68 | 84 | 92 | 99 | 106 | 115 | 130 |
| **$V_2$-Mahamaya** | | | | | | | | | |
| $D_1$-10 June | 25 | 44 | 65 | 79 | 89 | 96 | 104 | 113 | 129 |
| $D_2$-20 June | 25 | 42 | 63 | 78 | 88 | 95 | 102 | 110 | 126 |
| $D_3$-30 June | 25 | 41 | 63 | 76 | 85 | 91 | 98 | 106 | 122 |
| **$V_3$-MTU-1010** | | | | | | | | | |
| $D_1$-10 June | 25 | 40 | 59 | 71 | 81 | 88 | 95 | 103 | 120 |
| $D_2$-20 June | 25 | 38 | 56 | 68 | 78 | 85 | 91 | 98 | 116 |
| $D_3$-30 June | 25 | 37 | 54 | 66 | 76 | 83 | 88 | 95 | 113 |

**Table 2.** Plant height (cm) of rice varieties at 15 days interval under different sowing dates

| **Sowing dates** | **Days after transplanting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 20 | 35 | 50 | 65 | 80 | 95 | 110 | Maturity |
| **$V_1$-Karma mahsuri** | 42.6 | 58.1 | 81.3 | 98.7 | 105.5 | 106.5 | 107.6 | 107.7 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **$V_2$ -Mahamaya** | 44.9 | 59.7 | 80.6 | 94.8 | 111.5 | 112.5 | 116.2 | 118.7 |
| **$V_3$ -MTU-1010** | 46.3 | 60.9 | 80.1 | 107.4 | 113.0 | 113.2 | 114.5 | 114.5 |
| S Em± | 0.3 | 1.4 | 0.9 | 1.6 | 1.0 | 0.8 | 1.0 | 1.0 |
| CD (P=0.05) | 1.0 | NS | NS | 4.8 | 2.9 | 2.4 | 3.0 | 3.0 |
| **$D_1$ -10 June** | 48.1 | 58.7 | 85.1 | 104.4 | 114.2 | 115.2 | 115.9 | 115.9 |
| **$D_2$ -20 June** | 43.3 | 67.2 | 79.9 | 100.9 | 110.7 | 111.1 | 113.1 | 113.1 |
| **$D_3$ -30 June** | 42.3 | 52.8 | 76.9 | 95.6 | 105.3 | 106.7 | 106.8 | 111.9 |
| S Em± | 0.3 | 1.4 | 0.9 | 1.6 | 1.0 | 0.8 | 1.0 | 1.0 |
| CD (P=0.05) | 1.0 | 4.3 | 2.7 | 4.8 | 2.9 | 2.4 | 3.0 | 3.0 |
| VXD | | | | | | | | |
| S Em ± | 0.6 | 2.5 | 1.5 | 2.8 | 1.7 | 1.4 | 1.7 | 1.7 |
| CD (P=0.05) | 1.7 | NS | 4.6 | 8.3 | 4.9 | 4.2 | 5.1 | 5.2 |
| CV (%) | 2.3 | | 3.3 | 4.8 | 2.6 | 2.2 | 4.0 | 2.6 |

**Table 3.** Number of tillers/hill of rice varieties at 15 days interval under different sowing dates

| **Sowing dates** | **Days after transplanting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 20 | 35 | 50 | 65 | 80 | 95 | 110 | Maturity |
| **$V_1$- Karma mahsuri** | 5.5 | 10.1 | 11.8 | 12.1 | 9.1 | 8.8 | 8.6 | 8.3 |
| **$V_2$- Mahamaya** | 5.6 | 9.2 | 9.5 | 9.0 | 7.7 | 7.8 | 7.9 | 7.1 |
| **$V_3$- MTU-1010** | 5.6 | 8.5 | 9.7 | 10.5 | 7.6 | 7.7 | 7.3 | 7.3 |
| S Em± | 0.2 | 0.4 | 0.6 | 0.4 | 0.4 | 0.3 | 0.2 | 0.3 |
| CD (P=0.05) | NS | NS | 1.7 | 1.2 | 1.3 | 0.9 | 0.6 | 0.8 |
| **$D_1$ -10 June** | 5.5 | 9.4 | 12.0 | 11.9 | 9.2 | 9.3 | 8.9 | 8.4 |
| **$D_2$ -20 June** | 6.3 | 10.0 | 9.8 | 8.5 | 8.1 | 7.8 | 8.1 | 7.3 |
| **$D_3$ -30 June** | 4.9 | 8.3 | 9.2 | 11.2 | 7.2 | 7.2 | 7.7 | 7.0 |
| S Em± | 0.2 | 0.4 | 0.6 | 0.4 | 0.4 | 0.3 | 0.2 | 0.3 |
| CD (P=0.05) | 0.6 | 1.3 | 1.7 | 1.2 | 1.3 | 0.9 | 0.6 | 0.8 |
| VXD | | | | | | | | |
| S Em± | 0.3 | 0.4 | 1.0 | 0.7 | 0.7 | 0.5 | 0.3 | 0.5 |
| CD (P=0.05) | 0.6 | 0.7 | NS | NS | 2.2 | 1.6 | 1.0 | 1.6 |
| CV (%) | 10.6 | 14.0 | | | 15.6 | 11.3 | 10.4 | 9.4 |

