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Effect of Different Fertility Levels on Growth and Production Potential of Rice Genotypes

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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

A field experiment was conducted during *kharif* season of 2019 at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) for evaluation of six rice genotypes (IET-27263, IET-26418, IET-26420, NDR-359, PD-19 and PD-26) under varying fertility

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levels (Control, 100% RDF, 150% RDF). Treatments were tested in Split Plot Design with three replications keeping fertilizer levels in main plots and genotypes in sub plots.
Application of fertilizer at 150% RDF and genotype IET-27263 resulted in significantly taller plants, highest number of tillers, highest dry matter accumulation over all other fertilizer levels.
So, it can be recommended that application of fertilizers at higher dose is essential for obtaining higher yield of rice as most of the parameters of growth, development and yield were responding well up to 150% RDF. The new rice genotype IET27263 was found superior to all other tested genotypes.

Keywords: Genotype; RDF; tarai; tillers.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important and widely cultivated crop in the world. It is the staple food and a mainstay of Asian countries [1], where 90% of world's rice is grown and eaten in this continent and more than two billion people are getting 60-70% of their energy requirement from rice and its derived products [2]. Population of world is increasing day by day and it has to produce 50% more than what is produced now by 2050 to cope up with the growing demand of food (FAO, 2016). Despite of high production growth rate that has been achieved over the years, the rice productivity in the country still remains low as compared to other rice producing countries like China and Japan. Therefore, especial attention is needed to enhance rice yield and quality through improved production technology as well as application of agricultural inputs with better management. Among various factors that are responsible for better yield and quality, the proper use of fertilizers is of prime importance [3]. Among the major elements nitrogen is the most limiting nutrient for rice growth and yield which is required in higher amounts compared to other nutrients [4]. In its absence, the yield is reduced drastically [5]. Plants cannot reach their maximum yield without adequate supply of phosphorus [6], as it is a major growth limiting nutrient. Potassium is essential for the maintenance of electrical potential across cellular membranes and cellular turgor enhancing the cell expansion and enlargement, opening and closing of stomata, and pollen tube development. It is also involved in activation of many enzymes, translocation of nitrate and sucrose [7]. It has been noticed that farmers use imbalanced dose of fertilizer which leads to higher insects/disease attack ultimately producing lower yield [8]. Exploiting genotypic variability for improving the use efficiency of soil and fertilizers is of utmost importance in rice production [9]. Different genotypes have differences in their ability to absorb and uptake the plant nutrients because of their diverse attributes such as genetic yield potential. The mineral uptake and translocation are related to the genetic makeup of crop plants; therefore, different genotypes show differential behavior to similar fertilizers [10]. Thus, characterization of rice genotypes that are efficient in uptake and use of mineral nutrients is of major concern in rice production [11]. Keeping in view the above facts the experiment was conducted to see the effect of different fertility levels on growth and production potential of six rice genotypes.

2. MATERIALS AND METHODS

The experiment was conducted during the *kharif* season of 2019 in the A_2 block at N. E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, District U.S. Nagar, Uttarakhand. Pantnagar falls in sub-humid and subtropical climate zone and situated in *Tarai* belt of Shivalik range of foot hills of Himalayas. Geographically it is located at 29^0 N latitude, $79^0$29' E longitude and at an altitude of 243.84 m above mean sea level. The soil of experimental field (A_2) is silt loam in texture, alluvial origin and classified as Aquic hapludoll [12]. The experiment was carried out in split plot design with three replications. In the main plot three fertilizer levels i.e., control, 100% RDF (120 kg N, 60 kg P_20_5 and 40 kg K_2Oha^{-1}) and 150% RDF (180 kg N, 90 kg $P_2O_5$and 60 kg K_2Oha^{-1}) and in sub-plot seven genotypes of rice were taken i.e., IET-27263, IET-26418, IET-26420, NDR-359, PD-19, PD-26. The gross plot size was 15m^2. Rice was transplanted at 20 cm × 20 cm spacing. The plant height was measured on tagged four hills. The 16 hills (4 units of 2 × 2 hills) located in the third and fourth row of the plot on both sides were tagged for counting the number of tillers. The value was multiplied by a factor to convert into 1 m^2 at all the stages of the recording. The height of individual hill was measured (cm) with the help of a meter scale from the base of the hill to the tip of top most leaf up to flowering and upto tip of the panicle at maturity. The mean of four hills is reported as height (cm) of the plant. For determining the plant dry matter yield, the samples were collected from the third row of the plot leaving the tagged plants. The plant samples were clipped close to the ground and collected in polythene bags. Plants were then washed with water and collected in paper bags. After sun drying plant parts were dried in a drier at 70±2ºC till constant weight. The weight thereafter converted into gram per square meter. Other procedure was followed according to package of practices of rice.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant growth affects the yield and yield attributes directly. Plant growth and development during the vegetative stage decides both biological and economic yields because of the fact that during vegetative period green tissues are formed which provide photosynthates for seeds or storage tissues [13]. The results obtained from plant growth studies in terms of plant height, number of tillers m^{-2} and plant dry matter accumulation as recorded at different crop growth stages are explained and discussed here under following heads:

3.1.1 Plant height

The data on plant height as affected by various fertilizer treatments are summarized in Table 1 and depicted in Fig. 1.

The fertilizer levels had significant effect on plant height at all the crop growth stages. The plant height increased continuously with the advancement of crop age up to 90 DAT and thereafter it reduced slightly. This might be due to shrinkage of plant tissues at the time of full maturity. The plant height increased significantly up to 150% RDF. It might be due to higher amount of NPK supplied. An adequate and more supply of NPK resulted in increase of various metabolic process and performed better mobilization of synthesized carbohydrates into amino acid and protein, which in turn stimulated the rapid cell division and cell elongation, this allowed the plant to grow faster [14]. The results are in line with the findings of Joshi et al. [15].

The different rice genotypes had significant variations in plant height at all the stages of crop growth. At 30 DAT, genotype IET-27263 produced significantly taller plant (55.5 cm) than all other genotypes. It was followed by IET-26420 (53.2 cm). Genotype PD-19 recorded lowest plant height (44.3 cm) but it was statistically *at par* with NDR-359 (46.1 cm).

At 60 DAT, PD-26 produced significantly taller plant (88.6 cm) than all other genotypes except IET-27263 (85.8 cm). The plant height recorded in IET-26418 (82.2 cm) was statistically at par with genotypes IET-26420 (81.7 cm) and NDR-359 (79.2 cm). The plant height was lowest (76.3 cm) in PD-19 but it was *at par* with NDR-359.

Table 1. Plant height at different crop growth stages as influenced by levels of fertilizer and genotypes

Treatment	**Plant height (cm)**			
	30 DAT	**60 DAT**	**90 DAT**	**Maturity**
Fertilizer level				
Control	46.1	73.5	87.8	87.5
100% RDF	49.3	83.8	90.2	90.1
150% RDF	53.5	89.6	94.7	94.2
SEm±	1.1	1.8	0.9	1.8
C.D. (5%)	3.1	5.2	2.3	3.9
Genotype				
IET-27263	55.5	85.8	96.2	96.4
IET-26418	48.1	82.2	85.8	85.3
IET-26420	53.2	81.7	93.5	93.1
NDR-359	46.1	79.2	84.9	84.7
PD-19	44.3	76.3	87.2	87.0
PD-26	50.7	88.6	97.4	97.1
SEm±	0.7	1.4	1.3	1.5
C.D. (5%)	2.1	4.0	3.8	4.5
C.V. (%)	2.4	4.4	4.6	4.8

