



Influence of rice varieties and fertility levels on performance of rice and soil nutrient status under aerobic conditions

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Abstract: Scarcity of water resources in India is limiting the production of flooded rice crop. A field experiment was conducted in factorial RBD with sixteen treatment combinations including four rice varieties viz. V₁: PR-115, V₂: DRRH-3, V₃: PAC-837 and V₄: PR-121 and four fertility levels viz. F₁: control (N₀P₀K₀), F₂: N, P₂O₅, K₂O at 90: 45: 22.5 kg ha⁻¹, F₃: N, P₂O₅, K₂O at 120:60:30 kg ha⁻¹ and F₄: N, P₂O₅, K₂O at 150: 75: 37.5 kg ha⁻¹ replicated thrice. The results revealed that among the different varieties, PAC-837 recorded highest plant height and number of tillers m⁻² at all the growth stages. All yield attributes viz. number of effective tillers m⁻², number of seeds per panicle, 1000-grain weight, spikelet sterility and grain yield, straw yield and harvest index significantly differed in different varieties and were recorded highest in PAC-837 which were however, statistically at par with DRRH-3 except grain yield and effective tillers m⁻². Rice variety PAC-837 recorded highest grain yield of 45.65 q ha⁻¹ and straw yield of 59.98 q ha⁻¹. Among the fertility levels, number of effective tillers m⁻² significantly increased up to 120: 60: 30 N-P₂O₅-K₂O kg ha⁻¹ thereafter non significant differences were noticed. The grain and straw yield increased up to 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ and recorded grain yield of 52.78 q ha⁻¹ and straw yield of 73.85 q ha⁻¹ with application of 150:75:37.5 N-P₂O₅-K₂O kg ha⁻¹. Nutrient application of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ recorded highest available N (238.16 kg ha⁻¹), P (16.18 kg ha⁻¹) and K (163.25 kg ha⁻¹) in soil after harvest of the crop. Higher available nitrogen (235.28 kg ha⁻¹), phosphorus (16.38 kg ha⁻¹) and potassium (154.24 kg ha⁻¹) in soil were recorded with PR-121 and lowest available major nutrients were recorded with variety PAC-837. This study would help to introduction and adaptation of new rice variety PAC-837 with application of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ under aerobic conditions in Shiwalik foothills region of North-Western Himalayas.

Keywords: Aerobic rice, Fertility levels, Productivity, Soil status, Varieties

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of about 3 billion people and the demand is expected to continue to grow as population increases (Carriger and Vallee, 2007). India accounts for 22.3 % of the world's production of rice. In India, rice ranks first among all the crops in term of area and production. Rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 43.86 M ha with a production of 104.80 million tonnes of rice and average productivity of 23.90 q ha⁻¹ (Anonymous, 2015). In India, Rice is commonly grown by transplanting rice seedlings into puddle soils in Indo-Gangetic plains and other regions. But, over the coming decades, farmers, policy makers and researchers alike will need to adapt to several threats to rice productivity. Of the potential threats, water scarcity and increasing competition for water in irrigated rice systems are perhaps the most pressing in terms of potential impact on overall

production levels. Tuong and Bouman (2001) estimated that by 2025, approximately two million hectare of irrigated dry season rice and thirteen million hectare of wet season rice will experience water scarcity. The increasing water scarcity for agriculture and competition for water from non-agricultural sectors dictate to an urgent need to improve crop water productivity. Hence, water-saving irrigation technologies for rice are seen as a key component to deal with water scarcity in the days to come.

So there is need to focus our research on low water requiring rice growing technologies. Introduction of water-saving aerobic rice can reduce water use in rice production by as much as 50 %. The new concept of aerobic rice may be an alternate strategy as compared to traditional rice cultivation system, which combines the characteristics of rice varieties adopted in upland with less water requirement and irrigated varieties with high response to inputs. Aerobic rice promises substan-

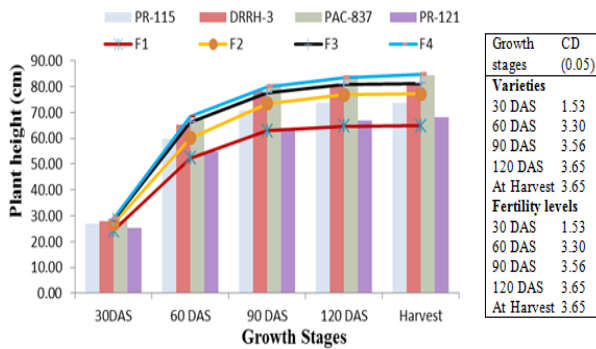


Fig. 1. Effect of different varieties and fertility levels on plant height (cm) at various growth stages.

