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Effect of differential nutrient management on growth and yield components in late sown rice (*Oryza sativa* L.)

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Abstract
Sowing time and fertilization for rice cultivation is very important for growth and optimum yield. Due to some or the other factors like poor weather condition, delayed monsoon, late harvest of previous crop, farmers have to go for late sown condition which has negative impact on growth and yield of rice resulting in yield reductions. Optimizing the dose and an understanding of the nutrient utilization capacity under late sown condition will help to improve the productivity of rice. Keeping in view the aforesaid facts, a field study was conducted in rainy season of 2017 and 2018 at GBPUA&T, Pantnagar, India to assess effect of differential nutrient management on the growth and yield of six rice genotypes *viz*. PR-113, PD-22, HKR-47, PD-24, NDR-359 and PD-19 under late sown conditions. The treatments included 50% RDF (60:30:20 kg NPK ha^{-1}), 100% RDF (120:60:40 kg NPK ha^{-1}), 150% RDF (180:90:60 kg NPK ha^{-1}) and 50%RDF+ FYM (5 t ha^{-1}). Incremental doses of N, P and K (150% RDF) significantly improved the growth parameters such as height, number of tillers, number of panicles per square meter, 1000-grain weight as well as grain and biological yield. When the dose was reduced to 50% RDF the growth and yield parameters decreased significantly. Application of FYM along with 50% RDF could not result in yield levels comparable to 100% RDF.

Keywords: Components, late sown rice, *Oryza sativa* L.

1. Introduction

Rice is the second most important cereal crop with global rice production averaging around 759.6 Million tonnes in 2018 (FAO, 2018). In general, South, South-east and east Asia contribute towards more than 90% of rice production and consumption. In particular, in India rice is the major staple food crop and is cultivated round the year in, in diverse ecologies spread over 43.86 M ha with a production of 106.5 million tonnes of rice and average productivity of 23.90 q ha-1 which is quite low as compared to the global average(Anonymous, 2015) [4]. In addition, role of delayed monsoon as well as scanty rainfall in shrinking rice production has become more visible over the past few years. Farmers are forced to delay the transplanting of paddy in view of the dry weather available during the optimum time of transplanting. Delayed transplanting coupled with excessive use of unbalanced fertilizers have become the two main determinants in reducing the yield as well as compromising the partial factor productivity that can be derived per kg of nutrient.

The sowing time of the rice crop is important for synchronization of three major phenophases. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperatures and total sunshine hours. Secondly, the optimum sowing time for each cultivar ensures the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved(Patel *et al*., 2019) [1].

Sowing date is pivotal for optimum rate of establishment and subsequent phenology for growth and development. A delay in sowing reduces the time for maximum tillering i.e. the vegetative period and thus the number of productive tillers. This in turn reduces the panicle number per square meter. An altered phenology leads to lesser time for spikelet maturity and majority of the spikelets remain as primordial in case of late sowing. Further, late sowing causes coincidence of lower than optimum temperatures at anthesis leading to reduced grain filling. Accordingly, it has been reported that the decreasing trend in grain yield with delayed sowing date might be associated with the reported significant lower number of filled grains per panicle, lower number of panicles m^{-2}, and lower test weight (Khalifa, 2009; Patel *et al*., 2019) [19, 1]. Thus it can be acknowledged that, a delay in sowing time reduces the optimum growth window both for the vegetative as well as the reproductive phases leading to reduced yield. However, it has been reported that supraoptimal doses of nutrients lead to superior growth, development and yield in case of rice plants. High balanced doses of fertilizers can significantly affect the nutrient uptake and assimilation which translates into better yields (Sampath *et al*., 2017) [39].

Different nutrients have their own specific roles and in combination lead to superior growth and development of plant. Nitrogen is involved in many plant compounds such as proteins, chlorophyll, enzymes, hormones, alkaloids and vitamins, but its excess delays maturity and unnecessarily prolongs vegetative growth duration (Brady and Weil 2008) [8]. Potassium is the most abundant ionic element in plants and directly affects the crop metabolism. Potassium has an additive influence on number of filled grains per panicle (Bahmanyar and Mashaee, 2010) [6]. Phosphorus stimulates root development and is required for cell division. This may lead to efficient establishment of seedlings even in late planted condition. It has been shown that addition of phosphorus increased numbers of active tillers per hill and thus yield (Khan and Imtiaz, 2013) [20].

In addition to the above the uptake and availability of nutrients is also complex and is affected by the input levels of other nutrients. More often the uptake of major nutrients is coupled together. Such as both P and K improve the efficiency of N uptake by plants and provide resistance to plants against disease and drought stress. Potassium is involved in regulating the translocation of nitrate. Nutrient availability is also affected by soil physical qualities which in turn are a function of soil organic carbon. Organic manures with high estimated mineralizable N can facilitate availability of N for a greater period. Thus, an optimum level of nutrient input in right combinations only can enhance the nutrient use efficiency (Marschner, 2012) [33]. The input of mineral nutrients must take into account the effect of genotype as well. The response of a genotype depends on environment while rhizospheric environment depends on soil nature and nutrient addition. (Kamal *et al*., 2015) [17].

2. Material and Methods

A field experiments was conducted on rice (*Oryza sativa* L.) during two consecutive rainy seasons of 2017 and 2018 at the Norman. E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, India. The site is situated at 29° N latitude, 79° 29'E longitude and at an altitude of 243.8 meter above mean sea level. The experiment was laid out in a split plot design with fertilizer doses in the main plots and the six rice genotypes in the sub-plot. All the main plot treatments were replicated thrice. Twenty-one-day old seedlings were transplanted with a spacing of 20cm x 20cm on 18th July during both the years. Gross plot size was 15m^2 and net plot size was 8.8 m^2. The treatments included 50% RDF (60:30:20 kg NPK ha^{-1}) (T1), 100% RDF (120:60:40 kg NPK ha^{-1}) (T2), 150% RDF (180:90:60 kg NPK ha^{-1}) (T3) and 50%RDF+ FYM (5 t ha^{-1}) (T40). The six rice genotypes were PR-113, PD-22, HKR-47, PD-24, NDR-359 and PD-19. Nutrients were applied as per the treatment primarily through NPK, Urea and Muriate of potash (MOP). Entire phosphorus and potassium and one-third of nitrogen in each treatment were applied as basal. Remaining N was applied in two splits at active tillering and panicle initiation stages. The crop was grown under standard cultural practices and plant protection measures. Data on growth, yield attributes and yield were collected at different growth stages such as maximum tillering, flowering and maturity. The data collected in both the years was subjected to pooled analysis. All statistical analysis was performed using STPR1 software and the treatments were compared using Fisher's least significant difference method at 5% level of significance.