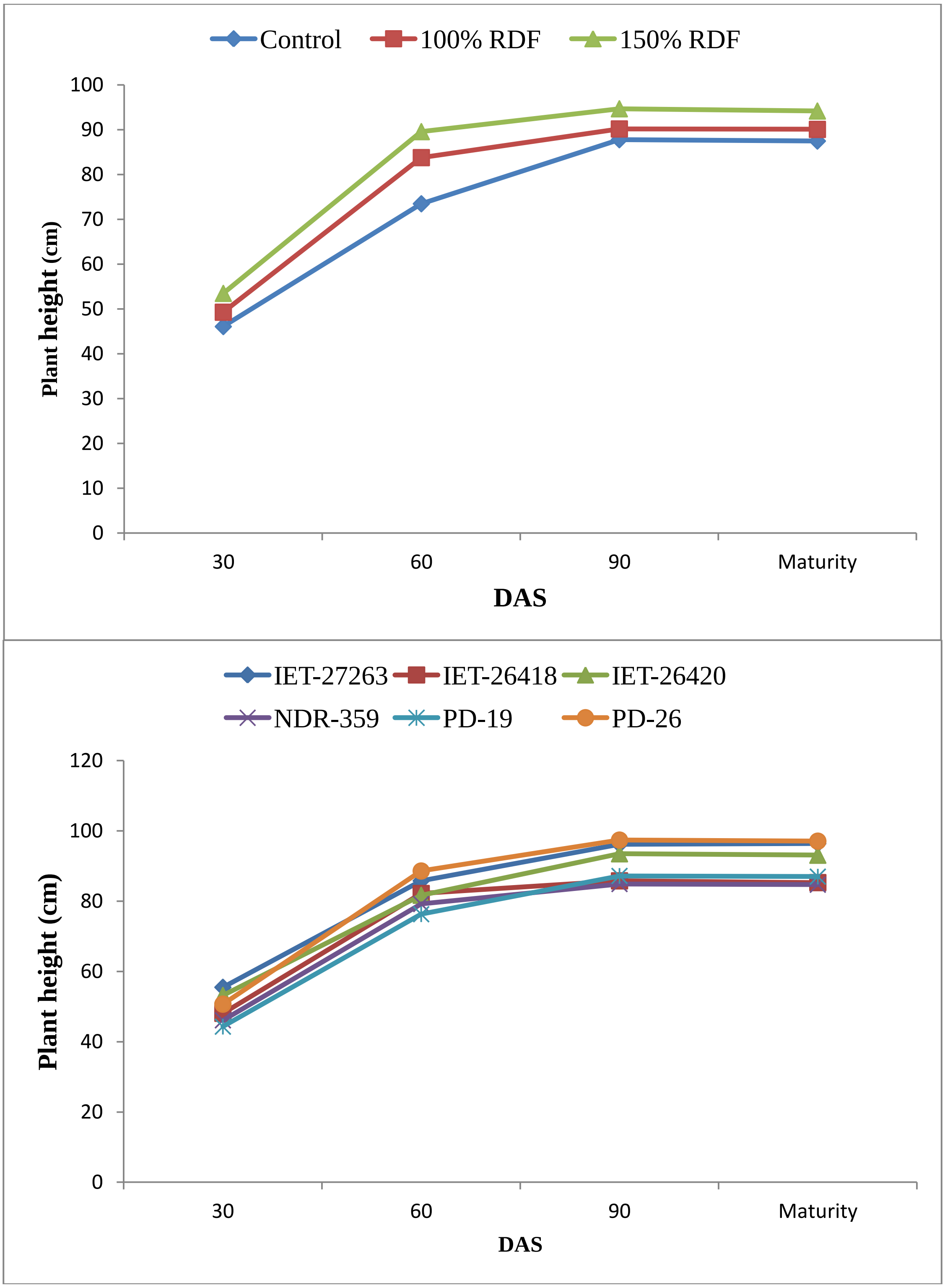


Fig. 1. Plant height at different crop growth stages as influenced by levels of fertilizer and genotypes

Again at 90 DAT, PD-26 produced significantly taller plant (97.4 cm) than all other tested genotypes except IET-27263 (96.6 cm). The next taller plants were recorded in IET-26420 (93.5 cm) which was significantly taller than all other genotypes. The plant height was lowest (84.9

cm) in NDR-359 which was statistically similar with IET-26418 (85.8 cm) and PD-19 (87.2 cm).

The similar trend was followed at maturity stage. The plant height varied from 84.7 cm in NDR-359 to 97.1 cm in PD-26. The variation in plant height is may be attributing to different genetic makeup of various genotypes [16]. The results are in line with the findings of Dangi et al. [17].

3.1.2 Number of tillers m^{-2}

The data pertaining to number of tillers m^{-2} recorded at a regular interval are presented in Table 2 and depicted in Fig. 2.

In general, the number of tillers m^{-2} increased rapidly up to 60 DAT; thereafter it was declined slightly. It might be due to self-thinning mechanism, resource constraint, and intra-plant competition [18].

