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PERFORMANCE OF RICE GENOTYPES FOR MORPHO-PHYSIOLOGICAL PARAMETERS AND YIELD IN SUMMER SEASON

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ABSTRACT

The present investigation was conducted during summer season of 2018-2019 at research farm of ZARS Sindewahi in Randomized Block Design (RBD) with seven treatments (seven rice genotypes viz., SYE-1, SKL-6, KJT-184, PKV-Akshad, PKV-Makrand, RTN-5 and PKV-Ganesh). The genotypes were replicated thrice.The data were recorded on the basis of different morpho-physiological parameters at 30, 60 and 90 DAT and at harvest. Genotype PKV-Ganesh and PKV Makrand recorded significantly more plant height, total dry matter production, number of tillers, RWC, RGR, NAR, Root:shoot ratio, LAI, Leaf area and grain yield plot^{-1}and said to be thermo-tolerant genotypes. Days to fifty per cent flowering and physiological maturity were delayed in these genotypes.

(Key words: Rice, thermo-tolerance, morpho-physiological parameters, yield)

INTRODUCTION

Rice (*Oryza sativa* L.) has a renowned relationship with the human since ages. It is the world's most important staple food crop, rice is among the worlds most important and second most produced crop worldwide. About 90% of the world's rice is grown in China, India, Pakistan, Japan, Korea, Southeast Asia and other adjacent areas. Rice is the most consumed cereal grain in the world, constituting the dietary staple food for more than half of the planets human population. Globally, rice is the second most widely consumed cereal next to wheat and it has occupied an area of 160.6 million hectares, with a total production of 738.2 million tonnes (Anonymous, 2015a). In India, rice occupies an area of 43.95 million hectares with an average production of 105.48 million tonnes with the productivity of 2424 kg ha^{-1}, though increasing marginally, but is still well below the world's average yield of 4360 kg ha^{-1}(Anonymous, 2015 b).

High temperature stress is one of the most important environmental factors influencing crop growth, development, and yield processes. Exposure of rice crop to heat stress at least during a part of its growth stages may drastically reduce the yield. It was reported that high temperature is negatively affects physiological processes in plants, it may increase stomatal conductance which leads to dehydration.Furthermore, high temperature leads to cellular membranes injury which negatively affects crop productivity. High temperature stress also affects the physiological processes of plants to a greater extent. Adverse effects of high temperature stress have been noticed during vegetative as well as reproductive stage in rice. Increasing severity of the problem in rice growing areas in Asia is due to rising temperatures (Cathenne *et al*., 2012). Temperature increases globally and estimated by 1.1 ^{0}C to 6.4 ^{0}C during the next century (Anonymous, 2012), thereby threatening rice production. Global warming results in high temperature induced floret sterility in rice. Jagdish, *et al*. (2012) reported that high temperature stress negatively affects rice production. Considering the above facts present investigation was under taken on different varieties of rice.

MATERIALS AND METHODS

An experiment was carried out at research farm ZARS Sindewahi, during 2018-19 in RBD with three replications and seven genotypes (SYE-1, SKL-6, KJT-184, PKV-Akshad, PKV-Makrand, RTN-5 and PKV-Ganesh). Experimental gross plot was 4.50 m X 2.40 m and net plot was 3.90 m X 2.00 m. Observations on plant height, leaf area, leaf area index, total dry matter, RWC, root:shoot ratio, were recorded at 30, 60, and 90 DAT. RGR was calculated as formula given by Blackman (1919) and NAR was calculated by using formula suggested by Williams (1946). The RGR and NAR were calculated at 30-60 and 60-90 DAT. Yield plot^{-1} was also recorded. Observation on days to 50% flowering and physiological maturity were also recorded.

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RESULTS AND DISCUSSION

Plant height

The data presented in Table 1 indicates that the summer rice genotypes exhibited significant differences at 30 DAT. The plant height was in the range of 18.20 cm (KJT-184) to 24.77cm (PKV-Ganesh) with an average plant height of 20.06 cm.

Only PKV-Ganesh recorded significantly highest plant height (24.77cm), whereas, PKV-Makrand (20.29cm), SKL-6 (19.64cm), PKV-Akshad (19.60cm) were found at par with each other and were moderate in plant height during early stage of growth, followed by SYE-1(19.20cm) and RTN-5 (18.70 cm), however, these two genotypes were found at par with each other. Genotype KJT-184 (18.20 cm) exhibited significantly lowest plant height among all the genotypes.

The data presented in Table 1 indicates that the summer rice genotypes exhibited significant differences at 60 DAT. The plant height was in the range of 49.47cm (KJT-184) to 64.27cm (PKV-Ganesh) with an average plant height of 54.87 cm.

Genotype PKV-Ganesh recorded significantly highest plant height (64.27cm). Genotypes PKV-Makrand (56.67cm), SKL-6 (55.27cm) and PKV-Akshad (54.37cm) were recorded moderate plant height during tillering stage. SYE-1 (52.20cm), RTN-5 (51.87cm) recorded comparatively lower plant height. However, these genotypes were found at par with each other. Genotype KJT-184 (49.47 cm) exhibited significantly lowest plant height among all the genotypes.