**Table 4.** Dry matter production (g/m$^2$) of rice varieties at 15 days interval under different sowing dates

| **Sowing dates** | **Days after transplanting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **20** | **35** | **50** | **65** | **80** | **95** | **110** | **Maturity** |
| **$V_1$-Karma mahsuri** | 40.1 | 169.7 | 313.3 | 594.7 | 912.3 | 1263.7 | 1482.0 | 1550.3 |
| **$V_2$-Mahamaya** | 46.2 | 207.1 | 409.9 | 650.7 | 883.3 | 1176.4 | 1354.6 | 1432.7 |
| **$V_3$-MTU-1010** | 44.2 | 210.2 | 391.5 | 587.8 | 809.5 | 1114.2 | 1383.8 | 1383.8 |
| **S Em±** | 1.4 | 11.2 | 12.8 | 15.3 | 14.5 | 22.4 | 22.8 | 26.4 |
| **CD (P=0.05)** | 4.2 | 33.7 | 38.4 | 45.9 | 43.6 | 67.3 | 68.5 | 79.3 |
| **$D_1$ -10 June** | 46.8 | 177.4 | 353.9 | 581.6 | 858.2 | 1269.8 | 1504.2 | 1514.9 |
| **$D_2$ -20 June** | 44.1 | 239.0 | 441.2 | 665.3 | 902.7 | 1189.7 | 1401.5 | 1461.1 |
| **$D_3$ -30 June** | 39.6 | 170.5 | 319.6 | 586.3 | 844.3 | 1094.8 | 1349.2 | 1390.8 |
| **S Em±** | 1.4 | 11.2 | 12.8 | 15.3 | 14.5 | 22.4 | 22.8 | 26.4 |
| **CD (P=0.05)** | 4.2 | 33.7 | 38.4 | 45.9 | 43.6 | 67.3 | 68.5 | 79.3 |
| **VXD** | | | | | | | | |
| **S Em ±** | 2.4 | 19.5 | 22.2 | 26.5 | 25.2 | 38.9 | 39.6 | 45.8 |
| **CD (P=0.05)** | 7.3 | 58.4 | 66.5 | 79.5 | 75.4 | 116.5 | 118.6 | 137.3 |
| **CV (%)** | 9.7 | 17.2 | 10.3 | 7.5 | 5.0 | 5.7 | 7.2 | 5.5 |

**Table 5.** Crop growth rate (g/m$^2$/day) of rice varieties at 15 days interval under different sowing dates

| **Sowing dates** | **Days after transplanting** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0-20 | 20-35 | 35-50 | 50-65 | 65-80 | 80-95 | 95-110 | Maturity |
| **$V_1$- Karma mahsuri** | 2.01 | 8.64 | 9.57 | 18.76 | 21.17 | 23.43 | 14.55 | 4.55 |
| **$V_2$- Mahamaya** | 2.31 | 10.72 | 13.52 | 16.06 | 15.51 | 19.54 | 11.88 | 5.20 |
| **$V_3$ - MTU-1010** | 2.21 | 11.06 | 12.09 | 13.08 | 14.78 | 20.31 | 17.98 | 0.00 |
| **S Em±** | 0.17 | 0.71 | 0.45 | 0.55 | 0.78 | 0.95 | 1.11 | 1.41 |
| **CD (P=0.05)** | 0.21 | NS | 1.36 | 1.66 | 2.33 | 2.85 | 3.33 | 2.00 |
| **Date of sowing** | | | | | | | | |
| **$D_1$ 10 June** | 2.34 | 8.71 | 11.77 | 15.18 | 18.44 | 27.44 | 15.63 | 0.71 |
| **$D_2$ 20 June** | 2.21 | 12.99 | 13.48 | 14.94 | 15.83 | 19.14 | 14.12 | 3.97 |
| **$D_3$ 30 June** | 1.98 | 8.73 | 9.94 | 17.78 | 17.20 | 16.70 | 16.96 | 2.77 |
| **S Em±** | 0.17 | 0.71 | 0.45 | 0.55 | 0.78 | 0.95 | 1.11 | 1.41 |
| **CD (P=0.05)** | 0.21 | 2.14 | 1.4 | 1.66 | NS | 2.85 | NS | 2.00 |
| **VXD** | | | | | | | | |
| **S Em±** | 0.12 | 1.24 | 0.79 | 0.96 | 1.35 | 1.65 | 1.92 | 2.45 |
| **CD (P=0.05)** | 0.47 | 3.71 | 2.36 | 2.88 | NS | 4.94 | 5.72 | NS |
| **CV (%)** | 9.73 | 21.13 | 11.52 | 10.68 | | 12.95 | 38.61 | |