Different levels of fertility had significant influence on the number of tillers m^{-2} at all the crop growth stages. The number of tillers m^{-2} increased significantly with the increasing fertility levels up to 150% RDF at all the crop growth stages except at maturity. At maturity, the number of tillers m^{-2} recorded under Control was 218, which increased significantly with 100% RDF to 267, however 150% RDF resulted the highest number of tillers m^{-2} (284) but it was statistically at par with 100% RDF.

The reason for increase in tiller number with increase in fertility levels might be due to adequate NPK supplied to the plants. Tiller number increases linearly with sheath NPK content [19]. A high sheath NPK content increases the cytokinin content within tiller nodes and enhances the germination of the tiller primordium [20]. The results are in line with the findings of Sharma et al. [21].

The different rice genotypes had significant effect on the number of tillers m^{-2} at all the crop growth stages. At 30 DAT, genotype NDR-359 produced significantly higher number of tillers m^{-2} (318)., than the next higher number of tillers m^{-2} was recorded in IET-27263 (285) which was significantly higher to all other genotypes tested except IET-26418 (239). Among the different rice genotypes, IET-26418 resulted significantly lowest number of tillers m^{-2} (239).

At 60 DAT, genotype PD-26 produced significantly higher number of tillers m^{-2} (443) than all other genotypes except NDR-359 (438). The next higher number of tillers m^{-2} was recorded in IET-27263 (409). However, IET-26418 resulted in significantly lower number of tillers m^{-2} (326) than all other tested genotypes.

At 90 DAT, genotype IET-27263 produced highest number of tillers m^{-2} (273) which was statistically *at par* with PD-19 (272) and IET-26420 (267). It was followed by genotype NDR-359 (261) which was comparable with PD-26 (260). The genotype IET-26418 produced significantly lower number of tillers m^{-2} (246) than all other genotypes.

Similar trend was observed at maturity stage. The number of tillers m^{-2} varied from 240 in IET-26418 to 266 in IET-27263. The variability may be accounted due to variable genetic makeup of different genotypes. The tiller productivity of rice depends on the genetic potentiality [22]. Similar results were also reported by Ramassami et al. [23] who stated that number of tillers differed due to the varietal variation.

3.1.3 Dry matter accumulation (g m^{-2})

The dry matter accumulation in 30, 60, 90 DAT and at harvest are summarized in Table 3. and depicted in Fig. 3. The dry matter accumulation was significantly affected by fertilizer treatments at all the stages of growth.

Results of the experiment revealed that different levels of fertility had significant effect on the dry matter accumulation at all the crop growth stages.

Dry matter accumulation at different crop growth stages increased significantly up to 150% RDF. At maturity, the percent increase in plant dry matter at 100 and 150% RDF was 57.8 and 76.5, respectively over the plant dry matter (555 g m^{-2}) obtained with Control. This might be due to adequate supply of NPK which positively led to increase in plant height, improving tillering and thus contributing to higher dry matter production through increased photosynthetic activity of leaves. Similar findings were also reported by Azarpouret al. [24].