Summer rice genotypes exhibited significant differences at 90 DAT. The plant height was ranged from 78.80 cm (KJT-184) to 102.60 cm (PKV-Ganesh) with an average plant height of 87.09 cm.

Significantly highest plant height was noted in genotype PKV-Ganesh (102.60cm), whereas, PKV-Makrand (87.60cm), SKL-6 (86.80cm), PKV-Akshad (85.80cm), SYE-1(84.80cm) and RTN-5(83.20cm) were comparatively recorded lower plant height than PKV-Ganesh. However, these genotypes were found at par with each other. Genotype KJT-184 (78.80 cm) exhibited significantly lowest plant height among all the genotypes studied.

At harvest genotypes exhibited significant results. The plant height was ranged from 79.81cm (KJT-184) to 103.57cm (PKV-Ganesh) with an average plant height of 87.79 cm.

Significantly highest plant height was noted in genotype PKV-Ganesh (103.57cm), whereas, PKV-Makrand (88.67cm), SKL-6 (86.98cm), PKV-Akshad (86.21cm), SYE-1(85.70cm) and RTN-5(84.01cm) were comparatively recorded lower plant height at harvest stage. However, these genotypes were found at par with each other. Genotype KJT-184 (79.81 cm) exhibited significantly lowest plant height among all the genotypes.

Plant height is an important character of the vegetative stage and indirectly influences yield components. At the flowering stage, maximum tillers converted in to reproductive development due to which height is nearly ceased. Due to heat stress plant height was affected severely. These results are in accordance with the findings of Allah *et al.* (2011), who identified heat tolerant rice genotypes under field conditions. The mean values for the plant height in his experiment ranged between 68 cm in Deegeowoo gene and 112 cm in Kameji, indicating that heat stress affected severely on plant height.

Similar results were noted by Jana *et al.*(2013), who revealed in their experiment that, yield of aerobic rice affected by high temperature stress during summer season. The average value of plant height was 91.6 cm. Khan *et al.* (2018) assessed the variability in acquired thermotolerance in rice (*Oryza sativa* L.) through temperature induction response (TIR) technique. The plant heights were ranged from 83.75 cm (RSR2011-12-1) to 160.70 cm (R 1919-573-1-160-1) with an average plant height of 122.96 cm. The variation in plant height was due to different environments.

Leaf area plant^{-1}

Leaves play and important role in the absorption of light variations and using it in photosynthetic process. Hence, yield depends on leaf area of crop.

The data shown in Table1 indicates that, the leaf area plant^{-1}at different growth stages influenced by different genotypes. Leaf area plant^{-1}gradually increased from 30 DAT and reached maximum value at 90 DAT by all the genotypes.

An observation recoded at 30 DAT indicates significant variation in leaf area plant^{-1}. Significantly highest plant leaf area was noted in genotype PKV-Ganesh (12.79 cm^2) followed by PKV-Makrand (10.29cm^2), SKL-6 (9.57cm^2) which recorded comparatively moderate leaf area. PKV-Akshad (8.71cm^2) and SYE-1(8.36cm^2) recorded lower leaf area and these genotypes were found at par with each other. RTN-5(8.02cm2) and KJT-184 (7.5cm^2) exhibited significantly lowest leaf area. However, these two genotypes were found at par with each other.

Genotype PKV-Ganesh (27.59cm2) recorded significantly highest leaf area at 60 DAT over all the genotypes. PKV-Makrand (24.37cm^2) and SKL-6 (23.76cm^2) recorded moderately higher leaf area plant^{-1} and found at par with each other, followed by PKV-Akshad (22.80cm^2) and SYE-1(22.41cm^2) which were found at par with each other. Genotypes RTN-5 (21.17cm^2) and KJT-184 (18.28 cm^2) exhibited significantly lowest leaf area plant^{-1} over PKV-Ganesh, PKV-Makrand, SKL-6 and PKV-Akshad.

At 90 DAT, significantly highest leaf area plant^{-1} was registered by genotype PKV-Ganesh (33.98cm^2) followed by PKV-Makrand (32.91cm^2) and SKL-6 (32.63cm^2). However, these genotypes were found at par with each other. PKV-Akshad (30.06cm^2), SYE-1(29.52cm^2), RTN-5(29.47cm^2) and KJT-184 (28.76cm^2) exhibited significantly lowest leaf area plant^{-1}. However, these genotypes were found at par with each other and significantly lower over PKV-Ganesh, PKV-Makrand and SKL-6.

Data on leaf area plant^{-1} showed that, PKV- Ganesh recorded highest leaf area over all other genotypes under summer condition during all growth stages. However, PKV-Makrand and SKL-6 also recorded moderately higher leaf area plant^{-1} resulted higher tillering, which improved the net photosynthetic area and ultimately grain yield also. Similar observations were also noted by Osada *et al*. (1993) and Khan *et al*.(2015) during their study. Osada *et al*. (1993) conducted the experiment on seasonal changes in growth pattern of tropical rice and observed the leaf area of February and March month in the range of 0.47- 1.14m^2.

Khan *et al*.(2015) studied that phenological traits of rice as influenced by seedling age and number of seedling hill^{-1} under temperate region. Data showed that seedling age and number of seedlings hill^{-1} significantly affected flag leaf area plant^{-1}. The interaction between seedlings age and number of seedlings hill^{-1} was non-significant. More flag leaf area plant^{-1} (22.26 cm^2) was recorded at seedling age of 25 days, while smaller flag leaf area plant^{-1} (19.77 cm^2) was attained at seedling age of 30 days.

