

Original Research Article

INFLUENCE OF NUTRIENT MANAGEMENT ON GROWTH, LODGING AND YIELD OF TRANSPLANTED RICE

ABSTRACT

A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli during *Rabi*, 2021 to evaluate the nutrient management techniques on lodging reduction and to improve the productivity of transplanted rice. The study comprised of eight treatments viz., 100 % NPK, 100 % NP + 125 % K, 75 % N + 100 % PK, 75 % N + 100 % P + 125 % K, 100 % NPK + K₂SiO₄ at 50 kg ha⁻¹, 100 % NPK + Ca₂SiO₄ at 50 kg ha⁻¹, 100 % NPK + Na₂SiO₃ at 50 kg ha⁻¹ and absolute control. The results revealed that the application of 100% NPK + K₂SiO₄ at 50 kg ha⁻¹ has recorded significantly taller plant height (131.7 cm), higher dry matter production (11360 kg ha⁻¹), grain (4535 kg ha⁻¹) and straw yield (7259 kg ha⁻¹) over absolute control. Minimum bending moment and lodging score were reported with 100 % NPK + K₂SiO₄ at 50 kg ha⁻¹ and it was on par with 100 % NPK + Ca₂SiO₄ at 50 kg ha⁻¹.

Keywords: Nutrient management, lodging, growth, yield, transplanted rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population. Among the rice growing countries, India stands first in area and second in production next to China. In India, it is grown in an area of about 45.7 million hectare with the production of 124.3 million tonnes and productivity of 2.7 tonnes per hectare (Indiastat, 2021). In Tamil Nadu, rice is grown in an area of 2.03 million hectares with a production of 6.88 million tonnes and productivity of 3.3 tonnes per hectare (Indiastat, 2021). Since, from the green revolution, the potential production of rice has increased significantly; there is a critical need to enhance rice production at a growth rate of 2.5% each year since it is predicted that the global population will increase to roughly 8.2 billion in 2030.

Globally, there are significant limits to the cultivation of this profitable crop. One among them is crop lodging, Lodging is described as the persistent relocation of stems from their

Comment [SC1]: Please introduce the work to the readers. i.e. orientation should be at first.

Comment [SC2]: Before objective state the problem or rationale of the study

Comment [SC3]: Mention the experimental design

Comment [SC4]: It is better to denote the treatment names by T₁ to T₈

Comment [SC5]: Need to state the key findings/message in last line.

Comment [SC6]: must mention the year/time

Comment [SC7]: this is total production?

Comment [SC8]: mean grain or de-husked yield?

Comment [SC9]: limitations

upright posture. In addition, whole grain fields are regularly flattened following storms due to lodging (Crook and Ennos 1995). A decrease in assimilates for grain filling results from severe lodging because it limits the passage of water, nutrients and assimilates through the xylem and phloem. Therefore, lodging can result in significant reductions in grain output and quality. Additionally, it makes harvesting operations more challenging, shattering of grains during harvesting increases demand for grain drying and ultimately increases production cost. Therefore, to prevent lodging in rice through agronomical practices, adequate nutrition management technique is needed. Nitrogen (N), Phosphorus (P), Potassium (K) and silicon (Si) fertilizer application that influence lodging in rice. With this background, the present investigation has been carried out to evaluate the influence of nutrient management on growth, lodging and yield maximization of rice.

Materials and methods

A This field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu during Rabi, 2021. The experimental site was located at 10° 45' N latitude, 78° 36' E longitude and at an altitude of 85 m above MSL. Total rainfall recorded during cropping season was 968.6 mm in 40 rainy days. The mean maximum and minimum temperature recorded during the cropping period were 35.1° C and 24.4 ° C, respectively. The mean relative humidity was 75.5 % (7.16 hrs) and 40.7 % (14.16 hrs), respectively. The mean bright sunshine hours and mean evaporation per day were 5.7 hrs and 3.7 mm day⁻¹. The mean wind velocity was 9.0 km hr⁻¹.