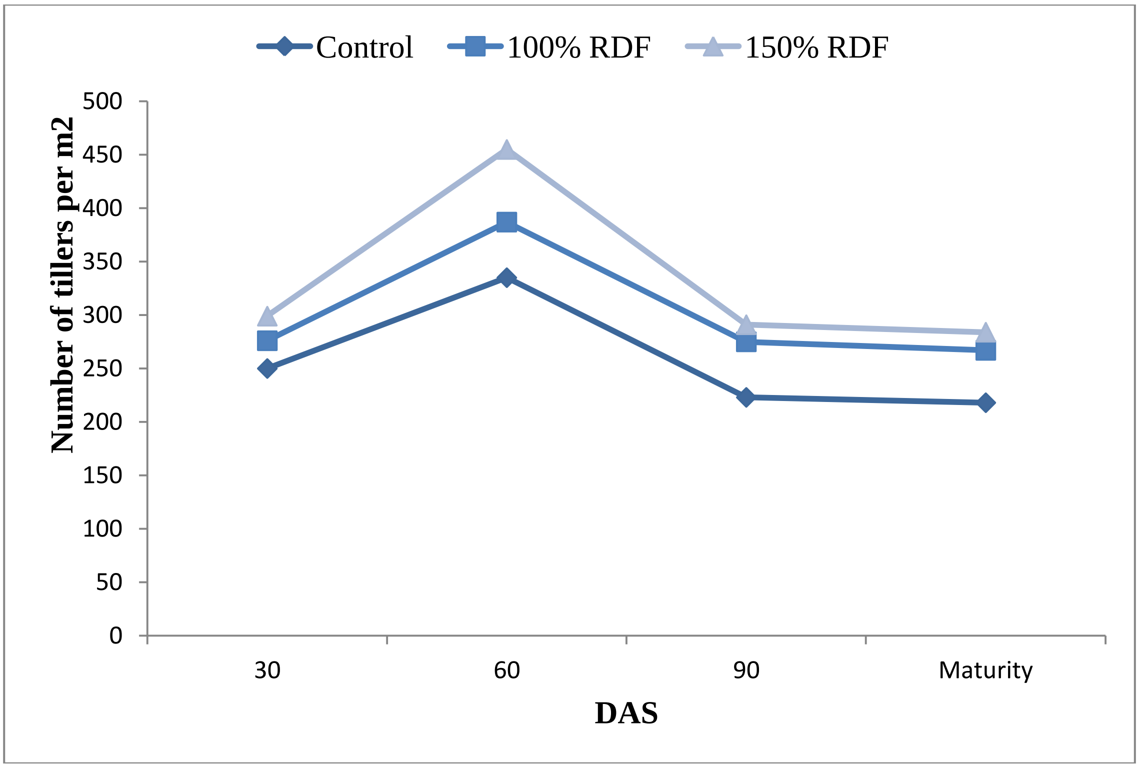
The different rice genotypes had significant variations in dry matter accumulation at all the stages of crop growth. At 30 DAT, genotype IET-27263 produced significantly higher plant dry matter (33 g m^{-2}) than all other genotypes except PD-26 (30 g m^{-2}). The higher plant dry matter at

30 DAT with genotype IET-27263 might be due to its taller plants. Kroda et al. [25] also reported that tall plant height along with more tillering is associated with high biomass production. Similar findings were also reported by Kharel et al. [26]. Genotype IET-26420 recorded lowest dry matter accumulation (22 g m^{-2}) and it was statistically *at par* with NDR-359 (25 g m^{-2}).

At 60 DAT, PD-26 produced significantly higher plant dry matter (216 g m^{-2}) than all other genotypes except PD-19 (210 g m^{-2}). The dry matter accumulation recorded in IET-27263 (198 g m^{-2}) was the second highest among the genotypes. The dry matter accumulation was lowest (176 g m^{-2}) in NDR-359 which was significantly lower to all other tested genotypes.

Table 2. Number of tillers m^{-2} at different crop growth stages as influenced by levels of fertilizer and genotypes

Treatment	Number of tillers m^{-2}			
	30 DAT	**60 DAT**	**90 DAT**	**Maturity**
Fertilizer level				
Control	250	335	223	218
100% RDF	276	387	275	267
150% RDF	299	455	291	284
SEm±	7	10	5	6
C.D. (5%)	20	31	15	18
Genotype				
IET-27263	285	409	273	266
IET-26418	239	326	246	240
IET-26420	264	368	267	261
NDR-359	318	438	261	256
PD-19	269	376	272	264
PD-26	275	443	260	254
SEm±	8	2	3	3
C.D. (5%)	23	8	10	9
C.V. (%)	8.8	6.8	7.9	8.5