Leaf area index

Leaf area index (LAI) is a dimensionless quantity that characterizes plant canopies. Leaf area index is the photosynthetic area of leaves occupying by the plant. The data are given in Table1. Leaf area index gradually increased from 30 DAT and reached maximum value at 90 DAT in all the genotypes.

Observations recoded at 30 DAT indicated significant variations in LAI plant^{-1}. Significantly highest leaf area index was noted in genotype PKV-Ganesh (2.03) followed by PKV-Makrand (1.95) and SKL-6 (1.91). However, these genotypes were found at par with each other. PKV-Akshad (1.88), SYE-1 (1.79) and RTN-5 (1.78) recorded moderate LAI plant^{-1} and found at par with each other. Genotype KJT-184 (1.58) exhibited significantly lowest leaf area index plant^{-1} among all other genotypes studied.

At 60 DAT, significantly highest leaf area index plant^{-1} was observed in genotype PKV-Ganesh (4.67) followed by PKV-Makrand (4.51) which was also recorded comparatively higher LAI plant^{-1}. SKL-6 (4.33), PKV-Akshad (4.33) and SYE-1(4.24) recorded moderately higher leaf area index plant^{-1}. However, these genotypes were found at par with each other, followed by genotype RTN-5(4.21). Genotype KJT-184 (4.02) exhibited significantly lowest leaf area index plant-1over all other genotypes.

At 90 DAT, significantly highest leaf area index plant^{-1} was registered by genotype PKV-Ganesh (6.17) over all other genotypes followed by PKV-Makrand (6.02) which was also recorded comparatively higher LAI plant^{-1}. SKL-6 (5.89), PKV-Akshad (5.81) and SYE-1(5.79) recorded moderately higher LAI plant^{-1}. However, these genotypes were found at par with each other. Genotype RTN-5 (5.74) recorded moderate leaf area index plant^{-1}. However, this genotype was found at par with PKV-Akshad and SYE-1. Genotype KJT-184 (5.48) exhibited significantly lowest leaf area index plant^{-1} among all the genotypes under study.

Higher the leaf area index better will be the dry matter accumulation and ultimately may increase grain yield. Similar results were noted by Baset and Shamsuddin (2011). They studied, physio-morphological appraisal of arromatic fine rice in relation to yield potential. Aromatic rice varieties showed tallest plant stature and modern rice varieties had higher leaf area index.

LAI is the ratio of photo synthetically active leaf area to the land occupied area by the plant. In this study, LAI increased from initial stage (30 DAT) to tillering stage (60 DAT) by nearly 2.5 times and from tillering (60 DAT) to flowering (90 DAT) increase was 1.5 times. Xie *et al*. (2011) studied two rice varieties (Yangda 06) and (Nanjing 43) for high temperature stress and found decline in LAI. Baset and Shamsuddin (2011) conducted field experiment to determine the physio-morphological attributes in relation to yield potential of modern and aromatic rice varieties and found that modern rice varieties had more LAI as compared to aromatic rice varieties.

Days to 50% flowering and physiological maturity

a) Days to 50% flowering

Days to 50% flowering was determined by recording the number of days after sowing until 50% of plant in a plot had at least one open flower. The general mean (average days) for 50% flowering was115 days.

PKV-Ganesh required significantly maximum days for 50% flowering (124.6 days) followed by PKV-Makrand (124.3 days) when compared with other genotypes. PKV-Akshad (118.0 days) also recorded moderately higher number of days required for 50% flowering. SKL-6 (114.6 days) and SYE-1(113.3 days) required moderately lesser number of days for 50% flowering and found at par with each other followed by RTN-5 (108.0 days). KJT-184 (103.6 days) required significantly lesser days for 50% flowering than all other genotypes.

b) Physiological maturity

PKV-Ganesh required significantly highest days for physiological maturity (156.6 days) when compared with other genotypes studied. PKV-Makrand (152.0 days) and PKV-Akshad (148.0 days) took comparatively higher days for physiological maturity than all other genotypes except PKV-Ganesh. SKL-6 (144 days) and SYE-1(145.0 days) recorded moderately lesser number of days for physiological maturity, however, both the genotypes were found at par with each other. Genotypes RTN-5 (139.33 days) and KJT-184 (134.33 days) required significantly lesser number of days for physiological maturity.

Genotypes tested for summer cultivation were early to mid-late duration (less than 120 days to 140 days). However, minimum temperature from MW 50 st to 6 th MW (nearly two months) was between 10.9^{o}C to 12.9^{o}C. This colder temperature delays early vegetative growth and hence, days for 50% flowering and days to physiological maturity periods were delayed.

The above results are in close agreement with the findings of Patel *et al*. (2014), who reported range of 91 to 121 days for 50% flowering in rice genotypes.

Total dry matter production plant^{-1}

Total dry matter production, its distribution and partitioning is integral part of growth and development over the entire growth period and is directly related to seed yield.

Dry matter is an important criterion used to identify genotypes for better yield. It determines source sink relationship and depends upon the net gain in processes on anabolism and catabolism of plant.