3. Results

3.1 Plant Height: Plant height of the rice genotypes at various growth stages *viz*. tillering, flowering and maturity is presented in Fig 1 (a-c). In general, plant height significantly increased with increase in dose of fertilizers at all the stages of growth. At 100% RDF, plant height ranged between 55.7cm to 72.2cm at tillering; 97.7cm to130.5cm at flowering and 104.4cm to 129.8cm at maturity across the six genotypes under study. When fertilizer application was reduced to 50% of RDF, plant height decreased significantly by about 8.6, 7.8 and 9.8% at tillering, flowering and maturity stages respectively, while the magnitude of decrease in plant height when 50%RDF supplemented with FYM supplemented dose was less. When 150% RDF was applied, significant increase in plant height was observed. It was observed that FYM application increased plant height by about 3.9, 5.3 and 6% at tillering, flowering and maturity stages respectively, when compared with that at 50%RDFonly. It is evident that in all the treatments the magnitude of increase in plant height was higher between tillering to flowering stages as compared to that between flowering and maturity stages except in HKR47 where plant height continued to increase between flowering and maturity stages at recommended and 150% fertilizer doses.

3.2Number of tillers: Data in Fig 2 represents the tiller number per metre square at active tillering, while Fig 3 represents the number of productive tillers at maturity for all the six varieties under study. Since number of tillers is a direct function of nutrition and spacing, the genotype effect was statistically insignificant. With recommended dose of fertilizer 176 to 195/m^2 tillers were reported at maximum tillering and 220-340/m^2 productive tillers at maturity. With 50% RDF average tiller number decreased significantly by 12% at maximum tillering, and 22% at maturity in terms of number of active tillers, while the decrease in tiller number was less when FYM is supplemented with 50%RDF. At 150% RDF the tiller number was significantly increased on an average by 18% at tillering, and by 20% in terms of number of productive tillers as compared to that with 100% RDF.

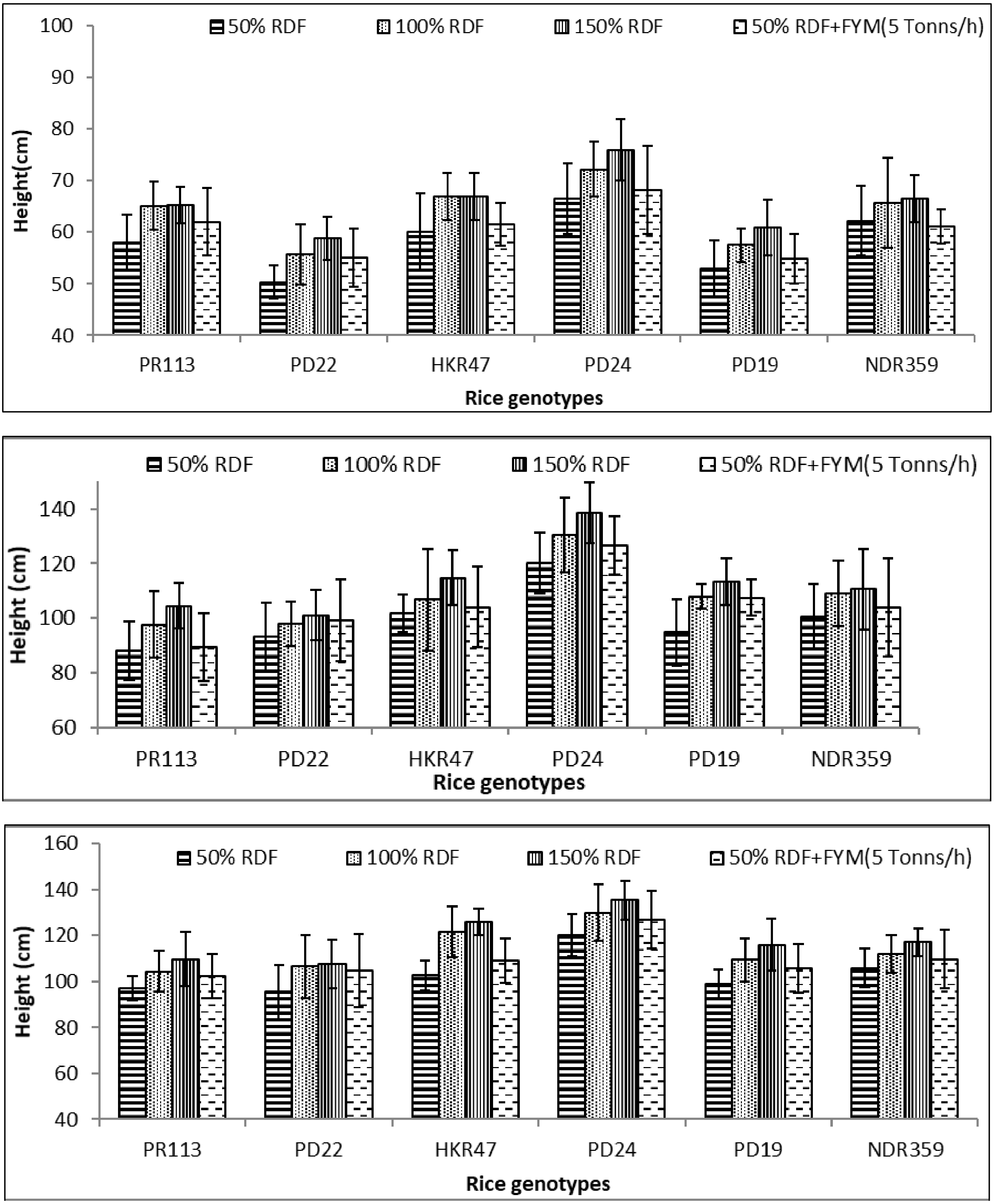
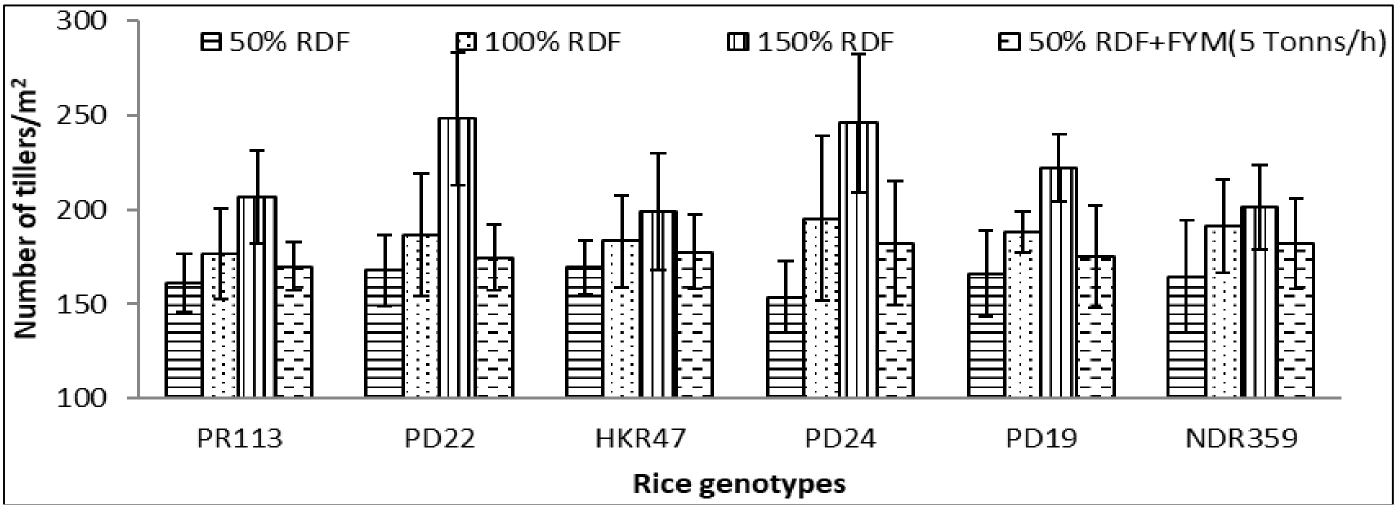