**Table 6.** Relative growth rate (g/g/day) rice varieties at 15 days interval under different sowing dates

| Sowing dates | Days after transplanting | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0-20 | 20-35 | 35-50 | 50-65 | 65-80 | 80-95 | 95-110 | Maturity |
| **$V_1$- Karma mahsuri** | 0.185 | 0.096 | 0.041 | 0.043 | 0.029 | 0.022 | 0.011 | 0.004 |
| **$V_2$- Mahamaya** | 0.192 | 0.100 | 0.046 | 0.031 | 0.020 | 0.019 | 0.009 | 0.004 |
| **$V_3$ - MTU-1010** | 0.189 | 0.104 | 0.041 | 0.027 | 0.021 | 0.021 | 0.014 | 0.003 |
| **S Em±** | | | | | | | | |
| | 0.002 | 0.003 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 |
| **CD (P=0.05)** | NS | NS | NS | 0.005 | 0.004 | NS | NS | 0.003 |
| **Date of sowing** | | | | | | | | |
| **$D_1$ 10 June** | 0.192 | 0.089 | 0.046 | 0.033 | 0.026 | 0.026 | 0.011 | 0.005 |
| **$D_2$ 20 June** | 0.189 | 0.113 | 0.041 | 0.027 | 0.020 | 0.018 | 0.011 | 0.007 |
| **$D_3$ 30 June** | 0.184 | 0.097 | 0.042 | 0.040 | 0.024 | 0.017 | 0.014 | 0.005 |
| **S Em±** | 0.002 | 0.003 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 |
| **CD (P=0.05)** | 0.005 | 0.010 | NS | 0.005 | 0.004 | 0.003 | NS | 0.003 |
| **VXD** | | | | | | | | |
| **S Em±** | 0.003 | 0.006 | 0.004 | 0.003 | 0.002 | 0.002 | 0.003 | 0.002 |
| **CD (P=0.05)** | 0.009 | 0.018 | NS | 0.008 | 0.007 | 0.006 | 0.010 | NS |
| **CV (%)** | 2.738 | 10.579 | | 13.611 | 17.074 | 16.980 | 51.033 | |