Data pertaining to the dry matter production plant^{-1} recorded at different stages (30, 60, and 90 DAT) are presented in Table 2.

Total dry matter production plant^{-1} recorded significant difference during all growth stages by different genotypes. PKV- Ganesh recorded significantly higher total dry matter production during all the growth stages.

The data recorded about the total dry matter production plant^{-1} was statistically and significantly differed at 30 DAT. Significantly highest total dry matter production plant^{-1} was recorded by PKV-Ganesh (0.86 g), PKV-Makrand (0.79 g) and SKL-6 (0.73 g). Genotypes PKV-Akshad (0.70 g), SYE-1 (0.69 g) and RTN-5 (0.60 g) significantly recorded moderate total dry matter production plant^{-1} and were found at par with each other. Genotype KJT-184 (0.50 g) exhibited significantly lowest total dry matter production plant^{-1} among all genotypes studied.

At 60 DAT, the range of total dry matter production plant^{-1} recorded was 18.37 and 25.09 g plant^{-1}. Significantly highest dry matter production plant^{-1} was registered in genotype PKV-Ganesh (25.09 g) followed by PKV-Makrand (22.51 g). Genotypes SKL-6 (20.17g), PKV-Akshad (19.86 g), SYE-1(19.48 g) and RTN-5 (18.94 g) recorded moderately higher total dry matter production plant^{-1}. However, these genotypes were found at par with each other. Genotype KJT-184 (18.37 g) exhibited significantly lowest total dry matter production plant^{-1} among all other genotypes.

At 90 DAT, the range of total dry matter production plant^{-1} recorded was 27.48 g to 43.02 g. Again significantly highest dry matter production plant^{-1} was registered by genotype PKV-Ganesh (43.02 g). PKV-Makrand (37.18 g), SKL-6 (36.22 g) and PKV-Akshad (35.36 g) recorded moderately higher total dry matter production plant^{-1}. However, these genotypes were found at par with each other. Genotypes SYE-1(32.80 g) and RTN-5 (31.02 g) recorded lower total dry matter production plant^{-1} and found at par with each other. Genotype KJT-184 (27.48 g) exhibited significantly lowest total dry matter production plant^{-1} among all other genotypes.

High temperatures not only decreases photosynthesis but also alter dry-matter delivery to roots and shoots. The negative effects of HS also equally and severely affect the rice roots due to increasing water temperature which lowers the absorption of water and minerals due to which total dry matter production plant^{-1} decreases. This impact of global warming on rice production needs to identify genotypes suitable for summer cultivation. Present investigation showed that PKV-Ganesh may be suitable for summer cultivation. These results are in conformity with findings of Fahad *et al*. (2018), who studied response of rice and their tolerance to high temperature. High temperatures not only decreases photosynthesis but also alter dry-matter delivery to roots and shoots. The negative effects of HS also equally and severely affect the rice roots due to increasing water temperature. Similar observations also recorded by Mondal *et al*. (2012). They had taken comparative study on growth and yield of promising rice cultivars during wet and dry season. Experimental results revealed that the variety Narendradhan showed better results with respect to all growth parameters and it was closely followed by Shatabdi and Khitish. However, in respect of grain yield both Narendradhan and Khitish varieties were at par, but Narendradhan produced more grain yield. Narendradhan produced maximum dry matter (999.67 and 897.85 g m^{-2} during boro and kharif season respectively).

Relative water content (RWC) (%)

Leaf relative water content (RWC) is an important indicator of water status in plant. It reflects the balance between water supply to the leaf tissue and transpiration rate. Data recorded on relative water content (RWC) at different stages (30, 60, and 90 DAT) are presented in Table 2.

At 30 days after transplanting it is evident from the Table 2 that, significantly highest mean relative water content was recorded by genotype PKV-Ganesh (55.99%) followed by PKV-Makrand (54.54%), however, these genotypes were found at par with each other. SKL-6 (46.66%) recorded moderately higher RWC. PKV-Akshad (43.75%) also recorded better relative water content (RWC). SYE-1(36.66%), RTN-5(36%) and KJT-184 (35.33%) recorded significantly lower leaf relative water content however, these genotypes were found at par with each other.

The data recorded about leaf relative water content (RWC) was found statistically significant at 60 DAT. Significantly highest relative water content (RWC) was noted by genotypes PKV-Ganesh (56.16%) and PKV-Makrand (55.37%), however, these genotypes were found at par with each other followed by SKL-6 (49.44%) which was moderately higher in RWC. PKV-Akshad (42.95%) recorded better RWC than rest of the genotypes. Genotypes SYE-1 (39.42%), RTN-5 (38.14%) and KJT-184 (37.47%) recorded significantly lower leaf relative water content and found at par with each other.

At 90 days after transplanting, it is evident from the Table 2 that, significantly highest mean relative water content was recorded by genotype PKV-Ganesh (55.12%) followed by PKV-Makrand (53.07%), however, these genotypes were found at par with each other. Genotypes SKL-6 (48.27%) and PKV-Akshad (45.45%) recorded moderately higher leaf relative water content. Genotypes SYE-1(40.58%), RTN-5(39.04%) and KJT-184 (37.81%) recorded significantly lowest leaf relative water content during flowering stage, however, these three genotypes were found at par with each other.