Fig 1: Effect of differential nutrient management on plant height of six rice genotypes at tillering (a), flowering (b) and maturity (c).



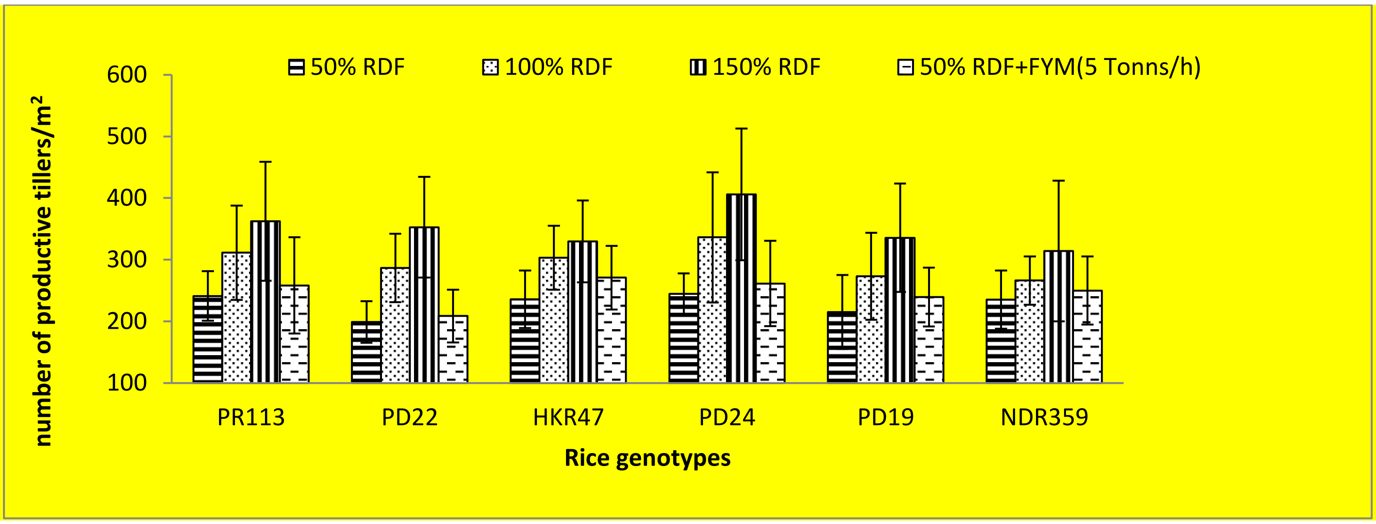


Fig 2: Effect of differential nutrient management on number of tillers of six rice genotypes at maximum tillering (a) and number of productive tillers at maturity (b)

3.3Yield and yield components

3.3.1 Number of panicles/m^2: The number of panicles/m^2 of rice increased with increase in the amount of fertilizers applied and the difference was highly significant for treatment effect only (Fig 3.3). At 100%RDF the number of panicles ranged between 226/m^2 to 336/m^2 in different genotype. A significant increase (between 8-23%) was recorded with 150%RDF treatment. When the dose was reduced by half, the number of panicles decreased significantly by 22%. As compared to 50% RDF treatment, application of FYM along with 50% RDF increased the panicle number by 4-8% for all the varieties except for HKR47 in which a 14% increase was recorded. However, genotype and interaction effect were non-significant.

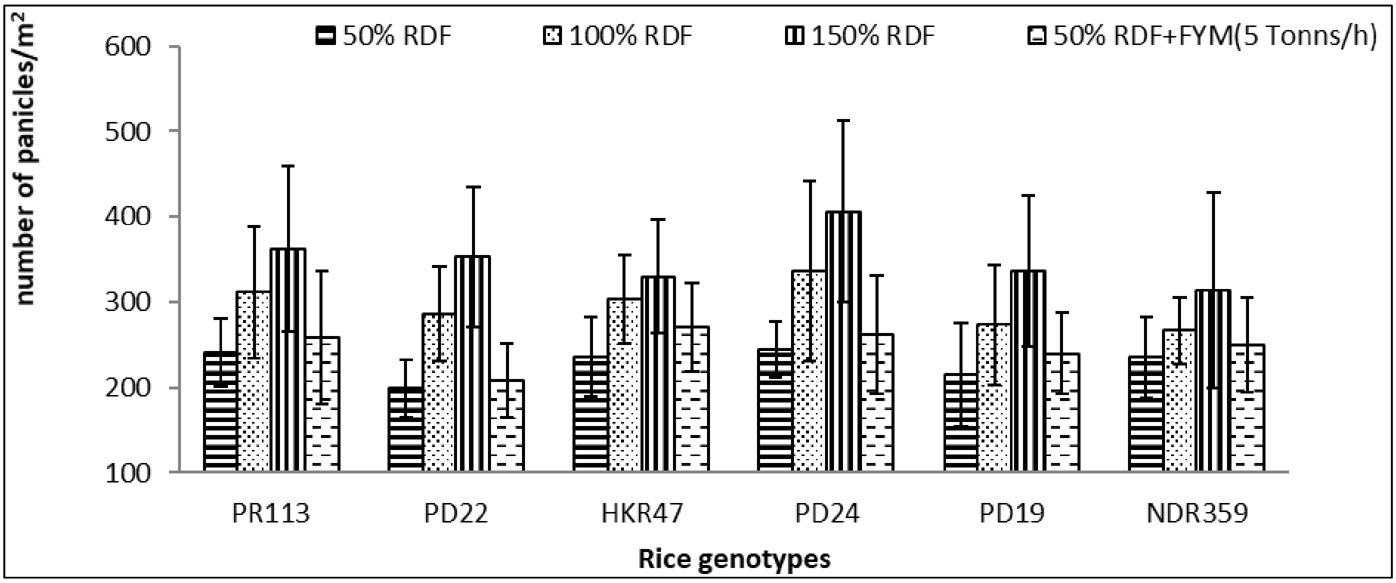


Fig 3: Effect of differential nutrient management on number of panicles/m^2 of six rice genotypes at maturity.