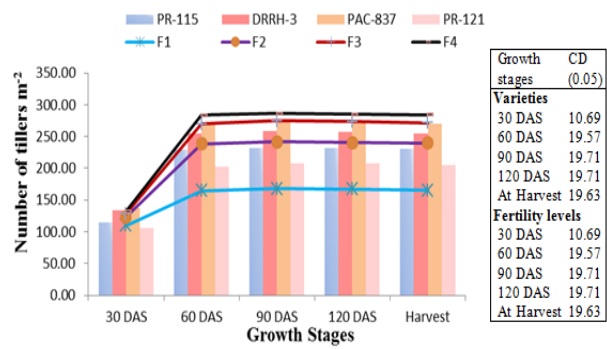


Fig. 2. Effect of different varieties and fertility levels on number of tillers m⁻² at various growth stages.

tial water savings by minimizing seepage and percolation and also greatly reducing evaporation (Bouman *et al.*, 2002). Agronomic practices has great role to play in increasing the yield and productivity of rice. Among different management practices, aerobic rice varieties and fertility levels can prove helpful in realizing the higher yield of rice.

Among the various cultural practices, fertilizer management is crucial factor, which influence the growth and yield of rice. One of the sound principles of aerobic rice is fertilizer management leading to good root development, better tillering potential, higher accumulation of dry matter, and efficient partitioning of dry matter to economically important plant parts. As aerobic rice culture is a new system, there is urgent need to develop suitable nutrient management schedule for this system. Also the nutrient behavior in aerobic soils and in puddled soil is quite different especially in relation to major nutrients. It is therefore, necessary to apply fertilizer elements, particularly N, P and K through inorganic sources in optimal quantity to improve and sustain the productivity (Yoshida, 1981). Moreover prevailing energy crises also necessitates for balanced and proper dose of fertilizers to be applied. The study

related to varieties suited for aerobic rice and their nutrient demand is meager in Jammu conditions. Keeping in view the apprehensions of water scarcity in coming times particularly in rice growing belt of Jammu, it seems to be pertinent that the aerobic rice production technology for rice cultivars of this belt needs to be standardized with the use of fertilizers.

MATERIALS AND METHODS

Experimental details: The field experiment was conducted at Agronomy Research Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha (Jammu and Kashmir), India during *kharif* 2014-15. Geographically, the experimental site was located at 32°-40° North latitude and 74-58° East longitude with an altitude of 332 meters above mean sea level in the Shiwalik foothills of North-Western Himalayas. The soil at the experimental site was sandy loam in texture with pH of 8.15, EC of 0.32 dS m⁻¹, Organic carbon of 4.6 g/kg, available N of 233.27 kg ha⁻¹, P₂O₅ of 13.42 kg ha⁻¹ and K₂O of 149.62 kg ha⁻¹. The experiment, replicated thrice, was laid out in factorial randomized block design with four varieties *viz.* V₁: PR-115, V₂: DRRH-3, V₃: PAC-837

Table 1. Effect of different rice varieties and fertility levels on yield and yield attributes under aerobic conditions.