Rice is a major cereal and water stress is one of the major constraints for production and yield stability in rain fed ecosystems. Data on RWC at flowering stage (90 DAT) indicates that PKV-Ganesh and PKV-Makrand were found to be tolerant genotypes for heat stress condition. This correlated with higher total dry matter production and grain yield.

Ibrahim *et al*. (2019) conducted an experiment to compare the impact of drought stress on growth and physiology of six Egyptian rice cultivars (Giza 177, Giza 178, Giza 179, Giza 182, Sakha 101 and Sakha 106). Results showed that drought stress were least affected RWC in cultivar Giza 179 as compared with other cultivars in the study.

PKV-Ganesh and PKV-Makrand also found to be tolerant genotypes for heat stress condition having more RWC.

Root:shoot ratio

Data pertaining to root: shoot ratio recorded at different stages (30, 60, and 90 DAT) are presented in Table 2.

Observations recorded at 30 DAT indicated significant variations. Significantly highest root: shoot ratio was noted by genotype PKV-Ganesh (1.00) followed by PKV-Makrand (0.90), however, these genotypes were found at par each other. Genotypes SKL-6 (0.81), PKV-Akshad (0.80), SYE-1(0.70) and RTN-5 (0.67) recorded moderately higher root: shoot ratio, however, these four genotypes were found at par with each other. Genotype KJT-184 (0.60) exhibited significantly lowest root: shoot ratio among all other genotypes.

Significantly higher root: shoot ratio was observed at 60 DAT by genotype PKV-Ganesh (2.40). Genotype PKV-Makrand (1.84) and SKL-6 (1.55) recorded moderately higher root: shoot ratio, however, these were found at par with each other. Genotypes PKV-Akshad (1.42), SYE-1(1.35), RTN-5(1.30) and KJT-184 (1.20) exhibited significantly lowest root: shoot ratio among all other genotypes and found at par with each other.

At 90 DAT, significantly highest root: shoot ratio was recorded by only PKV-Ganesh (2.55). All other genotypes viz., PKV-Makrand (1.71), SKL-6 (1.67), PKV-Akshad (1.56), SYE-1(1.43), RTN-5(1.42) and KJT-184 (1.30) exhibited lowest root: shoot ratio, however, all these genotypes were found at par each other.

Root: shoot ratio is the ratio of the amount of plant tissue that has supportive functions to the amount of those that have growth functions. Plant with a higher proportion of roots can compete more effectively for soil nutrients, while those with a higher proportion of shoots can collect more light energy.

Higher the root: shoot ratio higher will be water uptake and better will be the dry matter accumulation. In our study, PKV-Ganesh (2.55) recorded highest root: shoot ratio and found to be drought tolerance over all other varieties and showed better partition also. These findings are in accordance with the findings of Nejad (2011), who studied the effect of drought stress on root: shoot ratio. He also recorded that, increase in water stress intensity during each period of growth, the root weight and N_2 air trap, shoot and root weight plant-1 decreased comparing two periods of growth.

Nada and Abogadallah (2015) also noted that, restricting the above ground sink corrects the root: shoot ratio and substantially boosts the yield potential panicle-1 in field-grown rice (*Oryza sativa* L.). Rice has shallow, weak roots, but it is unknown how much increase in yield potential could be achieved if the root: shoot ratio is corrected. We provide evidence that improving the root performance by increasing the root: shoot ratio would eliminate the current limitations to photosynthesis and growth in rice.

Numbers of tillers plant^{-1}

The data shown in Table 2 indicates that, mean number of tillers plant^{-1}in all rice genotypes under study showed significant differences.

The significantly highest number of tillers plant^{-1} was observed at 60 DAT in all the genotypes under study except KJT-184. Genotypes PKV-Ganesh and SKL-6 (16.67) each recorded numerical higher number of tillers plant^{-1} followed by PKV-Makrand, PKV-Akshad (16.33), SYE-1(15.67) and RTN-5 (15.33).However, all these six genotypes were found at par with each other. Genotypes KJT-184 (13.67) recorded significantly lowest tillers plant^{-1} than all above genotypes.

Observations recorded on number of tillers plant^{-1} at 90 DAT indicate significant variations. The most pronounced effect observed in genotypes PKV-Makrand (20.67) and PKV-Ganesh (20.33) which recorded significantly higher number of tillers plant^{-1} followed by SKL-6 (19.33), PKV-Akshad (18.67). However, these four genotypes were found at par with each other. Genotypes SYE-1(18.33) and RTN-5 (16.33) recorded significantly lower number of tillers plant^{-1}. However, these two genotypes were found at par with each other. Genotypes KJT-184 (15.33) recorded significantly lowest number of tillers plant^{-1} than all above genotypes.