3.3.2 Filled grain percentage: The filled grain% was significantly affected only by incremental fertilizer dosage whereas the effect of genotype was statistically insignificant. At 100%RDF, the filled grain% ranged from 71-85%, while reducing the nutrient dose to half, filled grain% significantly decreased by 12%. The value increased significantly by 5% at 150%RDF. Application of FYM, increased the filled grain% by an average of 8-10% in rice genotypes when compared with that to 50%RDF alone. The interaction effect was non significant (Fig 4)

3.3.3 Grain Yield and Biological Yield (Kg ha^{-1}): Grain yield and biological yield of the rice genotypes under study is presented in Fig.5a & b**.** At 100%RDF, the grain yield and biological yield ranged between 3080 kg ha^{-1} to 5247 kg ha^{-1} and 8521kg ha^{-1} to 11481 kg ha^{-1} respectively, while reducing the nutrient dose to half, resulted in

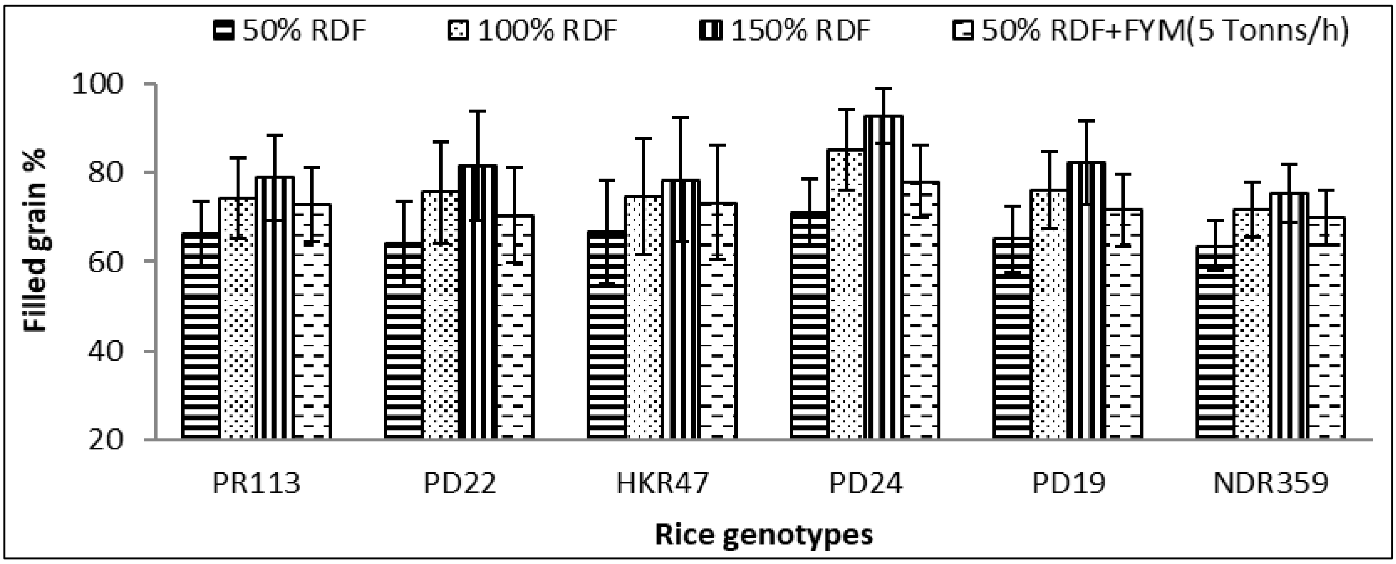
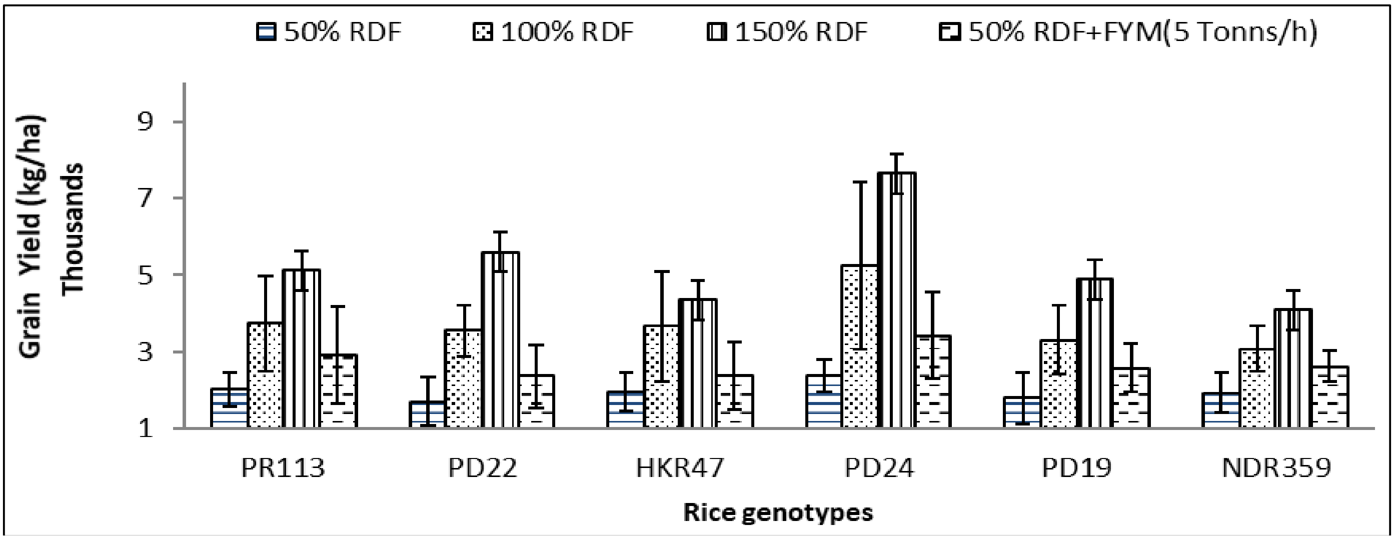


Fig 4: Effect of differential nutrient management on filled grain% of six rice genotypes at maturity

47% and 46% significant reduction in grain yield and biological yield respectively. For both the parameters, the yield increased significantly by 30-60% at 150% RDF for all genotypes except HKR47 in which yield is increased by 18% only. Application of FYM enhanced grain and biological yield between 21-44% and 20-44% of the rice genotypes when compared with that to 50%RDF alone. The interaction effect was non-significant for both the parameters.

