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Effect of different Levels of Nitrogen and Growth Retardant on Yield and Lodging Percent in Transplanted Rice (*Oryza sativa* L.)

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ABSTRACT: Lodging of rice reduces production and may be related to the agronomic practices, regard to this an experiment was conducted during *kharif* - 2021 at Agricultural Research Station, Dhadesugur to study the effect of different levels of nitrogen and growth retardant on yield and lodging per cent of rice. The experiment was laid out in Randomized Complete Block Design with eleven treatments and replicated thrice. The results revealed that, application of 150% RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray resulted in higher yield parameters *viz.*, more number of tillers per hill (26.3), productive tillers (22 hill^{-1}), filled grains per panicles (246.6), panicle weight (4.5 g) and highest test weight (21.2 g) which in turn resulted in higher grain (6215 kg ha^{-1}) and straw yield (7181 kg ha^{-1}). Application of nitrogen in combination with mepiquat chloride spray also resulted in higher uptake of NPK (135.83, 42.56 and 121.18 kg ha^{-1} respectively). Among the different treatments, application of 150% RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray recorded smaller plant height (84 cm) and lower lodging per cent (2 %) than other treatments which intern recorded higher gross returns (Rs. 124162 ha^{-1}), net returns (Rs. 73642 ha^{-1}) and B:C ratio (2.46).

Keywords: RDN - Recommended dose of Nitrogen, Mepiquat chloride, plant height, yield and lodging per cent.

INTRODUCTION

Rice is the world's most important crop and is a staple food for more than half of the world's population. Worldwide, rice is grown in 161 m ha, with an annual production of about 678.7 m t of paddy. To meet the global rice demand, it is estimated that about 114 million tons of additional milled rice need to be produced by 2035, which is equivalent to an overall increase of 26 per cent in the next 25 years (FAO, 2018). In India, rice is grown in an area of 45.76 m ha with a production of 124.36 m t with an average productivity of 2.71 t ha^{-1} (Anon., 2021 a). In Karnataka, rice is cultivated in Cauvery, Tungabhadra and Upper Krishna command areas. The total area under rice cultivation in Karnataka is 1.4 m ha with an annual production of 4.29 m t and a productivity of 3.07 t ha^{-1} (Anon., 2021 b). The possibility of expanding the area under rice in the near future is limited. Therefore, this extra rice production needed has to come from a productivity gain. Rice is the important crop of Tungabhadra Project (TBP) command area and known as "rice bowl" of Karnataka. In TBP command area paddy is one of the most cereal crop cultivated to an extent of 3.62 lakh hectares. In recent decades, we noticed indiscriminate and unscientific management of both fertilizers and pesticides are the most common features being followed apart from excess use of water for paddy cultivation in this part of the state. In addition to this, lodging is the main problem in transplanted paddy because of excess use of nitrogen fertilizers and varieties susceptible to lodging. Lodging is usually referred to as that condition in which the stems of crops bend at or near the surface of the ground, which could lead to the collapse of the canopy. Lodging is a major limiting factor for tall cultivars of basmati rice as it reduces 30-35 per cent production, which may be due to the high rates of nitrogen fertilization. It is more prevalent with heavy rains and strong winds at the beginning of the grain-filling period and results in significant yield losses (Pablico *et al*., 2003). The adverse effect of lodging during grain filling is mainly because of incomplete light interception due to bending of shoot from vertical stance and mutual shading of leaves and panicles (Setter *et al*., 1997). It also interferes with nutrient and water uptake, reduces light interception and translocation of photosynthates from lower leaves of plant to grains, increases the harvesting cost and decrease grain yield (Mohammadin *et al*., 2011). Therefore, it is important to work out the optimum nitrogen dose for tall rice cultivars for higher productivity, by minimizing/avoiding lodging.