Genotypes PKV-Makrand (20.67), PKV-Ganesh (20.33) and SKL-6 (19.33) recorded significantly higher number of tillers which resulted in to greater seed yield than other genotypes. The results are in agreement with the findings recorded byWirnas *et al*. (2015). They studied contribution of genetic x temperature interaction to performance and variance of rice yield. Efforts were taken to maintain rice productivity grown under global temperature changing in growing high temperature tolerant varieties namely Mekongga, IR-64, Inpari-13, Situ Patenggang, Kalimutu, IPB 3S, IPB 4S, IPB 5R, IPB 6R, and IPB 7R. Kiranmayee *et al*. (2018) studied on correlation and path coefficient analysis for yield and yield contributing traits in maintainer (B lines) lines of hybrid rice (*Oryza sativa* L.) Grain yield plant^{-1} had significant positive correlation with productivity day^{-1} (0.95) namely days to fifty per cent flowering, number of productive tillers plant^{-1}.

Net assimilation rate (NAR)

Net assimilation rate (NAR), synonymously called as unit leaf rate which expresses the rate of dry matter accumulation. The analyzed data of NAR are presented in Table 2.

At first stage of observation i.e. 30-60 DAT, genotypes PKV-Akshad (0.0499g dm^{-2} day^{-1}) and SYE-1(0.0497 g dm^{-2}day^{-1}) recorded significantly higher net assimilation rate (NAR), however, these two genotypes were found at par with each other. Genotypes, PKV-Ganesh (0.0487gdm^{-2}day^{-1}) and PKV-Makrand (0.0479 g dm^{-2} day^{-1}) recorded moderately higher net assimilation rate (NAR) than remaining genotypes. However, these two genotypes were found at par with each other. Genotypes SKL-6 (0.0458 g dm^{-2} day^{-1}), recorded moderately lower net assimilation rate (NAR). Genotypes RTN-5 (0.0417 g dm^{-2} day^{-1}) and KJT-184 (0.0415 g dm^{-2} day^{-1}) recorded significantly lowest net assimilation rate (NAR) than all above genotypes, however, both these genotypes were found at par with each other.

At second stage of observation i.e. 60-90 DAT, range of NAR recorded was 0.0125-0.0213 g dm^{-2} day^{-1}, but data was found non- significant.

Increase in the rate of dry weight with increase at any instant time on a leaf area basis with leaf representing an estimate of the size of the assimilatory surface area (Gregory, 1926). Increase in NAR during reproductive phase might be due to increase in efficiency of leaves for photosynthesis as a response of photosynthetic apparatus to increase demands for assimilates by growing seed fraction and also due to photosynthetic contribution by pod and sink demand on photosynthetic rate of leaves.

Shipley (2006) studied net assimilation rate, specific leaf area and leaf mass ratio which is most closely correlated with relative growth rate. Data were compiled consisting of 1240 observations (614 species) from 83 different experiments in 37 different studies, in order to quantify the relative importance of net assimilation rate (NAR). He further concluded that NAR was the best general predictor of variation in RGR.

Rajput *et al.* (2017) studied physiological parameters viz., leaf area index, crop growth rate, relative growth rate and net assimilation rate of different varieties of rice grown under different planting geometries and depths in SRI. They concluded that relative growth rate (RGR) measures the increase in dry matter with a given amount of assimilatory material at a given point of time and net assimilation rate (NAR) is the net gain in total dry matter unit-1 leaf area unit^{-1} time.

In our study PKV-Ganesh and PKV-Makrand recorded significantly higher NAR which indicates higher dry matter partitioning which correlates with the finding of Gregory (1926) and Rajput *et al*. (2017).

Relative growth rate (RGR)

Relative growth rate (RGR) represent total dry weight gained over existing dry weight in unit time. This was originally termed as "efficiency index" because it expresses growth in terms of rate of increase in size unit^{-1} of time. As such, it permits more equitable comparisons between organisms than absolute growth rate. Normally, relative growth rate deals with total dry weight plant^{-1}, through other measure of size have also been used. Data revealed that RGR was more during the period of 30-60 DAT.

The analyzed data of RGR are presented in Table 2. Considering all genotypes under study, significantly maximum RGR was observed in genotypes PKV-Ganesh (0.1220g g^{-1} day^{-1}) at 30-60 DAT and 0.02001 g g^{-1} day^{-1} at 60-90 DAT. But it was significantly lowest in KJT-184 (0.1074 g g^{-1}day^{-1}) at 30-60 DAT and 0.01240 g g^{-1} day^{-1}at 60-90 DAT.

At first stage of observation i.e. 30-60 DAT, significantly highest RGR was registered by genotype PKV-Ganesh (0.1220 g g^{-1} day^{-1}) followed by genotype PKV-Makrand (0.1196g g^{-1} day^{-1}). However, both these genotypes were found at par with each other. SKL-6 (0.1139 g g^{-1} day^{-1}) and PKV-Akshad (0.1118 g g^{-1} day^{-1}) recorded moderately higher RGR plant^{-1} and were found at par with each other. Genotypes SYE-1(0.1086 g g^{-1} day^{-1}), RTN-5 (0.1084 g g^{-1} day^{-1}) and KJT-184 (0.1074 g g^{-1} day^{-1}) recorded lowest RGR plant^{-1} over all other genotypes, however, these three genotypes were found at par with each other.