The soil of the experiment field was sandy clay loam in texture, moderately drained and classified as *Vetric Ustropept* with pH of 8.8 and EC of 0.24 dS m⁻¹. The experimental soil was low in available nitrogen (197.0 kg/ha), medium in available phosphorus (15.4 kg/ha), high in available potassium (285.7 kg/ha) and low in available silicon (67 mg/ha). The field experiment was laid out in randomized block design (RBD) with three replications and eight treatments. The treatments comprised of 100 % NPK, 100 % NP + 125 % K, 75 % N + 100 % PK, 75 % N + 100 % P + 125 % K, 100 % NPK + K₂SiO₄ at 50 kg ha⁻¹, 100 % NPK + Ca₂SiO₄ at 50 kg ha⁻¹, 100 % NPK + Na₂SiO₃ at 50 kg ha⁻¹ and absolute control. The rice variety IW Ponni was grown during the course of investigation. The recommended fertilizer dose for medium duration variety was 75: 50:50 NPK kg ha⁻¹. NPK were applied in the form of urea, DAP and MOP. Whereas Si at 50 kg ha⁻¹ was applied in soil in the form of potassium silicate, calcium silicate and sodium

Comment [SC10]: Please rewrite. Sentence not clear

Comment [SC11]: Mention the role of these nutrients and their management strategies done so far in lodging prevention. This should have proper justification about why you are trying to see the effects of these nutrients in transplant rice. Try to search for relevant papers and include the gist points(s) as per this work.

Comment [SC12]: needs elaboration for the first time.

Comment [SC13]: Reference?

Comment [SC14]: Mention Unit plot size and seedling age

silicate. At the time of transplanting, 25% N, K, Si and 100% P were applied as basal. During active tillering (AT), panicle initiation (PI) and flowering of transplanted rice, the remaining 75% of N, K, Si were top dressed in three equal splits.

Plant height and dry matter production were recorded at active tillering, panicle initiation, flowering and maturity by adopting standard procedure. Lodging characteristics was observed at flowering stage. Fifteen days after flowering, lodging-related stem characteristics were identified. The lengths of the third and fourth internodes from the top, as well as the stem length (the distance between the plant base and panicle neck node) were measured. The following formula was used to compute the bending moment (BM) at the N3 or N4 internode (Islam *et al.*, 2007).

$BMN3 = \text{Length from the lowest node of N3 to the top of panicle} \times W_1 + W_2.$

$BMN4 = \text{Length from the lowest node of N4 to the top of panicle} \times W_1 + W_2.$

Where, W_1 - Fresh weight of third internode and

W_2 - Fresh weight of third internode with leaf sheath

The calculation of the lodging score took into account both the percentage and angle of the lodging and described its gravity; the highest lodging score indicates more lodging.

$$\text{Lodging score} = \frac{(\text{Lodged area/netplot area}) \times 100 \times \text{Angle of lodging}}{90}$$

The grain and straw yields were recorded from the net plot at harvest stage. All the recorded data were analyzed statistically as per the method suggested by Gomez and Gomez (1984).

Results and Discussion

Effect of nutrient management on growth parameters of transplanted rice

Plant height

Adoption of different nutrient management practices has significantly influenced the plant height (Table 1). Application of 100 % NPK + K_2SiO_4 at 50 kg ha^{-1} (T_5) registered the tallest plant height (87.2, 114.2, 130.4 and 131.7 cm) which was on par with 100 % NPK + Ca_2SiO_4 at 50 kg ha^{-1} (84.1, 107.9, 128.9 and 129.3 cm) at active tillering, panicle initiation, flowering and maturity. The shortest plant height was recorded in absolute control at all the stages (54.3, 62.1, 77.8 and 78.1 cm). The increase in plant height is due to increase in protoplasm, cell division, cell enlargement and vegetative growth with higher rates of nitrogen and application of silicon aids in upright of leaves which further increases photosynthetic activity causes plants to grow taller. These findings are in conformity with the results obtained by Mallick (1992), Roy *et al.* (2004) and Fallah (2012).

Comment [SC15]: ?

Formatted: Not Superscript/ Subscript

Formatted: Subscript

Formatted: Not Superscript/ Subscript

Comment [SC16]: mention as T_x beside for easy understanding.