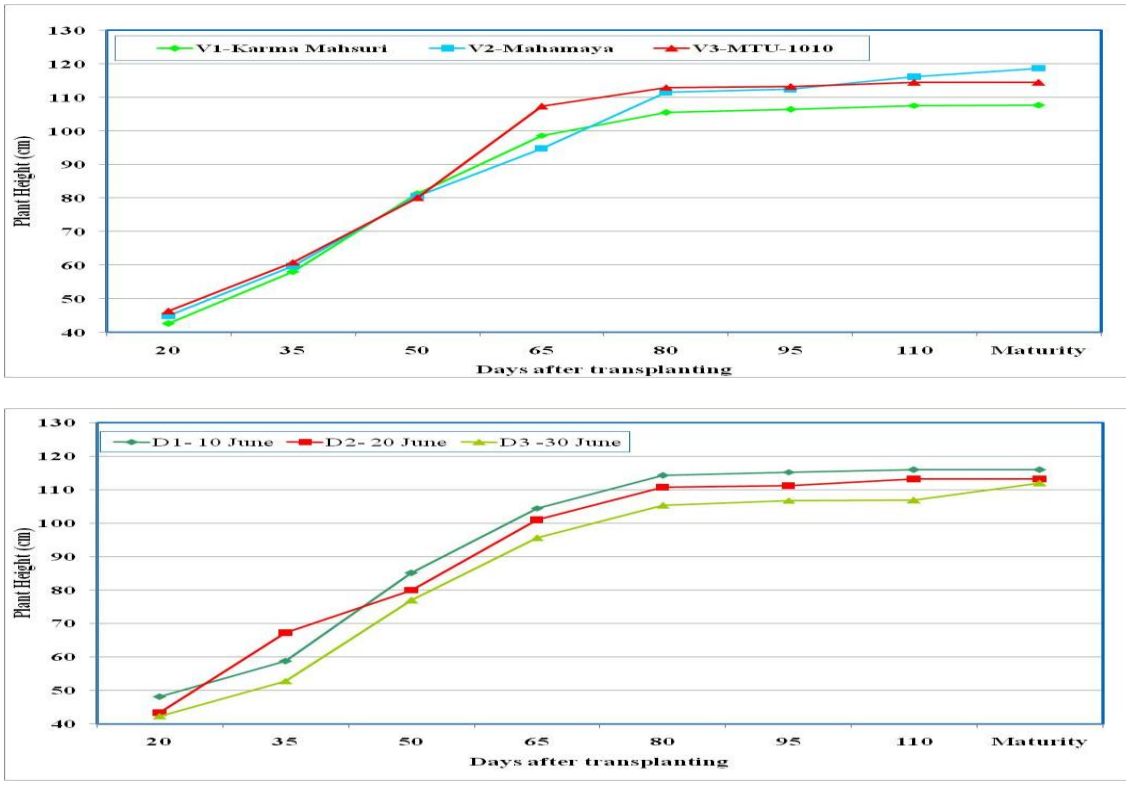
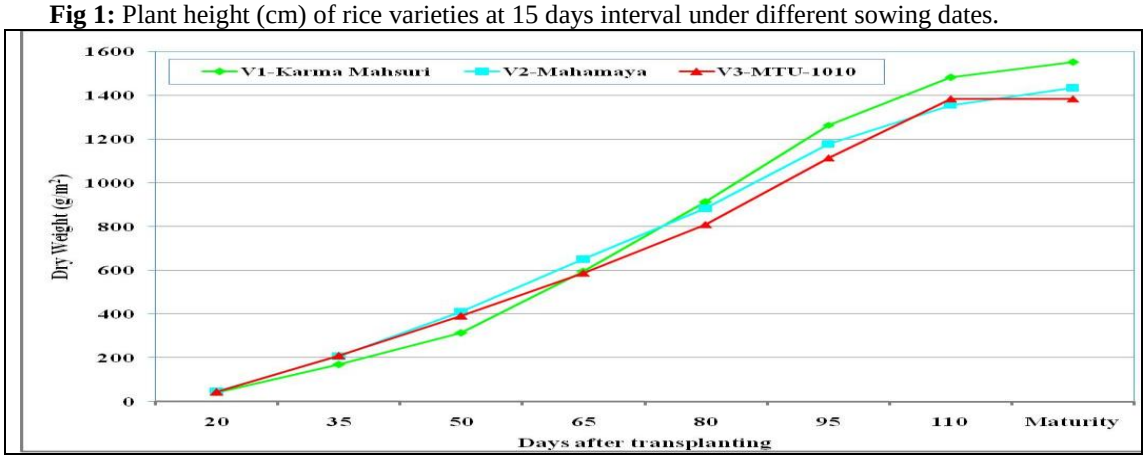



**Fig 1:** Plant height (cm) of rice varieties at 15 days interval under different sowing dates.



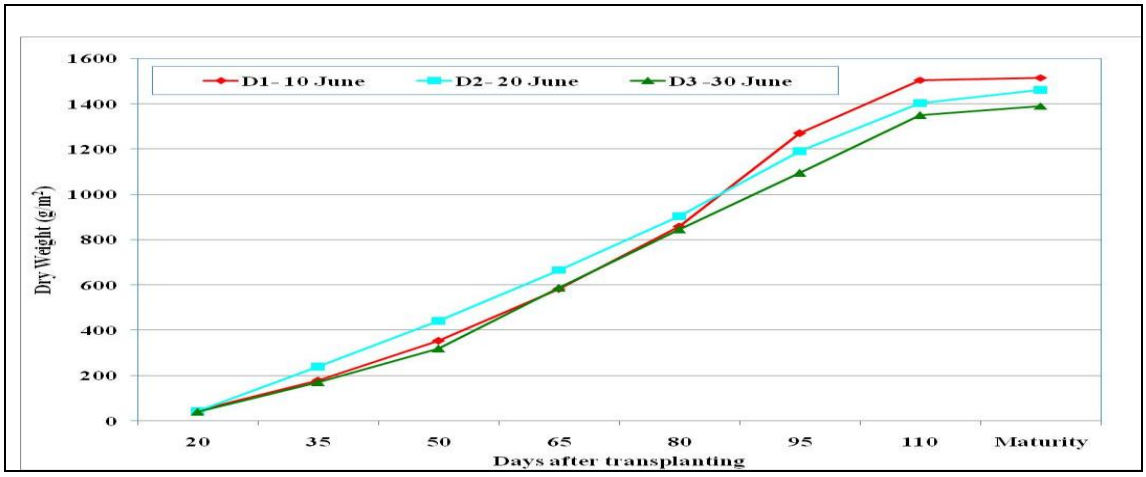



**Fig 2:** Dry matter production (g/m$^2$) of rice varieties at 15 days interval under different sowing dates.

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