Plant growth regulators (PGRs) are natural or synthetic organic compounds that control or modify one or more in reducing plant height. The most commonly used and known PGR group is the gibberellins. Gibberellins affect many physiological functions in plants. They are essentially responsible for controlling cell elongation and shoot and stem growth (Spitzer *et al.,* 2011). Growth enhancer or retardant have tremendous effects on growth and flowering stage of paddy crop without imposing any deleterious effect on the environment and human health as well. Plant growth retardant *i.e*. mepiquat chloride is also used to control the vegetative growth of paddy plants, thereby increasing the plant population per unit area with regard to yield. The application of paclobutrazol significantly reduces the plant height and the length of basal second internode along with high accumulation of lignin in stem, which gives the strength to stem against lodging (Sinniah *et al.*, 2012). There are various growth retardants such as cycocel, paclobutrazol, trinexepac-ethyl etc., which can prevent lodging by decreasing the internodal length and provide mechanical strength to the plant (Miziniak and Matysiak, 2016). Foliar application of plant growth regulators (PGRs) is reported to overcome the problem of lodging, thereby improving grain yield and quality of rice (Kim *et al.,* 2007). Adjustment of plant growth and development using plant growth retardants such as cycocel, mepiquat chloride, *etc*., to reduce the plant height and increases the tolerance to lodging is a simple technique permitating the greater amount of nitrogen to attain higher yield.

Hence, use of tolerant varieties or management of lodging is the main concern in transplanted rice. In this view, this experiment was conducted to study the effect of different levels of nitrogen and growth retardant on lodging per cent of transplanted rice.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* -2021 at Agricultural Research Station, Dhadesugur (15º 77´ N, 76º 75´ E and altitude 358 m), University of Agricultural Sciences, Raichur, Karnataka. The soil of the experimental site belongs to *Vertisols* (medium black soil). The experiment was laid out in randomized complete block design (RCBD) with three replications. The treatments were consists of different levels of nitrogen application and mepiquat chloride spray at different stages. Application of 75%, 100%, 125% and 150% RDN along with water spray (500 l ha^{-1}). Application of 100%, 125% and 150% RDN + Mepiquat chloride (5% AS @ 75 g *a.i* ha^{-1}) with one spray (1.5 l ha^{-1}) at tillering stage (40 DAT). Similarly, application of 100%, 125% and 150% RDN + Mepiquat chloride (5% AS @ 75 g *a.i* ha^{-1}) with two spray (1.5 l ha^{-1}) at tillering stage (40 DAT) and panicle initiation stage (80 DAT) and application of fertilizer as per farmers practice 200%. Regional recommended rate of P and K fertilizers were 75 and 75 kg ha^{-1} respectively was applied to all the treatments. Half dose of total N was applied as basal and remaining half dose of N was top dressed in two equal installments at active tillering and panicle initiation stage. The rice variety RNR-15048 was selected the study. Seedlings were transplanted at a spacing of 20 cm x 10 cm. From randomly tagged five plants, plant height was measured from the base of the plant at ground surface up to growing tip of the plant. Biometric observations were recorded at 30, 60, 90 DAT and at harvest. The economics was worked out based on the prevailing market price for the existing year. Data analysis and interpretation was done using Fischer’s method of variance technique as described by Gomez and Gomez (1984). The percentage of the plot area lodged to the total area of the plot was recorded and presented as per cent lodging (0-100%) of the plot.

$$\text{Lodging per cent (\%)} = \frac{\text{Number of lodged plants/m}^2}{\text{Total number of plants/m}^2} \times 100$$

RESULT AND DISCUSSION

Bridgemohan and Bridgemohan (2014) reported that the lodging is a severe problem in rice and is influenced by cultivar, production system, irrigation, nutrition, and weather conditions. Among the management practices, judicious use of nitrogen fertilizer is prime significance. Foliar application of plant growth regulators (PGRs) is reported to overcome the problem of lodging, thereby improving grain yield and quality of rice (Kim *et al.*, 2007). Adjustment of plant growth and development using plant growth retardants such as cycocel, mepiquat chloride, *etc*., to reduce the plant height and increases the tolerance to lodging is a simple technique permitting the greater amount of nitrogen to attain higher yield.

Plant height of rice was significantly influenced by the application of different levels of nitrogen and growth retardant (Table 1). Application of fertilizer as per the farmers practice (200 % N) recorded significantly taller plants at 30, 60, 90 DAT and at harvest (45.6, 73.6, 93.6 and 97.6 cm, respectively) followed by the application of 150 % RDN (225 kg N ha^{-1}) + Water spray (44.6, 64.2, 88.0 and 93.3 cm, respectively). Whereas application of 100 % RDN (150 N kg ha^{-1}) + Mepiquat chloride with two spray recorded significantly smaller plants (42.6, 63.2, 80.3 and 81.0

cm, respectively). Further, application of varied levels of nitrogen along with mepiquat chloride spray reduced the plant height at harvest (81.0 cm to 84.0 cm).