Table 1. Effect of nutrient management on plant height (cm) of transplanted rice

Treatments	Plant height			
	Active Tillering	Panicle initiation	Flowering	Maturity
T ₁ - 100 % NPK	71.7	90.8	108.5	108.9
T ₂ - 100 % NP + 125 % K	74.4	95.4	113.8	114.5
T ₃ - 75 % N + 100 % PK	63.8	79.6	96.3	96.4
T ₄ - 75 % N + 100 % P + 125 % K	65.8	81.5	98.4	99.2
T ₅ - T ₁ + K_2SiO_4 at 50 kg ha^{-1}	87.2	114.2	130.4	131.7
T ₆ - T ₁ + Ca_2SiO_4 at 50 kg ha^{-1}	84.1	107.9	128.9	129.3
T ₇ - T ₁ + Na_2SiO_3 at 50 kg ha^{-1}	81.3	98.6	121.5	121.9
T ₈ - Absolute control	54.3	62.1	77.8	78.1
SEd	2.7	3.5	3.6	3.8
CD(P=0.05)	5.4	7.0	7.2	7.6

Comment [SC17]: unit?

Dry matter production (DMP)

Practicing various nutrient management techniques had marked, influence on DMP (Table 2). At active tillering, panicle initiation, flowering and maturity stages, application of 100 % NPK + K₂SiO₄ at 50 kg ha⁻¹ recorded significantly higher DMP (1296, 4875, 8212 and 11360 kg ha⁻¹) and it was comparable with 100 % NPK + Ca₂SiO₄ at 50 kg ha⁻¹ (1242, 4749, 7985 and 11032 kg ha⁻¹). The lowest DMP was recorded in absolute control at all the stages (753, 3157, 4708 and 6484 kg ha⁻¹). This might be due to the application of recommended dose of NPK and silicon increased the photosynthetic activity and transfer of photosynthates from source to sink which in turn increases dry matter production. This is in accordance with the findings of Stalin *et al.* (1999), Rao *et al.* (2004) and Prasad *et al.* (2011).

Table 2. Effect of nutrient management on DMP (kg ha⁻¹) of transplanted rice

Treatment	DMP (kg ha ⁻¹)			
	Active tillering	Panicle initiation	Flowering	Maturity
T ₁ - 100 % NPK	1025	4149	6680	8854
T ₂ - 100 % NP + 125 % K	1049	4178	6915	9693
T ₃ - 75 % N + 100 % PK	877	3545	5363	7761
T ₄ - 75 % N + 100 % P + 125 % K	902	3742	5972	7890
T ₅ - T ₁ + K ₂ SiO ₄ at 50 kg ha ⁻¹	1296	4875	8212	11360
T ₆ - T ₁ + Ca ₂ SiO ₄ at 50 kg ha ⁻¹	1242	4749	7985	11032
T ₇ - T ₁ + Na ₂ SiO ₃ at 50 kg ha ⁻¹	1164	4582	7624	10613
T ₈ - Absolute control	753	3157	4708	6484
SEd	53	198	325	421
CD(P=0.05)	106	398	650	843

Effect of nutrient management on bending moment and lodging score

Different nutrient management practices had significantly influenced the bending moment (Table 3). At maturity, application of 100 % NPK + K₂SiO₄ at 50 kg ha⁻¹ recorded minimum bending moment (1406.8 g.cm) and it on par with 100 % NPK + Ca₂SiO₄ at 50 kg ha⁻¹ (1425.2 g.cm). The minimum bending moment was recorded in absolute control (1926.9 g.cm). It might

be due to the thickening of cell wall of the sclerenchyma tissue in the culm and/or thickening of internodes or increase in silicon content of lower internodes provides mechanical strength to enable the plant to resist lodging and also this study showed that bending moment decreased with silicon concentration. Bhih *et al.* (2010) and Zhang *et al.* (2021) were also noticed an increase in resistance to lodging due to application of silicon fertilizer to rice.