At second stage of observations i.e. 60-90 DAT, significantly higher RGR was noticed in four genotypes viz., PKV-Ganesh (0.02001 g g^{-1} day^{-1}), PKV-Makrand (0.01932 g g^{-1} day^{-1}), SKL-6 (0.01887 g g^{-1} day^{-1}) and PKV-Akshad (0.01795 g g-^{1} day^{-1}), however, these genotypes were found at par among each other. Genotypes SYE-1(0.01672 g g^{-1} day^{-1}) and RTN-5 (0.01550 g g^{-1} day^{-1}) recorded moderately lower RGR plant^{-1}. However, these genotypes were found at par with each other. Genotype KJT-184 (0.01240 g g^{-1} day^{-1}) exhibited significantly lowest RGR among all the genotypes under study.

Yield

Data regarding grain yield plot^{-1} showed significant differences and same are presented in Table 2.

Significantly highest grain yield plot^{-1} was observed in genotype PKV-Ganesh (3.52 kg) followed by PKV-Makrand (3.43 kg) and SKL-6 (3.40 kg), however, these three genotypes were found at par with each other. Genotype PKV-Akshad (3.18 kg), SYE-1 (3.14 kg) and RTN-5 (3.09 kg) recorded moderately lower grain yield plot^{-1}than PKV-Ganesh and PKV-Makrand. However, these three genotypes found at par with each other and significantly superior over KJT-184 (2.94 kg) which recorded significantly lowest grain yield plant^{-1} than all other genotypes.

Considering the morpho-physiological parameters effects of heat stress was less in genotypes PKV-Ganesh and PKV-Makrand over other genotypes studied. But grain yield of these two genotypes was more as compared to remaining genotypes in heat stress conditions. Hence, these two genotypes can be grown in summer conditions.

Table1. Plant height, LA, LAI, days to 50% flowering, physiological maturity and number of tillers plant^{-1}of rice genotypes under summer conditions

Genotypes	Plant height (cm)				Leaf area plant^{-1}(dm^2)			Leaf area index			Days to 50% flowering	Physio-logical maturity days	No.of tillers plant^{-1}	
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT			60 DAT	90 DAT
SYE-1	19.20	52.20	84.80	85.70	8.36	22.41	29.52	1.79	4.24	5.79	113.33	145.00	15.67	18.33
SKL-6	19.64	55.27	86.80	86.98	9.57	23.76	32.63	1.91	4.33	5.89	114.67	144.00	16.67	19.33
KJT-184	18.20	49.47	78.80	79.81	7.50	18.28	28.76	1.58	4.02	5.48	103.67	134.33	13.67	15.33
PKV-Akshad	19.60	54.37	85.80	86.21	8.71	22.80	30.06	1.88	4.33	5.81	118.00	148.00	16.33	18.67
PKV-Makrand	20.29	56.67	87.60	88.67	10.29	24.37	32.91	1.95	4.51	6.02	124.33	152.00	16.33	20.67
RTN-5	18.70	51.87	83.20	84.01	8.02	21.17	29.47	1.78	4.21	5.74	108.00	139.33	15.33	16.33
PKV-Ganesh	24.77	64.27	102.60	103.57	12.79	27.59	33.98	2.03	4.67	6.17	124.67	156.67	16.67	20.33
SE (m) ±	**0.252**	**0.310**	**1.510**	**1.636**	**0.217**	**0.516**	**0.692**	**0.040**	**0.034**	**0.038**	**1.114**	**0.810**	**0.512**	**0.692**
CD at 5 %	**0.753**	**0.930**	**4.527**	**4.908**	**0.650**	**1.545**	**2.076**	**0.120**	**0.101**	**0.114**	**3.341**	**2.425**	**1.536**	**2.072**

Table 2. Total dry matter plant^{-1}, RWC, Root: shoot ratio, RGR, NAR and yield plot^{-1}of rice genotypes under summer conditions

Genotypes	Total dry matter			RWC (%)			Root : shoot ratio			RGR (g g^{-1} day^{-1})		NGR (g dm^{-2} day^{-1})		Yield plot^{-1} (kg)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30-60 DAT	60-90 DAT	30-60 DAT	60-90 DAT	
SYE-1	0.69	19.48	32.80	36.66	39.42	40.58	0.70	1.35	1.43	0.1086	0.01672	0.0458	0.0212	3.40
SKL-6	0.73	20.17	36.22	46.66	49.44	48.27	0.81	1.55	1.67	0.1139	0.01887	0.0415	0.0125	2.94
KJT-184	0.50	18.37	27.48	35.33	37.47	37.81	0.60	1.20	1.30	0.1074	0.01240	0.0499	0.0194	3.18
PKV-Akshad	0.70	19.86	35.36	43.75	42.95	45.45	0.80	1.42	1.56	0.1118	0.01795	0.0479	0.0212	3.43
PKV-Makrand	0.79	22.51	37.18	54.54	55.37	53.07	0.90	1.84	1.71	0.1196	0.01932	0.0417	0.0152	3.09
RTN-5	0.60	18.94	31.02	36.00	38.14	39.04	0.67	1.30	1.42	0.1084	0.01550	0.0487	0.0213	3.52
PKV-Ganesh	0.86	25.09	43.02	55.99	56.16	55.12	1.00	2.40	2.55	0.1220	0.02001	0.0497	0.0165	3.14
SE (m) ±	**0.047**	**0.407**	**1.115**	**0.897**	**0.985**	**0.964**	**0.054**	**0.118**	**0.148**	**0.0002**	**0.0001**	**0.0004**	**0.003**	**0.049**
CD at 5 %	**0.140**	**1.220**	**3.343**	**2.691**	**2.953**	**2.890**	**0.160**	**0.354**	**0.441**	**0.005**	**0.003**	**0.0010**	**0.009**	**0.165**

REFERENCES

Anonymous, 2012. Advance climate change adaptation .Special report of the intergovernemental panel on climate change.C.B. IPCC.