Treatments	Effective tillers m ⁻²	Number of seeds panicle ⁻¹	1000-grain weight	Spikelet sterility (%)	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Harvest index (%)
Varieties							
V ₁ : PR-115	220.17	92.92	20.99	15.23	41.06	59.50	40.17
V ₂ : DRRH-3	236.33	98.75	19.13	16.55	43.37	58.65	42.44
V ₃ : PAC-837	264.00	72.17	24.17	23.21	45.65	59.98	43.12
V ₄ : PR-121	192.50	71.17	27.33	29.89	32.99	51.42	39.36
SEM±	4.53	1.77	0.29	0.65	0.68	1.04	0.69
CD (0.05)	13.09	5.13	0.85	1.87	1.96	3.01	1.99
Fertility Levels (N-P₂O₅-K₂O kg ha⁻¹)							
F ₁ : N ₀ P ₀ K ₀	155.08	67.25	22.28	27.18	20.86	31.33	40.15
F ₂ : N ₉₀ P ₄₅ K _{22.5}	231.17	80.50	23.08	21.75	39.22	54.85	41.57
F ₃ : N ₁₂₀ P ₆₀ K ₃₀	260.08	90.67	23.13	18.38	50.21	69.53	41.82
F ₄ : N ₁₅₀ P ₇₅ K _{37.5}	266.67	96.58	23.14	17.57	52.78	73.85	41.56
SEM±	4.53	1.77	0.29	0.65	0.68	1.04	0.69
CD (0.05)	13.09	5.13	NS	1.87	1.96	3.01	NS
Interaction	NS	S	NS	NS	S	S	NS

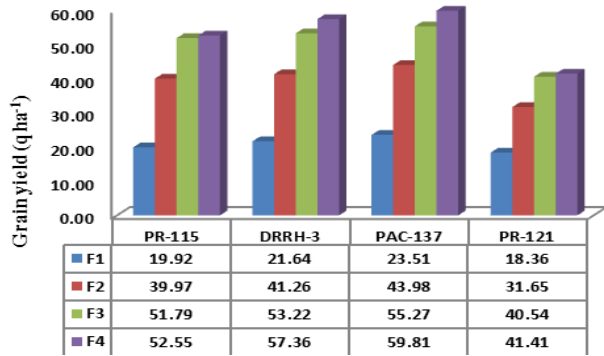


Fig. 3. Interaction effect of different rice varieties and fertility levels on grain yield under aerobic conditions.

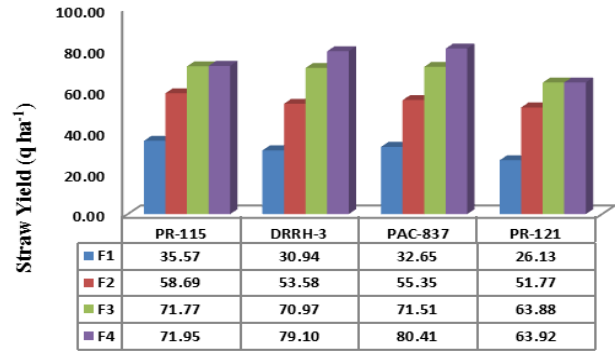


Fig. 4. Interaction effect of different rice varieties and fertility levels on straw yield under aerobic conditions.

and V₄: PR-121 and four fertility levels *viz.* F₁: control (N₀P₀K₀), F₂: N, P₂O₅, K₂O at 90:45:22.5 kg ha⁻¹, F₃: N, P₂O₅, K₂O at 120: 60: 30 kg ha⁻¹ and F₄: N, P₂O₅,K₂O at 150: 75: 37.5 kg ha⁻¹ under aerobic conditions. The crop was sown on 15 June 2015 at a spacing of 20 cm rows apart in 15 m² plot size with a seed rate of 50, 40, 50 and 60 kg ha⁻¹ for PR-115, DRRH-3, PAC-837 and PR-121, respectively. Half dose of N and the entire dose of P and K were applied at the time of sowing through urea, di-ammonium phosphate and muriate of potash, respectively. Remaining half dose of N was applied in two equal splits at active tillering and flowering stage. To maintain aerobic conditions, irrigations were applied whenever soil appears to have developed hair line cracks and excess water of rainfall is removed after 24 hours of occurrences.

Growth, yield and yield attribute determination: For all the growth and development studies during the crop growth period, five plants were selected randomly and tagged in each plot. Initially the growth parameters were recorded at 30 days after sowing and subsequent observations were taken at an interval of 30 days. Yield and yield attributing characters was determined using standard procedures. Finally yield was expressed as q ha⁻¹.