3.3.4 1000 -grain weight and harvest index (HI): 1000-grain weight and harvest index (HI) of the rice genotypes under study is presented in Fig 6a & b. 1000-grain weight ranged from 21-23g at 100%RDF, the value reduced by 5.2% which is insignificant, when dose is reduced by 50%. At 150% RDF 1000-grain weight significantly increased by 3-7% of the rice genotypes under study. Application of organic manure (50%RDF+FYM) had only a slight effect on 1000-grain weight and it was increased by only 2% when compared with 50% RDF alone. Unlike 1000 grain weight the harvest index is largely governed by genotype only and effect of treatments was statistically insignificant. At 100% RDF the value ranged from 36-38%, while on reducing the nutrient dose to half, value did not reduce significantly. At 150%RDF the harvest index is increased by only 0.2%, which is non-significant. The interaction effect was non-significant for both the parameters.



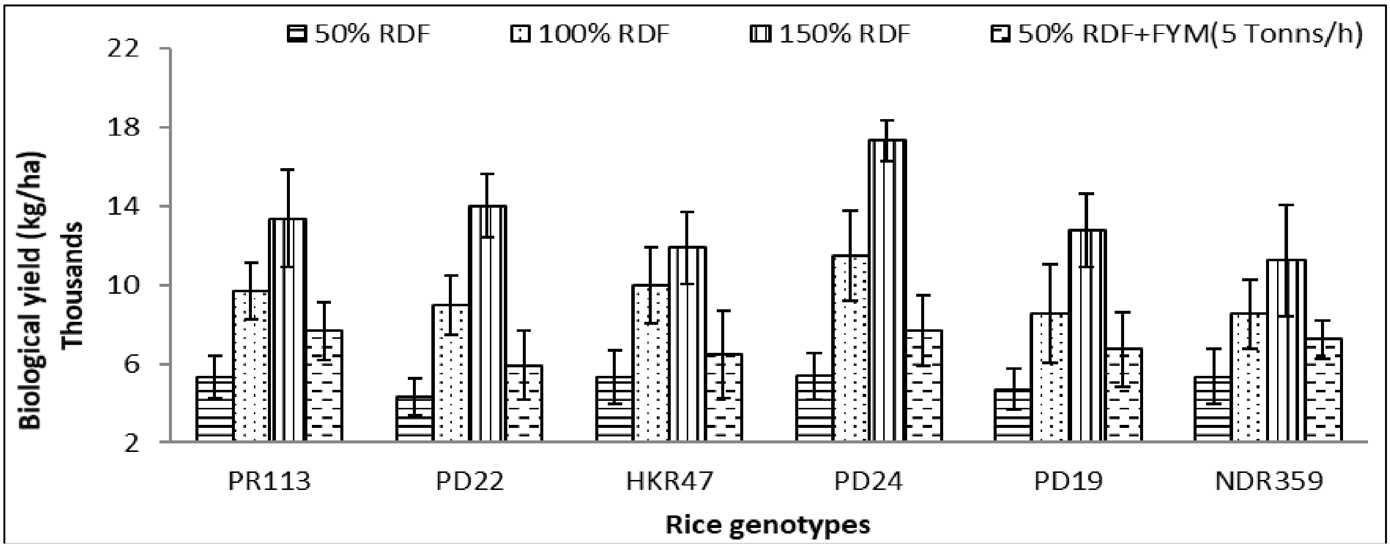


Fig 5: Effect of differential nutrient management of six rice genotype on grain yield (a) and biological yield (b).

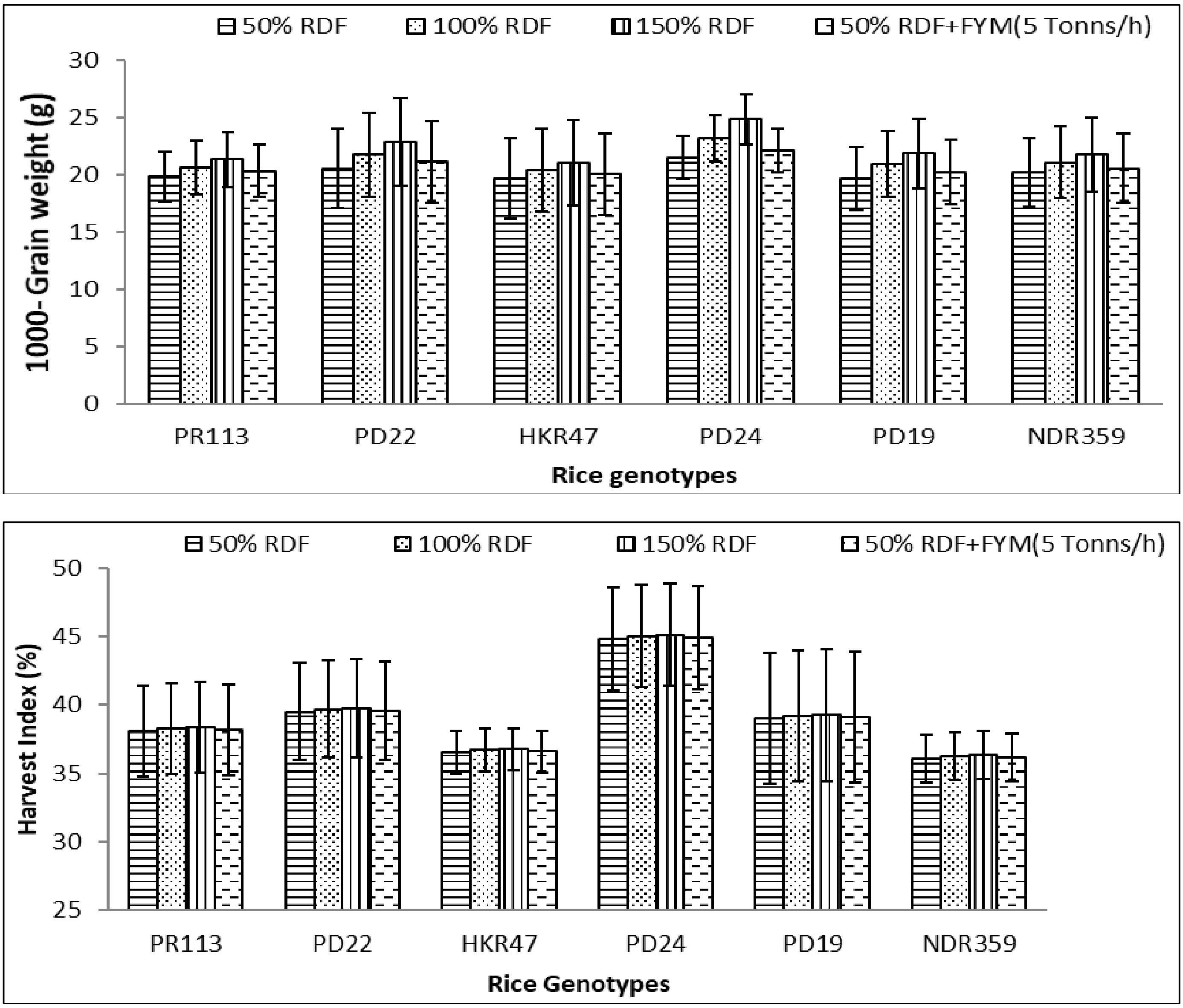


Fig 6: Effect of differential nutrient management of six rice genotype on 1000-grain weight (a) and Harvest index (b).