The lodging score of rice altered by various nutrient management practices (Table 3). Application of 100 % NPK + K_2SiO_4 at 50 kg ha⁻¹ registered minimum lodging score (2.7) and it was comparable with 100 % NPK + Ca_2SiO_4 at 50 kg ha⁻¹ (2.9). The maximum lodging score was recorded in absolute control (5.9). The lowest lodging score is due to application of silicon which positively affects the culm thickness that increases the stem strength, resulted in minimum breaking resistance and consequently, minimum stem strength causes reduction in culm thickness thereby, resulted in poor lodging resistance in rice. Similar findings were also reported by Wei *et al.* (2008), Yang *et al.* (2009), Wang *et al.* (2012) and Zhang *et al.* (2013).

Table 3. Effect of nutrient management on bending moment and lodging score of transplanted rice

Treatment	Bending moment (g.cm)	Lodging score
T ₁ - 100 % NPK	1727.9	5.3
T ₂ - 100 % NP + 125 % K	1616.1	4.1
T ₃ - 75 % N + 100 % PK	1772.7	5.6
T ₄ - 75 % N + 100 % P + 125 % K	1635.5	4.4
T ₅ - T ₁ + K_2SiO_4 at 50 kg ha ⁻¹	1406.8	2.7
T ₆ - T ₁ + Ca_2SiO_4 at 50 kg ha ⁻¹	1425.2	2.9
T ₇ - T ₁ + Na_2SiO_3 at 50 kg ha ⁻¹	1519.3	3.3
T ₈ - Absolute control	1926.9	5.9
SEd	47.3	0.11
CD(P=0.05)	94.2	0.25

Effect of nutrient management on grain and straw yield

The grain and straw yields of rice were significantly influenced by different nutrient management practices (Table 4). The highest grain and straw yields (4535 and 7259 kg ha⁻¹) were recorded in application of 100 % NPK + K₂SiO₄ at 50 kg ha⁻¹ and it was on par with 100 % NPK + Ca₂SiO₄ at 50 kg ha⁻¹ of (4329 and 6915 kg ha⁻¹). The lowest grain and straw yields were obtained from absolute control (1200 and 3029 kg ha⁻¹). It might be due to the split application of nutrients, resulting in more photosynthesis and a positive source-sink relationship which increases the yield attributing characters which ultimately reflected on grain and straw yield. In addition, application of silicon reduced the lodging of rice and ultimately increased the grain yield to the tune of 29.5%. However, the combined application of N and Si has a positive effect in increasing the grain and straw yields due to synergistic effect between nitrogen and silicon. Silicon application further improved P uptake, growth and yield in rice as because silicate anions occupies the phosphate anion's adsorption sites, leads to increasing availability of silicon to plants and thus results in improved growth and yield. This investigation is in agreement with the findings of Sardar *et al.* (1988) and Kim *et al.* (2012).

Table 4. Effect of nutrient management on grain yield, straw yield of transplanted rice

Treatment	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
T ₁ - 100 % NPK	3501	5402
T ₂ - 100 % NP + 125 % K	3804	6196
T ₃ - 75 % N + 100 % PK	3182	5008
T ₄ - 75 % N + 100 % P + 125 % K	3583	5802
T ₅ - T ₁ + K ₂ SiO ₄ at 50 kg ha ⁻¹	4535	7259
T ₆ - T ₁ + Ca ₂ SiO ₄ at 50 kg ha ⁻¹	4329	6915
T ₇ - T ₁ + Na ₂ SiO ₃ at 50 kg ha ⁻¹	4125	6623
T ₈ - Absolute control	1200	3029
SEd	123	198
CD(P=0.05)	247	395

Comment [SC18]: A graphical presentation would have been better in this case

Conclusion

From this field experiment, it could be concluded that application of 100 % NPK (75:50:50 kg NPK ha⁻¹) + K₂SiO₄ at 50 kg ha⁻¹ was recommended for lodging reduction and to improve the productivity of transplanted rice.

Comment [SC19]: Please express your views in a more suitable justified manner. This may not be same for all type of soil/rice cultivars. You should clearly mention the limitations also .