Soil chemical analysis: Before sowing of the crop a composite soil sample is taken for determination of pH, EC, OC, available nitrogen, phosphorus and potassium and after harvesting of rice crop, individual soil samples from all the plots were taken from the surface for determination of same. Soil pH and EC was measured in a soil-water suspension using glass electrode pH meter and systronics conductivity meter, respectively (Jackson, 1967). Soil organic carbon was determined by the rapid titration method (Walkley and Black, 1934), available N by alkaline Potassium permanganate method (Subbiah and Asija, 1956), available P by Sodium Bicarbonate method (Olsen *et al.*, 1954) and available K by Ammonium acetate method (Jackson, 1973).

Statistical analysis: The statistical analysis of factorial randomized block design with 4 levels of both two factors was done by standard procedures suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth and development: Growth parameters like plant height, tillers m⁻² and dry matter production of aerobic rice were positively influenced by different

Table 2. Effect of different rice varieties and fertility levels on soil fertility status after harvest under aerobic conditions.

Treatments	Soil pH	EC (dS m ⁻¹)	Soil O.C. (g kg ⁻¹)	Available nutrient status (kg ha ⁻¹)		
				Nitrogen	Phosphorus	Potassium
Varieties						
V ₁ : PR-115	8.16	0.33	4.7	223.69	12.03	143.80
V ₂ : DRRH-3	8.16	0.33	4.8	217.47	10.35	140.44
V ₃ : PAC-837	8.15	0.32	4.8	214.19	9.09	138.00
V ₄ : PR-121	8.17	0.34	4.5	235.28	16.38	154.24
SEm±	0.02	0.01	0.00	2.84	0.66	2.89
CD (0.05)	NS	NS	NS	8.20	1.89	8.35
Fertility Levels (N-P₂O₅-K₂O kg ha⁻¹)						
F ₁ : N ₀ P ₀ K ₀	8.11	0.31	4.6	201.45	6.49	112.22
F ₂ : N ₉₀ P ₄₅ K _{22.5}	8.16	0.33	4.6	220.85	10.78	142.85
F ₃ : N ₁₂₀ P ₆₀ K ₃₀	8.18	0.34	4.7	230.17	14.41	158.16
F ₄ : N ₁₅₀ P ₇₅ K _{37.5}	8.19	0.34	4.9	238.16	16.18	163.25
SEm±	0.02	0.01	0.00	2.84	0.66	2.89
CD (0.05)	NS	NS	NS	8.20	1.89	8.35
Interaction	NS	NS	NS	NS	NS	NS
Initial Status	8.15	0.32	4.6	233.27	13.42	149.62

fertility levels and varieties. Significantly higher plant height (91.50 cm) was obtained with higher fertility level of 150:75:37.5 N-P₂O₅-K₂O kg ha⁻¹ at harvesting stage. During the entire period of study, the lowest plant height was observed in case of control (0:0:0 N-P₂O₅-K₂O kg ha⁻¹). Application of varying level of fertilizers in rice under aerobic conditions had significant influence on number of tillers m⁻² at 30, 60, 90 and 120 DAS and at harvesting stage (Fig. 2). Increase in number of tillers m⁻² was recorded only up to 90 DAS thereafter, it declined gradually up to maturity. Maximum number of tillers m⁻² (284.17) recorded at harvesting stage with fertility level of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ and showed superiority with magnitude of 71.8, 18.6 and 4.7 per cent over other fertility levels *viz.* control, 90: 45: 22.5 and 120: 60: 30 N-P₂O₅-K₂O kg ha⁻¹, respectively. The abundant supply of N, P and K is considered essential for growth and development of rice. NPK fertilization leads to increase in plant height and number of tillers m⁻². Similar findings *i.e.* increase in fertility levels leads to increase in plant height and number of tillers of rice have been reported by Sowmyalatha *et al.* (2012) and Songyikhangsuthor *et al.* (2014).

The performance of rice varieties also differed significantly under aerobic conditions. In general, plant height of different rice varieties increased till 120 DAS with the advancement of age of crop plant. Among the different varieties, PAC-837 variety recorded the highest and variety PR-121 recorded lowest plant height at all the growth stages. Maximum number of tillers m⁻² was observed in variety PAC-837 at all growth stages. Number of tillers m⁻² (fig. 2) increased up to 90 DAS in all varieties. Lowest tiller count m⁻² was recorded in PR-121. This might be due to differential genetic makeup of varieties and ability to accumulate the photosynthates in the vegetative plant parts. Significant differences in plant growth characteristics of rice as influenced by various genotypes under aerobic conditions were also reported by Parashivamurthy *et al.* (2012).