Discussion

Among the many factors that govern rice yield and productivity, time of sowing has the most significant influence, followed by fertilization levels and weather-based aberrations like intermittent dry spell at the time of sowing or delayed monsoon. There is unequivocal scientific proof that time of sowing and nitrogen fertilization are the two most important agronomic factors for obtaining optimum rice yields and their importance is further underlined in the current climatic scenario where, the incidences of late monsoons are increasing year after year. Delayed transplanting of rice in view of dry weather conditions at the time of sowing coupled with unbalanced or inadequate fertilizer use lead to reduced yield as well as partial factor productivity in rice. A delay in sowing affects the rate of establishment and hence alters the phonological synchronization between and climatic conditions and various growth stages. An altered phenology reduces the optimal growth window for vegetative and reproductive phases resulting in reduced number of productive tillers as well as less time for grain filling thus leading to an overall decrease in yield and productivity. Applying supraoptimal fertilizer doses under late sown conditions significantly affects rice yield and productivity. Chemical fertilizers offer readily soluble nutrients to plants that lead to quick establishment and uptake. A high balanced dose of nutrients gears up the vegetative growth positively affecting the tiller number and canopy establishment. Based on the above background, the present study was conducted in an attempt to understand the effect of differential nutrient management on growth, yield and nutrient use efficiency of six rice genotypes under late sown conditions.

It has been reported that a delay in sowing time results in reduced plant height and number of productive tillers (Shah and Bhurer, 2005) [41]. Soomro *et al*. (2000) reported that a delay in sowing reduced plant height by 12-15%. A two-month delay in transplanting of rice reduced plant height from 107cm to 83cm. Experiments with hybrid rice indicate that timely sowing results into optimal number of total as well as effective tillers per hill, and that a delayed sowing results in a decrease of 30-38% (Nayak *et al*., 2003; Wani *et al*., 2016) [37, 52]. Results of the present study indicate that incremental fertilizer dose of 150% RDF resulted in maximum plant height at all the growth stages as well as maximum number of total and productive tillers. The increased plant height and tiller number observed under incremental nutrient supply are in corroboration with the related previous studies. Gala *et al*. (2011) reported that there is supplemental effect of nitrogen fertilization on vegetative growth. Similar results have been obtained when level of N ranged from 0-150kg/ha, with maximum plant height reported at N_{150} for variety SSRC91216 (Somasundaram *et al*., 2002) [46]. In a similar study maximum number of tillers was observed under 150Kg/ha N fertilizer and minimum tiller number was obtained for 50Kg/ha N fertilizer Hukum *et al.* 2014 also reported increase in plant height and tiller number of different rice genotypes with increase in fertilizer dose from N_0 to N_{200}.The increase in plant height with increase in fertilizer dose is due to the enhanced uptake by roots as well as translocation of N from culm to leaves leading to the production of sufficient photosynthates required for growth of developing panicle. Easy solubility of inorganic nutrients leads to greater availability in the soil solution, thus leading to quick establishment of seedling as faster uptake (Awan *et al*., 2011) [5]. The development of the tiller primordium depends on the N, P, and K contents in leaves and sheaths (Yoshida, 1981) [53]. Tiller number increases linearly with sheath N content. A high sheath N and P content increases the cytokinin content within tiller nodes and enhances the germination of the tiller primordium (Hasanuzzaman *et al*., 2010; Liu *et al*., 2011) [15, 27]. Similar findings where increase in fertility levels lead to increase in plant height and number of tillers of rice have been reported by Sowmyalatha *et al*. (2012) [49] and Songyikhangsuthor *et al*. (2014) [47]. Yield in any given environment is the result of yield components developed in different development phases and growth stages. Yield potential is determined by the number of tillers formed during the vegetative growth phase, the number of panicles induced at the end of the vegetative stage, the number of spikelets formed in each panicle during panicle development, the number of fertile spikelets determined during the booting and flowering stage and the final individual grain weight determined during the grain filling phase (Dingkuhn and Kropff, 1996) [11].

It has been reported by Baloch, *et al.* 2006 that a one-month delay in sowing decreases the grain yield by 24.3%. Similar reduction in total dry matter accumulation and grain yield in view of delayed sowing has been reported by Safdar, *et al.* (2008). Khalifa (2009) [19]. reported that the decreasing trend in grain yield with delayed sowing date might be associated with the significant decrease in number of filled grains per panicle, lower number of panicles m^{-2}, and lower test weight of grains. Moreover Patel *et al*. (2019) [1]. conclude that an altered phenology in view of delayed sowing leads to lesser time for spikelet maturity and majority of the spikelets remain as primordial. Delayed sowing also causes coincidence of lower than optimum temperatures at anthesis leading to reduced grain filling and an overall decrease in grain yield.

From the results of the present study it follows that total dry matter, yield and yield attributes significantly increased with increase in fertilizer dose under late sown condition. While grain and biological yield increased from 30 to 60%, increase in panicle number per square meter was around 20%. 1000 grain weight showed minimal increment, while differences in harvest index values were negligible. Similar findings were reported in previous studies regarding increase in rice yield with high balanced dose of fertilizers by Mahajan *et al*. (2012) [31], Mallareddy*et al*. (2013) [32] and Uddin *et al*. (2013) [50]. Dekhane *et al*. (2014) [10]. concluded that increasing the rate of nitrate fertilizer considerably improves yield parameters such as: number of panicles per plant, the number of panicle m^{-2} and the weight of 1000 grains. However, it has been reported by Yadnar *et al*. (2018) that, even though nitrogen contributes to sink size by decreasing the number of degenerate spikelets and increasing the hull size, this effect of nitrogen is not visible if it not supplemented by equivalent dose of potassium fertilizer. In addition to this, high dose of phosphorus fertilizer reduces spikelet sterility and ensures maximum grain filling leading to increased yield. Ability of a cultivar to partition dry matter towards seeds is largely affected by the nutrient status as well as genotype. It has been reported by Ndaeyo *et al*. (2008) [38] that one basis of increased yield attributes is the affinity of the genotype to produce a greater number of tillers m^{-2} in early growing period followed by its differential ability to assimilate as well as partitioning of photo assimilates. On the basis of related studies by Onaga *et al*. (2012) [40] and Vanitha and Mohandass (2014) [51] it can be concluded that source size and activity as well as sink potential is affected not only by incremental fertilizer dose but by genotype as well. Moreover, rice varieties with greater sink capacity and source activity per plant could produce heavier grain weight. High nitrogen levels not only increase total dry matter on a whole plant basis, but the increment is stage specific. High nitrogen influenced dry matter accumulation after heading stage and its synchronization with grain filling might be the key reason for increase in yield. High nitrogen levels delay senescence and maintains the capacity of functional leaves after heading. This promotes greater photosynthate transfer towards grain and thus the increase in yield (Zhou *et al*., 2017).