Anonymous, 2018. Ann. report 2017-18 website www. krishi. maharashtra. gov.in.

Anonymous, 2015(a). Food and Agriculture organization. www.fao.org.

Anonymous.2015 (b). Joint Director of agriculture office ,Nagpur division.

Allah, Abd, AAAB Shimaa, I.M.O. Elrewainy and A.M. Elkhyar, 2011. Identifying heat tolerance rice genotypes under field conditions of Egypt. J. Agron. **33**(2) : 167-178

Baset,M.A. and Z. H. Shamsuddin, 2011. Physio-morphological appraisal of arromaticfine rice in relation to yield potential.Int.J.Botany **7**(3).223-229.

Blackman, V. M. and J. Hamblin, 1919.Growth and development in physiology of crop plants, IInd Ed. Scientific publishers. Jodhpur. pp. 198-199.

Catherine, C., N. D.Gemma, Victoria teVelde of Agulhas, 2012. Managing climate extremes and disasters in Asia: Lessons from the IPCC SREX reports. Climate and Development Knowledge Network.

Fahad, S., A Muhammad, H. Shah, S. Shah, H. Saddam, W. Chao, W. Depe, K. Rehman, F. Alharby, V. Turan, K. Mustaq and J. Huang. 2018. Rice responses and tolerance to high temperature. Advances in rice res. for abiotic stress tolerance, DOI : https.//doi.org/10.101016/B978-0-12-814332-2.00010-1

Ibrahim, E.K., H.A. Hashem, R.M. Abouali and A.A. Hassanien, 2019. Comparative physiological study on six Egyptian cultivars differing in their drought stress tolerance. Acta Scientific Agri.. **3.3** : 44-52.

Jana, K., G. K. Mallick and S. Ghosh,2013. Yield of aerobic rice affected by high temperature stress during summer season, A study from red and laterite zone of West Bengal, Ind. J. Applied and Natural Sci. **5** (2): 394-396.

Jagadish, S. V. K., E. M.Septiningsih,A.Kohli,M. J.Thomson Ye C.Redoña E., A. Kumar, G. B.Gregorio, R. Wassmann, A.M. Ismail , R. K.Singh, 2012. Genetic advances in adapting rice to a rapidly changing climate. J.Agron. Crop Sci,**198**(5): 360–373.

Khan, A.F.,L.Imran, Z. Muhammad and N. Muhammad, 2015. Phenologicaltraits of rice as influenced by seedling age and number of seedling per hill under temperate region. J. Biol. Agric. and Healthcare www.iiste.org ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) **Vol.5**, No.3.

kiranmayee, B., R. Damodar, K.B. Kampa Raju and M. Balram, 2018, A study on correlation and path coefficient analysis for yield and yield contributing traits in maintainer (B Lines) Lines of hybridgice (*Oryza satava* L.). Int. J. Curr. Microbiol. App. SC. **7**(6) 2918-2929

Mondal, P., S. Pal, A. Alipatra, J. Mandal and H. Banerjee,2012. Comparative study on growth and yield of promising rice cultivars during wet and dry season.PlantArchives, **12** (2) : 659-662.

Nada, R. M. and G. M. Abogadallah,2015. Restricting the above ground sink corrects the root/shoot ratio and substantially boosts the yield potential per panicle in field-grown rice (*Oryzasativa* L.). Physiologia Plantarum**156**: 371–386.

Nehad, T.S. 2011. Effect of drought stress on shoot : rest ratio . World Acad. 54, Engg. and Tech. **57** : 598-600.

Osada, A.,T.Hitoshi ,D.Sommart,S.Vichian and B.Sumet, 1993. Seasonal changes in growth pattern of tropical Rrice.Proc.Sci.Soc.Japan **42**(3):343-350.

Patil, S.G., V.N. Sahu and P.A. Deokar,2009.Study of variability of rice germplasm accessions used for wild rice eradication. Int. J. Plant Sci. **4**(2) : 535-537.

Patel, N.B., R. Shrivastava, V. Kumar And N. Dhirhi,2014. Genetic diversity among some traditional aromatic rice (*Oryzasativa* L.) land races of Chhattisgarh. J. Progressive Agri. **6** (1) : 1-4

Shipley, B. 2006. Net assimilation rate, specific leaf area and leaf mass ratio which is most closely correlated with relative growth rate, A meta-analysis Functional Ecol.**20** : 565–574.

Wirnas, D., R. H. Mubarrozzah, M. Noviarini, S.Marwiyah, Trikoesoemaningtyas, H. Aswidinnoor, S. HadiSutjahjo, 2015.Contribution of genetic x temperature interaction to performance and variance of rice yield in Indonesia. Int. J.agro.and agri. Res.**6**.(4) : 112-119.

Williams, R. S. 1946. The physiology of plant growth with special references to the concepts of net assimilation rate. Ann. Bot**. 10** (10) : 41-42.

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