Yield and yield attributes: Fertility levels and varie-

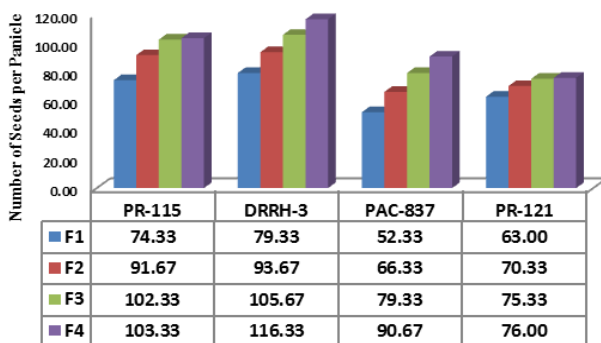


Fig. 5. Interaction effect of different rice varieties and fertility levels on number of seeds per panicle under aerobic conditions.

ties significantly influenced all the yield attributes *viz.* number of effective tillers m⁻², number of seeds per panicle, 1000-grain weight, spikelet sterility, grain yield, straw yield and harvest index. The number of effective tillers m⁻² significantly increased up to 120: 60: 30 N-P₂O₅-K₂O kg ha⁻¹ thereafter non significant difference was noticed. Highest number of effective tillers m⁻² was recorded at fertility dose of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ with superiority of 71.9, 15.4 and 2.5 per cent over control, 90:45:22.5 and 120: 60: 30 N-P₂O₅-K₂O kg ha⁻¹. Increased level of fertilizer application up to 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ resulted in increased number of seeds per panicle. The spikelet sterility decreased with increase in fertility levels. Lowest spikelet sterility (17.57 %) was recorded in 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ which was however, statistically at par with 120: 60: 30 N-P₂O₅-K₂O kg ha⁻¹ (18.38 %). Non significant difference in 1000-seed weight was observed in response to increasing fertility levels. The grain and straw yield increased up to 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹. Maximum grain yield (52.78 q ha⁻¹) was observed in fertility level of 150:75:37.5 N-P₂O₅-K₂O kg ha⁻¹ with a magnitude of superiority of 5.31, 34.6 and 153.0 per cent over 120:60:30 N-P₂O₅-K₂O kg ha⁻¹, 90:45:22.7 N-P₂O₅-K₂O kg ha⁻¹ and control, respectively. Lowest grain yield was observed with control (0: 0: 0 N-P₂O₅-K₂O kg ha⁻¹). The harvest index found to be non significant irrespective of fertility levels. Increased applications of fertilizers are responsible for greater root development followed by higher nutrient uptake and leaf area development consequently significant improvement in yield and yield attributes. Further, this might be because of increased CO₂ assimilation resulting from increased nutrient uptake by application of higher doses of nutrient level. Similar findings were reported by Mahajan *et al.* (2012), Mallareddy *et al.* (2013) and Uddin *et al.* (2013). Vanitha and Mohandass (2014) also reported that spikelet number, grain and straw yield of rice increased due to increase in source size and activity a result of increased fertility levels.

The performance of rice varieties differed significantly under aerobic conditions. Rice variety PAC-837 recorded significantly higher effective tillers m⁻² (264.00), grain yield (45.65 q ha⁻¹), straw yield (59.98 q ha⁻¹) and harvest index which were however, statistically at par with DRRH-3 except grain yield and effective tillers m⁻². This might be attributed to higher affinity of these varieties to produce more number of tillers m⁻² in early growing period followed by differential ability of cultivars to utilize the fertilizer nutrients as well as partitioning of photoassimilates. Ndaeyo *et al.* (2008) and Mahajan *et al.* (2012) also reported differential ability of partitioning of dry matter and utilization of available nutrients by various varieties of rice. Higher number of seeds panicle⁻¹ were recorded in rice variety DRRH-3 followed by PR-115 and lower number of seeds per