1000 grain weight and harvest index did not show much variation with the increased nutrient status. 1000 grain weight is a stable varietal trait and the size of grain is limited by hull, which in turn is loosely genetically regulated, hence the variation observed is minimal. Similarly, harvest index is a property that is mostly genetically determined and hence difference in harvest index was found to differ non-significantly with fertility levels showing only a slight improvement with incremental fertilizer dose. The results are in congruence with those obtained by Murthy *et al*. (2015) [36] and Abbas *et al*. (2016b) [18].

Conclusion

The results indicate that late sown rice responds to a higher dose of fertilizers (150%RDF) which significantly improved the plant height (6-10%) and tiller numbers at active tillering (18-22%) and also number of productive tillers at maturity (15-20%). The number of panicles per square meter (16-20%), 1000 grain weight (3-7%) and grain yield (25-40%) also increased at 150% RDF. Response to nutrient doses varied among genotypes under study. When supplied with half the recommended dose along with organic manure (50% RDF+5 t ha^{-1}FYM), the performance of genotypes was still below that at 100% RDF.

References

1. Patel AR, Patel ML, Patel RK, Mote BM. Effect of different sowing date on phenology, growth and yield of rice– a review. Plant Archives. 2019; 19(1):12-16
2. Abbas M, Shah JA, Irfan M, Memon MY. Evaluating nitrogen and phosphorus requirement for the economical harvest of rice genotype ‘NIA-19/A’. Sci. Intl.2016; 28(4):3977-3982.
3. Alam MS, Islam MS, Islam MA. Farmers efficiency enhancement through input management: the issue of USG application in modern rice. Bangladesh Journal of Agricultural Research. 2011; 36(1):129-141.
4. Anonymous. Agricultural Statistics at a Glance. Directorate of Economics & Statistics. Ministry of Agriculture Department of Agriculture & Cooperation. Government of India, 2015.
5. Awan TH, Ali RI, Manzoor Z, Ahmad M, Akhtar M. Effect of different nitrogen levels and row spacing on the performance of newly evolved medium grain rice variety, KSK-133. J Anim. Plant Sci. 2011; 21(2):231-234.
6. Bahmanyar MA, Mashaee SS. Influences of nitrogen and potassium top dressing on yield and yield components as well as their accumulation in rice (Oryza sativa). African Journal of biotechnology. 2010; 9(18):2648-2653.
7. Bindra AD, Kalia BD, Kumar S. Effect of graded levels of nitrogen and dates of transplanting on growth, yield and yield attributes of scented rice. Advances in Agricultural Research in India. 2000; 13:209-212.
8. Brady NC, Weil RR. The nature and properties of soils Upper Saddle River: Pearson Prentice Hall, 2008, 360.
9. Chen JH. The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. In International workshop on sustained management of the soil-rhizosphere system for efficient crop production and fertilizer use. Land Development Department Bangkok Thailand. 2006; 16:20.
10. Dekhane SS, Patel DJ, Jadhav PB, Kireeti A, Patil NB, Harad NB *et al*. Effect of organic and inorganic fertilizer on growth and yield of paddy cv gr 11. Int. J Inf. Res. Rev. 2014; 2:26-28.
11. Dingkuhn M, Kropff M. Rice. In: [E Zamski, AA. Schaffer], Photoassimilate Distribution in Plants and Crops, Source-Sink Relationships. Marcel Dekker, Inc., New York/Basel/Hong Kong, 1996,519-547
12. Dutta S, Ghose TJ, Dey PC. Influence of potash levels on growth, yield, nutrient uptake and economics in irrigated summer rice of Assam. ORYZA-An International Journal on Rice. 2013; 50(4):334-339.
13. Gagnoa CDI. Effects de la fertilisation minéralesur des variétésaméliorées de riz en condition irriguée à Gagnoa, Côte d’Ivoire. Journal of Applied Biosciences. 2010; 35:2235-2243.
14. Haque M, Haque M. Growth, Yield and Nitrogen Use Efficiency of New Rice Variety under Variable Nitrogen Rates. American Journal of Plant Sciences. 2016; 7:612-622.
15. Hasanuzzaman M, Ahamed KU, Rahmatullah M, Akhter N, Nahar K, Rahman ML. Plant growth characters and productivity of wetland rice (*Oryza sativa* L.) as affected by application of different manures. Emirates Journal of Food and Agriculture. 2010, 46-58.
16. Jérémie GBT, Maméri CAMARA, Albert Y, Jules KZ. Rentabilité des engraisminéraux en riziculturepluviale de plateau: Cas de la zone de Gagnoadans le Centre Ouest de la Côte d’Ivoire. Journal of Applied Biosciences. 2011; 46:3153-3162.
17. Kamal MA, Rasool F, Zohaib A, Ahmed K, Nawaz M. Growth response of rice hybrids to different levels of NPK. Intl. J Mod Agri. 2015; 4:52-56.
18. Kamal MA, Rasul F, Zohaib A, Ahmad K, Abbas T, Rasool T, Nawaz M. Effect of NPK application at various levels on yield and quality of two rice hybrids. Scientific Journal pf Seoul Sciences. 2016; 4(1):14-19.
19. Khalifa AABA. Physiological evaluation of some hybrid rice varieties under different sowing dates. Australian Journal of Crop Science. 2009; 3(3):178-183.
20. Khan P, Imtiaz M. Studies on the nutritional requirements of candidate rice genotype Bas-15-1. Journal of Agricultural Research and Development. 2013; 3(4):064-070.
21. Khan P, Imtiaz M, Aslam M, Memon MY, Suleman M, Baby A, Siddiqui SH. Studies on the nutritional requirements of candidate rice genotype IR6-25/A evolved at NIA, Tando Jam. Soil and Environment. 2008; 27(2):202-207.
22. Khush GS. What it will take to feed 5.0 billion rice consumers in 2030. Plant molecular biology. 2005; 59(1):1-6.
23. Kumar R, Kumar S, Kumar A, Singh H, Kumar S. Effect of top-dressing nitrogen and potassium on yield and yield components of rice (*Oryza sativa* L.). Agriways. 2013; 1(2):90-94
24. Kundu R, Brahmachari K, Karmakar S. Impact of different organic manures in enhancing the growth and productivity of rice (*Oryza sativa*) under coastal saline tract of West Bengal. Journal of Crop and Weed. 2010; 6(2):42-45.
25. Laroo N, Shivay YS. Effect of nitrogen and sulphur levels on growth and productivity of scented rice (*Oryza sativa*). Current Advances in Agricultural Sciences (An International Journal). 2011; 3(1):45-48.
26. Lea PJ, Miflin BJ. Nitrogen assimilation and its relevance to crop improvement. Foyer CH Zhang (Eds.). West