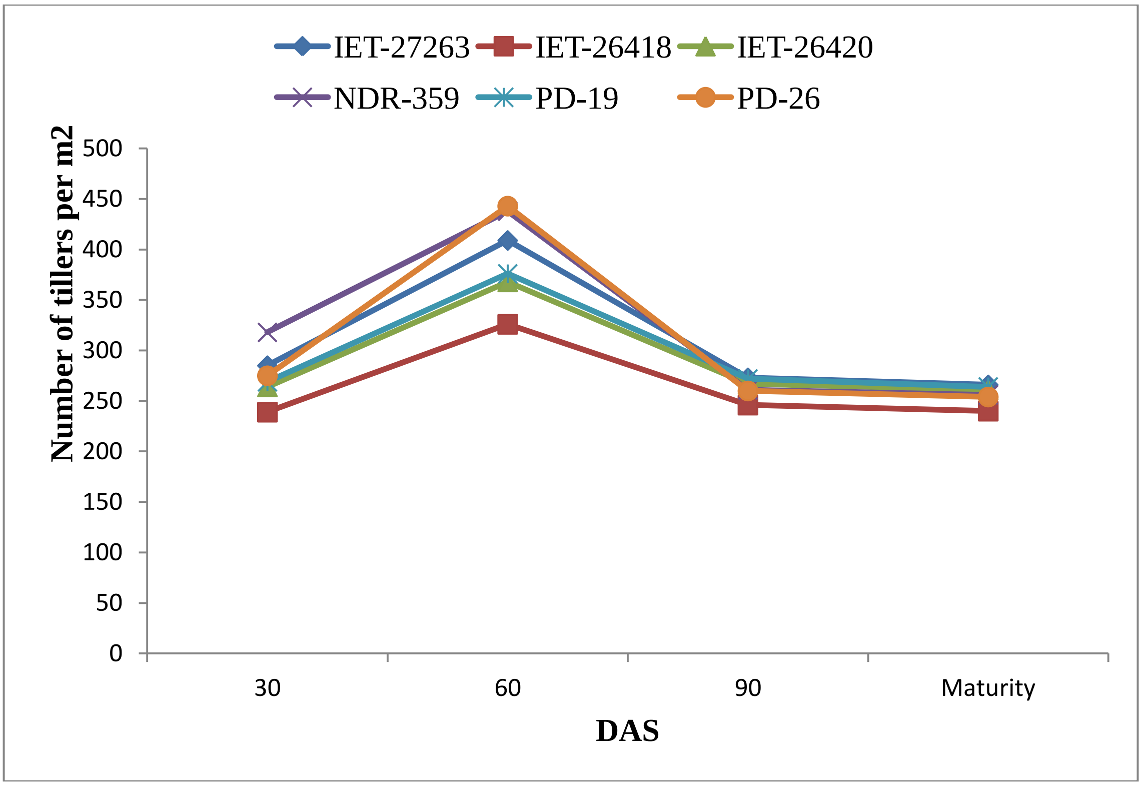


Fig. 2. Number of tillers m^{-2} at different crop growth stages as influenced by levels of fertilizer and genotypes

Table 3. Plant dry matter accumulation at different crop growth stages as influenced by levels of fertilizer and genotypes

Treatment	Dry matter production (g/m^2)			
	30 DAT	60 DAT	90 DAT	Maturity
Fertilizer level				
Control	24	173	512	555
100% RDF	28	197	823	876
150% RDF	32	216	947	980
SEm±	1	4	31	32
C.D. (5%)	2	16	95	101
Genotype				
IET-27263	33	198	849	895
IET-26418	26	189	732	752
IET-26420	22	183	659	696
NDR-359	25	176	843	890
PD-19	28	210	762	803
PD-26	30	216	719	779
SEm±	2	2	9	18
C.D. (5%)	3	6	28	54
C.V. (%)	9.3	8.9	6.3	5.4

At 90 DAT, IET-27263 produced significantly highest plant dry matter (849 g m^{-2}) than all other tested genotypes except NDR-359 (843 g m^{-2}). The next highest plant dry matter was recorded in PD-19 (762 g m^{-2}) which was significant to all other genotypes. However, the plant dry matter accumulated was significantly lowest in IET-26420 (659 g m^{-2}).

At maturity, genotype IET-27263 produced significantly highest plant dry matter (895 g m^{-2}) than all other genotypes except NDR-359 (890 g

m^{-2}). Next higher dry matter accumulation was recorded in PD-19 (803 g m^{-2}) which was statistically *at par* with PD-26 (779 g m^{-2}) and IET-26418 (752 g m^{-2}). The genotype IET-26420 accumulated significantly less (696 g m^{-2}) dry matter as compared to remaining genotypes.