panicle were reported by PR-121. This might be attributed to genetic makeup of different rice cultivars. Variation in number of seeds panicle⁻¹ with rice varieties was reported by Ramanjaneyulu *et al.* (2014) and Mahajan *et al.* (2012). Higher 1000-grain weight was recorded in PR-121 as compared to other varieties which may be due to ability of this cultivar to partition dry matter towards seeds. These results corroborate the findings of Onaga *et al.* (2012). Similarly, Kastura and Nakaide (2011) found that the rice varieties with greater sink capacity and source activity per plant could produce heavier grain weight under aerobic conditions. Spikelet sterility also reported highest in rice variety PR-121 (29.89 %). Reddy *et al.* (2012) also reported variation in spikelet sterility of rice among the different rice cultivars.

Interaction effect of varieties and fertility levels (fig 3, 4 and 5) revealed that hybrid varieties, DRRH-3 and PAC-837 responded significantly up to fertility levels of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ in term of number of seeds panicle⁻¹, grain and straw yield whereas, rice varieties, PR-115 and PR-121 responded only up to 120: 60: 30 N-P₂O₅-K₂O kg ha⁻¹. Highest grain yield of 59.81 q ha⁻¹ was recorded from the variety PAC-837 with 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹. Variety PR-121 with no application of fertilizers recorded lowest grain yield (18.36 q ha⁻¹). This may be due to the reason that hybrids have greater nutrient utilization capacity. The interactions between rice varieties (Vikas, Doddabyanellu, Thanu, Rasi and BPT-5204) and fertility levels under aerobic conditions also have been reported by Parsahivamurthy *et al.* (2012).

Soil chemical properties: After harvesting of rice crop, soil samples were analyzed treatment wise (Table 2) and it was observed that the effect of treatments on soil pH, EC and OC was non significant however, increase in fertility levels resulted in increase in soil available N, P₂O₅ and K₂O. Among the various fertility levels, available N, P₂O₅ and K₂O in soil improved significantly with increased application of fertilizers from control to 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹. Highest available N, P and K in soil were observed in 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹. This might be due to increased application of fertilizers that leave some residual nutrient in soil besides nutrient uptake by crop. Similar results of rice were also observed by Choudhary and Suri (2014) and Yuanqiu He *et al.* (2007). Further, it was also observed that increased root growth of rice with increased application of fertilizers added nutrients in soil after decaying (Devi *et al.*, 2012).

Rice varieties could not bring any significant effect on the pH, EC and organic carbon of the soil but available N, P and K differed significantly among the varieties at 5 % level of significance. However, a marginal increase in soil pH, EC and organic carbon content of soil was noticed. Significantly higher available nitro-

gen, phosphorus and potassium in soil was recorded with PR-121 and lowest available major nutrients was recorded with variety PAC-837. This might be due to differential uptake of N, P and K by rice cultivars. Rice variety PR-121 recorded lowest uptake of nutrient which might brings more nutrient status in soil. Fageria *et al.* (2010) also reported differential soil nutrient status after harvest of rice crop and observed that highest available N, P₂O₅ and K₂O in soil with variety that uptake significantly lower N, P and K by both grain and straw.

Conclusion

From the present study, it can be inferred that nutrient-management system through judicious use of chemical fertilizers along with suitable varieties can play a key role for improving crop productivity and soil fertility under aerobic conditions. The study conclusively revealed that application of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ coupled with suitable germplasm *viz.* PAC-837 and DRRH-3 can prove to be a boon to enhance plant growth & development and productivity of rice under aerobic conditions in northwestern Himalayas. Higher yield attributes were recorded highest in PAC-837 which was however, statistically at par with DRRH-3 except grain yield and effective tillers m⁻². Rice variety PAC-837 recorded highest grain yield of 45.65 q ha⁻¹ and straw yield of 59.98 q ha⁻¹. The grain and straw yield increased up to 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ and recorded grain yield of 52.78 q ha⁻¹ and straw yield of 73.85 q ha⁻¹ with application of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹. Nutrient application of 150: 75: 37.5 N-P₂O₅-K₂O kg ha⁻¹ recorded highest available N, P and K in soil after harvest of the crop. Higher available nitrogen, phosphorus and potassium in soil were recorded with PR-121.

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