Sussex: Blackwell Publishing Ltd., In: Nitrogen Metabolism in Plants in The Post-Genomic Era. Annual Plant Review. 2011; 42:1-40.
27. Liu Y, Ding Y, Wang Q, Meng D, Wang S. Effects of nitrogen and 6-benzylaminopurine on rice tiller bud growth and changes in endogenous hormones and nitrogen. Crop science. 2011; 51(2):786-792.
28. Ma BL, Yan W, Dwyer LM, Fregeau-Reid J, Voldeng H D, Dion Y *et al.* Graphic analysis of genotype, environment, nitrogen fertilizer, and their interactions on spring wheat yield. Agronomy Journal. 2004; 96(1):169-180.
29. Mahajan ANIL, Bhagat RM, Gupta RD. Integrated nutrient management in sustainable rice-wheat cropping system for food security in India. SAARC Journal of Agriculture. 2008; 6(2):29-32.
30. Mahajan A, Choudhary AK, Bhagat RM. Integrated plant nutrient management (IPNM) system for sustainability in cereal based cropping system. Indian Farmers' Digest. 2002; 35(7):29-32.
31. Mahajan G, Timsina J, Jhanji S, Sekhon NK, Kuldeep Singh. Cultivar response, dry-matter partitioning, and nitrogen-use efficiency in dry direct-seeded rice in northwest India. Journal of Crop Improvement. 2012; 26(6):767-790.
32. Mallareddy M, Padmaja B. Response of rice (Oryza sativa) varieties to nitrogen under aerobic and flooded conditions. Indian Journal of Agronomy. 2013; 58(4):500-505.
33. Marschner P. Marschner’s Mineral Nutrition of Higher Plants 3rd edition, Academic press, London, 2012.
34. Matsua T, Kumazawa K, Ishii R, Ishihara K, Hirata H. Science of the plant. Volume Two phyliosophy. Food and Agriculture Policy Research Centre, Tokyo. Japan, 1995, 1240.
35. Mishra D, Ispalasmed M, Rao KV, Bentor JS. Rice research in India: Green revolution to gene revolution. J Rice Res. 2006; 1:38-51.
36. Murthy KD, Rao AU, Vijay D, Sridhar TV. Effect of levels of nitrogen, phosphorus and potassium on performance of rice. Indian J Agric. Res. 2015; 49(1):83-87.
37. Nayak BC, BB Dalei, BK Chodhury. Response of hybrid rice to date of planting, spacing and seedling rate during wet season. Indian J Agron. 2003; 48(3):172-174.
38. Ndaeyo NU, Iboko KU, Harry GI, Edem SO. Growth and yield performances of some upland rice (*Oryza sativa* L) cultivars as influenced by varied rates of PNK (15: 15: 15) fertilizer on an ultisol. Agro-Science, 2008, 7(3).
39. Sampath O, Srinivas A, Ramprakash T, Avil Kumar K. Nutrient Uptake of Rice Varieties as Influenced by Combination of Plant Density and Fertilizer Levels under Late Sown Conditions. Int. J Curr. Microbiol. App. Sci. 2017; 6(6):1337-1346.
40. Onaga G, Asea G, Lamo J, Kikafunda J, Bigirwa G. Comparison of response to nitrogen between upland NERICAs and ITA (*Oryza sativa*) rice varieties. Journal of Agricultural Science. 2012; 4(6):197.
41. Shah LM, Bhurer KP. Response of wet seeded rice varieties to sowing dates, Nepal Agric. Res. J. 2005; 6:35-38.
42. Sharma MP, Bal P, Gupta JP. Long term effects of chemical; fertilizers on rice-wheat productivity. Annals of Agricultural Research. 2003; 24(1):91-94.
43. Sharma PK, Sharma SP, Jain PK. Nutrient mining in different agro-climatic zones of Himachal Pradesh. Fertiliser news, 2001; 46(8):69-74.
44. Shormy SAS, Chowdhury MAH, Saha BK, Haque MA. Effects of different sources of organic materials on nutrient contents and their uptake by T. aman rice. J Agrofor. Environ. 2013; 7(1):37-40.
45. Singh H, Verma A, Ansari MW, Shukla A. Physiological response of rice (*Oryzasativa* L.) genotypes to elevated nitrogen applied under field conditions, Plant Signaling & Behavior, 2014; 9(7):1559-2324.
46. Somasundaram E, Velayutham A, Poonguzhalan R, Sathiyavelu A. Effect of nitrogen levels on growth and yield of rice (SSRC 91216, TRY 2) under sodic soil condition. Mad Agric J. 2002; 89:506-8
47. Songyikhangsuthor K, Sybounheuang S, Samson BK. Response of rice landraces and promising cultivars to nitrogen fertilizer on sloping uplands. Inter-national Journal of Agricultural Science Research. 2014; 3(9):181-186
48. Songyikhangsuthor K, Sybounheuang S, Samson BK. Response of rice landraces and promising cultivars to nitrogen fertilizer on sloping uplands. International Journal of Agricultural Science Research, 2014; 3(9):181-186
49. Sowmyalatha BS, Ramachandra C, Shivakumar N, Manjunatha KB. Effect of methods of cultivation and fertility levels on growth and yield of rice hybrids. Mysore Journal of Agricultural Sciences. 2012; 46(1):171-173
50. Uddin S, Sarkar MAR, Rahman MM. Effect of nitrogen and potassium on yield of dry direct seeded rice cv. NERICA 1 in aus season. Int. J Agron. Plant Prod. 2013; 4(1):69-75.
51. Vanitha K, Moh S. Drip fertigation could improve source-sink relationship of aerobic rice (*Oryza sativa* L.). African Journal of Agricultural Research. 2014; 9(2):294-301.
52. Wani Sheeraz, Bhat Mohammad, Anwar Bhat Mohammad. An overview on the significance of sowing dates and nitrogen fertilization on growth and yield of rice. International Journal of Chemical Studies. 2018; 6(2):2640-2655.
53. Yoshida S. Fundamental of Rice Crop. Science, 1st ed.; International Rice Research Institute: Los Baños, Laguna, Philippines, 1981, 269
54. Zaidi SFA, Tripathi HP. Effect of nitrogen levels on yield, N uptake and nitrogen use efficiency of hybrid rice. ORYZA-An International Journal on Rice. 2007; 44(2):181-183.