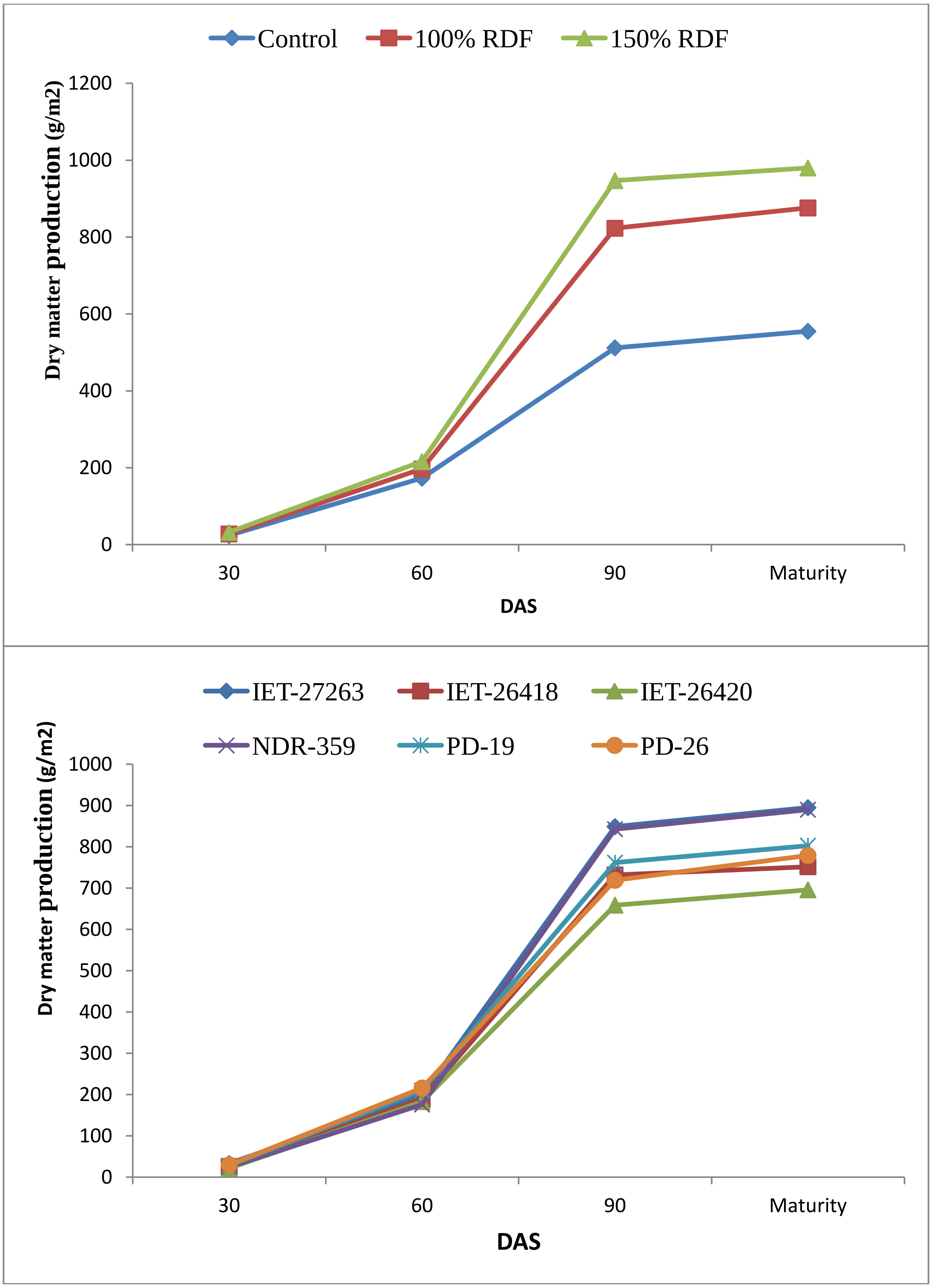


Fig. 3. Plant dry matter accumulation at different crop growth stages as influenced by levels of fertilizer and genotypes

4. CONCLUSION

From the observations, it was concluded that rice genotypes IET-27263 and NDR-359 should be fertilized with 150% RDF (180:90:60 kg NPK/ha) to achieve higher yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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