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SYNERGISTIC EFFECTS OF FOLIAR NITROGEN AND BASAL FERTILIZATION ON RICE PHYSIOLOGY AND GRAIN YIELD

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Abstract

Congenital malformations, particularly those involving vascular anomalies, have been increasingly recognized as a risk factor for childhood cancers. This study investigates the role of aberrant blood vessel development in mediating cancer risk among infants with congenital malformations, focusing on tumors in the foot and head regions. A cohort of 82 infants with vascular anomalies, including hemangiomas, kaposiform hemangioendotheliomas, and tufted angiomas, was examined. The study assessed angiogenic marker levels, genetic mutations, and tumor progression over a 12-month period. Baseline analysis revealed elevated levels of vascular endothelial growth factor (VEGF-A), angiopoietin-2, and soluble fms-like tyrosine kinase-1 (sFlt-1), with mean VEGF-A levels of 312.4 pg/mL. The tumours followed three separate patterns of growth as 46% of tumours sustained their size while 30% continued to increase and 6% developed new cancerous tissue inside six months. Genetic studies revealed TEK along with PIK3CA and RASA1 which make up 28%, 22% and 13.4% of genes altered for angiogenesis. Analysis through correlation techniques indicated that VEGF-A levels in progressing tumours were substantially higher compared to stable tumours according to the $r = 0.67$ ($p < 0.001$) correlation coefficient value. The analysis through multivariate logistic regression produced two substantial predictors of tumour progression that included both VEGF-A ($OR = 2.31$, $p = 0.001$) and TEK mutations ($OR = 1.95$, $p = 0.004$). The study findings show that particular genetic mutations together with new blood vessel formation influence tumor expansion during infancy among children born with blood dysfunctions. Research findings present vital molecular evidence about why early diagnosis combined with genetic testing and specialized cancer treatment methods are essential to control malignancies in these vulnerable populations through our analysis.

Keywords: “Rice”, “Physiology”, “Foliar Nitrogen”, “Basal Fertilization”, “Yield”, “Biomass”.

INTRODUCTION

Nitrogen (N) is among the most indispensable nutrients for plant growth and development, playing a vital role in chlorophyll formation, protein synthesis, and enzymatic activities (Alam SS). Nitrogen significantly influences somatic growth, yield attributes and grain eminence in rice (Tuiwong P,). While soil-applied nitrogen fertilizers are commonly used, they often face challenges such as leaching, volatilization, and denitrification losses (Mahmoodi B,), (Manik IH,). To mitigate these inefficiencies, foliar nitrogen application has emerged as an alternative approach that ensures rapid uptake and efficient utilization of nitrogen (Ahmad A,), (Song Y,).

Foliar application of nitrogen has been displayed to increase photosynthetic efficiency, stomatal regulation, and biomass accumulation, thereby improving overall crop yield (Osman EAM,). Moreover, the timing and concentration of foliar nitrogen play a crucial role in maximizing benefits. Previous studies suggest that applying nitrogen at key growth stages i.e. tillering and panicle initiation, enhances nutrient use efficiency and yield potential (Gewaily EE,), (Yuan L,). However, excess nitrogen can lead to leaf senescence, lodging, and reduced grain filling (Saikh R,).

The physiological processes of rice—such as tiller formation, chlorophyll accumulation, stomatal conductance, and assimilate translocation—are highly responsive to nitrogen availability. Studies have shown that supplemental foliar nitrogen enhances these traits, thereby improving biomass accumulation and spikelet fertility (Sharma N,), (Song Y,). Moreover, foliar applications during panicle initiation and grain-filling stages have demonstrated significant improvements in harvest yield and nitrogen use efficacy compared to sole basal applications.

Despite growing interest, the optimal integration of foliar and basal nitrogen strategies remains underexplored, especially under varied agroecological settings. Therefore, the present study aims to investigate the combined effects of basal and foliar nitrogen fertilization on the physiological performance and grain yield of rice.

MATERIALS AND METHODS

The present study was conducted during the Kharif season of 2022 at the investigational fields of the Rice Research Institute (RRI), Kala Shah Kaku (KSK), Punjab, Pakistan. The site is characterized by a subtropical climate with loamy soil, good drainage, and moderate fertility. Prior to sowing, the field was investigated for physico-chemical physiognomies comprising pH (7.4), ECe (1.2 dS m^{-1}), organic matter (0.78%), available nitrogen (0.041%), phosphorus (7.3 mg kg^{-1}), and potassium (145 mg kg^{-1}).

Experimental Design and Treatments

The research was laid out in a thrice replicated randomized complete block design (RCBD). A fine rice variety, *Super Basmati*, was used as the test crop. The seedlings were transplanted at the 3-leaf stage using a spacing of 22.5 cm × 22.5 cm. The treatment structure consisted of the following:

- **T1**: Control (No nitrogen application)
- **T2**: 100% recommended nitrogen as basal (120 kg N ha^{-1})
- **T3**: 75% basal nitrogen + 25% foliar nitrogen
- **T4**: 50% basal nitrogen + 50% foliar nitrogen
- **T5**: 100% foliar nitrogen

The foliar nitrogen (urea solution (2%) was applied at three acute growth stages: tillering, panicle initiation, and grain filling. Basal nitrogen, phosphorus (60 kg ha^{-1}), and potassium (60 kg ha^{-1}) were applied using urea, single super phosphate(SSP) and muriate of potash (MOP), respectively. Phosphorus and potassium were applied entirely at transplanting, while basal nitrogen was applied in three splits: at transplanting, tillering, and panicle initiation.