References

- Bhiah, K. M., Guppy, C., Lockwood, P., and Jessop, R. 2010. Effect of potassium on rice lodging under high nitrogen nutrition. *World congress of soil science, soil solutions for a changing world*, 45(9): 650-658.
- Crook, M. J. and Ennos, A.R. 1995. The effect of nitrogen and growth regulators on stem and root characteristics associated with lodging in two cultivars of winter wheat. *Journal of Experimental Botany*, 46(8): 931-938.
- Fallah, A. 2012. Silicon effect on lodging parameters of rice plants under hydroponic culture. *International Journal of Agriculture Science*, 2(7): 630-634.
- Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. John Wiley and Sons.
- Indiastat (2021). www.indiastat.com
- Islam, M.S., Peng, S.H., Visperas, R.M. and Ereful, N. 2007. Lodging-related morphological traits of hybrid rice in a tropical irrigated ecosystem. *Field Crops Res.*, 104 (2): 240-248.
- Kim, Y.H., Khan, A.L., Shinwari, Z.K., Kim, D.H., Waqas, M., Kamran, M. and Lee, I.J. 2012. Silicon treatment to rice (*Oryza sativa* L. cv. 'Gopumbyeo') plants during different growth periods and its effects on growth and grain yield. *Pakistan Journal of Botany*, 44(3): 891-897.
- Mallick, A. 1992. Integrated nutrient management in Basmati, Rice-Lentil System under irrigated upland conditions. *Ph.D., Thesis (Agronomy)*, Faculty of the Post Graduate School, Indian Agricultural Research Institute, New Delhi, India.

- Prasad,R.V.,Subbaiah,G.,Chandrasekhar,K.andPrasuna,R.P.2011. Validation of nitrogen recommendations for popular rice (*Oryza sativa* L.) varieties of costal Andhra Pradesh. *The Andhra Agricultural Journal*, 58(1): 1-4.
- Rao,V.U.,Reddi,R.Y.,Radha,K.C.andRaghava,R.C.2004.Effectof organic and inorganic sources of nitrogen on growth, yield, nitrogen uptake and economics of lowland rice. *Madras Agricultural Journal*, 91(7-12): 389-393.
- Roy,B.C.,Leihner,D.E.,Hilger,T.H. andSteinmueller,N.2004.Tillering pattern of local and modern T. Aman varieties as influenced by nitrogen rate and management practices. *Journal of Subtropical Agricultural Research and Development*, 2(2): 6-14.
- Sardar, N.A., Shams, U.A.M. and Khan, N.H. 1988. Yield components of wetland rice under various sources and levels of nitrogen. *Philippines Journal of Crop Science*, 13: 155-158.
- Stalin, P., Thiyagarajan, T.M. and Rangarajan, R. 1999. Nitrogen application strategy and use efficiency in rice. *Oryza*, 36(4): 322-326.
- Wang,C.Y.,Dai,X.L.,Shi,Y.H.,Wang,Z.L.,Chen,X.G.andHe,M.R. 2012. Effects of nitrogen application rate and plant density on lodging resistance in winter wheat. *Acta Agronomica Sinica*, 38: 121-128.
- Wei, F.Z., Li, J.C., Wang, C.Y., Qu, H.J. and Shen, X.S. 2008. Effects of nitrogenous fertilizer application model on culm lodging resistance in winter wheat. *Acta Agronomica Sinica*, 34: 1080-1085.
- Yang. S., Xie, L. and Yuan, J.C. 2009. Effect of nitrogen rate and transplanting density on physical and chemical characteristics and lodging resistance of culms in hybrid rice. *Acta Agronomica Sinica*, 35(1): 93-103.
- Zhang,J.,Li,G.H.,Song,Y.P.,Zhang,W.J.,Yang,C.D.,Wang,S.H.and Ding, Y. F. 2013. Lodging resistance of super-hybrid rice in two ecological regions. *Acta Agronomica Sinica*, 39: 682-692.
- Zhang, T., He, X., Chen, B., He, L. and Tang, X. 2021. Effects of different potassium fertilizer rates on yield formation and lodging of rice. *Phyton*. 90(3): 815-818.