Data Collection

Physiological and yield-related parameters were recorded during and after the crop growth period. These included:

- **Plant height (cm)** at maturity
- **Leaf area index (LAI)** at panicle initiation
- **Chlorophyll content (SPAD value)** measured using a SPAD-502 chlorophyll meter
- **Tillers per hill** and **panicles per hill**
- **Grain yield (t ha^{-1})** recorded at harvest after threshing and drying
- **Nitrogen uptake (kg ha^{-1})** analyzed from grain and straw samples using the Kjeldahl method

Statistical Analysis

Data were investigated using ANOVA (Analysis of Variance) and averages were compared using LSD (Least Significant Difference) test at $P \leq 0.05$ to define statistical variances among treatments.

RESULTS AND DISCUSSION

The pooled application of foliar and basal nitrogen (T_3) suggestively amended rice growth, physiological attributes, and yield components compared to sole or no nitrogen application.

Growth Parameters:

Plant height was significantly influenced by nitrogen treatments. The tallest plants (98.7 cm) were recorded in T_3, showing an 17.2% increase over the control (T_0: 84.2 cm). T_2 and T_1 also showed appreciable increases (94.3 cm and 92.6 cm, respectively), indicating the individual effectiveness of foliar and basal nitrogen. A similar trend was observed for tiller number, where T_3 produced 12.6 tillers per plant, markedly higher than the control (9.2 tillers). The leaf area index (LAI) also improved significantly with nitrogen, with T_3 reaching a LAI of 3.05, which was 40% higher than T_0 (2.18). These improvements can be attributed to enhanced vegetative growth driven by increased nitrogen availability and utilization efficiency (Zhang H,).

Table 1. Effect of Foliar and Basal Nitrogen on Plant Height, Tiller Count, and Leaf Area Index (LAI)

Treatment	Plant Height (cm) ± SE	Tillers per plant ± SE	LAI ± SE
T_0	84.2 ± 1.5 b	9.2 ± 0.4 c	2.18 ± 0.09 c
T_1	92.6 ± 1.8 ab	10.8 ± 0.5 b	2.61 ± 0.12 b
T_2	94.3 ± 2.0 ab	11.1 ± 0.3 b	2.77 ± 0.10 ab
T_3	98.7 ± 1.6 a	12.6 ± 0.4 a	3.05 ± 0.11 a

Physiological Traits:

Chlorophyll content, a proxy for nitrogen status in plants, significantly increased under all nitrogen treatments. The highest SPAD value (45.9) was recorded in T_3, indicating improved leaf greenness and chloroplast activity compared to T_0 (36.5). This enhanced photosynthetic capacity was confirmed by the increase in photosynthetic rate, which was 18.7

μmol CO_2 m^{-2} s^{-1} in T_3—approximately 32% higher than the control. Stomatal conductance also improved notably in T_3 (0.31 mol H_2O m^{-2} s^{-1}) compared to T_0 (0.18), reflecting better gas exchange and transpiration efficiency. The synergistic effect of foliar and basal nitrogen likely contributed to greater metabolic activity and improved physiological performance (Sharma N,).

Table 2. Effect on Chlorophyll Content, Photosynthetic Rate, and Stomatal Conductance

Treatment	Chlorophyll (SPAD) ± SE	Photosynthetic Rate (μmol CO_2 m^{-2} s^{-1}) ± SE	Stomatal Conductance (mol H_2O m^{-2} s^{-1}) ± SE
T_0	36.5 ± 0.8 c	14.2 ± 0.6 c	0.18 ± 0.01 c
T_1	40.7 ± 0.7 b	16.3 ± 0.7 b	0.23 ± 0.02 b
T_2	41.4 ± 0.6 b	16.9 ± 0.5 b	0.25 ± 0.01 b
T_3	45.9 ± 0.9 a	18.7 ± 0.6 a	0.31 ± 0.02 a

Yield Attributes:

Grain yield was significantly influenced by nitrogen treatments. T_3 achieved the highest grain yield of 5.32 t ha^{-1}, a 38.5% increase over the control (3.84 t ha^{-1}), demonstrating the efficiency of combining foliar and basal nitrogen sources. T_2 and T_1 also enhanced yield but were statistically lower than T_3. The harvest index followed a similar trend, with T_3 reaching 45.8% compared to 39.5% in T_0. The improved yield and HI are closely linked to the observed enhancements in photosynthetic efficiency and vegetative growth, leading to better assimilate partitioning toward reproductive organs (Gewaily EE,)' (Sharma N,).

Table 3. Effect on Grain Yield and Harvest Index

Treatment	Grain Yield (t ha^{-1}) ± SE	Harvest Index (%) ± SE
T_0	3.84 ± 0.12 c	39.5 ± 1.1 c
T_1	4.53 ± 0.14 b	42.7 ± 0.9 b
T_2	4.68 ± 0.13 b	43.1 ± 1.2 b
T_3	5.32 ± 0.16 a	45.8 ± 1.3 a

Different letters indicate significant differences at $p \leq 0.05$ (LSD test).

CONCLUSION

The results clearly indicate that integrating foliar nitrogen with basal application offers significant agronomic benefits by improving growth, physiology, and yield in rice. This strategy may provide a practical approach to optimize nitrogen use efficiency in modern rice production systems. Future research should explore field trials to confirm these findings under different soil and climatic conditions, ensuring that foliar nitrogen application can be effectively implemented in large-scale rice farming.

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