The application of 200 per cent N significantly recorded the higher plant height at all the stages of crop growth. This was mainly because of primarily due to enhanced vegetative growth with more nitrogen supply to plant. Similar results were supported by Manzoor *et al.* (2006); Rukhsana *et al.* (2018). Whereas, application of 100 per cent RDN (150 N kg ha^{-1}) along with mepiquat chloride spray resulted in shorter plants and was found on par with 150 per cent RDN (225 N kg ha^{-1}) with mepiquat chloride spray. The reduction in plant height with mepiquat chloride due to slow down of cell division and reduction in cell expansion due to antigibberellins quality. Similarly, Alvarez *et al.* (2014); Tang *et al.* (2019) showed that paclobutrazol, mepiquat chloride and trinexapac-ethyl reduced rice plant height up to 16-20 per cent. Mehbub *et al.* (2006); Fattah *et al.* (2013), who reported that application of growth retardants, reduced plant height significantly.

Lodging per cent of rice was significantly influenced by the application of different levels of nitrogen and growth retardant (Fig. 1). Lodging causes huge loss of grain yield in long stature cultivars of rice. Application of fertilizer as per the farmers practice (200 % N) registerd significantly higher lodging per cent (16.8 %). Whereas, application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray resulted in lower per cent of lodging (2.0 %) and it was found on par with 125 % RDN (187.5 N kg ha^{-1}) + Mepiquat chloride with two spray (3.1 %) followed by the application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat chloride with one spray (2.3 %).

In all cases, the plant stem base is unusually weak with a reduced diameter. Adjustment of plant growth and development using plant growth retardants such as chlormequat chloride, mepiquat chloride to reduce the plant height and increase the tolerance to lodging is a simple technique permitting the greater amount of nitrogen to attain higher yield (Bridgemohan and Bridgemohan 2014). Most common utilized anionic compounds are cycocel and mepiquat chloride. These compounds prevent the cyclic conversion of geranial pyrophosphate to copayol prophosphate and gradually they will be inhibitors of gibberellins. A major applying of plant growth reducers in agriculture is controlling the lodging of grain cereals like wheat, rice, rye and barley.

The findings of nitrogen and growth retardant on lodging reduction are in harmony with the results of Hui *et al*. (2013); Bridgemohan and Bridgemohan (2014); Zhang *et al*. (2014); Faten *et al*. (2016); Hashem *et al*. (2016); Taksin *et al.* (2017); Meena *et al.* (2020). Application of nitrogen increased lodging area, while application of growth retardant reduced the lodging in transplanted rice even with higher level of nitrogen application.

Yield attributing characters such as productive tillers per hill, grain weight per panicle, filled grains, thousand grain weight, grain yield and straw yield were significantly higher with the application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray. Grain yield and straw yield of rice was significantly influenced by the application of different levels of nitrogen and growth retardant (Table 2). Application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray produced significantly higher grain yield (6215 kg ha^{-1}) and straw yield (7182 kg ha^{-1}) followed by the application of 125 % RDN (187.5 N kg ha^{-1}) + Mepiquat chloride with two spray (5850 kg ha^{-1}) and (6747 kg ha^{-1}). Whereas, application of 75 % RDN (112.5 N kg ha^{-1}) + Water spray recorded significantly lower grain yield (3866 kg ha^{-1}) and straw yield (5410 kg ha^{-1}). Harvest index did not differ significantly due to application of different levels of nitrogen and growth retardant.

It is evident that, increase in N level from the recommended dose did not increase grain yield because excessive plant height at the higher level of nitrogen (200 % N) triggered lodging of plants, which reduced number of filled grains per panicle and ultimately decreased grain yield. Sidhu *et al.* (2004) were also reported that, increased nitrogen dose over the recommended dose of nitrogen did not increases the grain yield.

Data indicates significant effect of growth regulation treatments on grain yield. It was observed that 150 % RDN (225 N kg ha^{-1}) + Mepiquat Chloride with two spray increased the grain yield and straw yield due to combination of nitrogen and mepiquat (Ghuman, 2019). It might be ascribed to more production of photosynthates in leaves by the growth regulation treatments during early stages of the crop, which were afterward partitioned to the reproductive parts because growth retardants trigger the sucrose lyase and Acid Invertase (AI) activity in grains accelerating the transportation of photosynthates towards grains (Tang *et al.,* 2019) and secondly there was less lodging in mepiquat chloride treated plots as compared to non treated plots. These findings are in line with the results of Roja *et al.* (2012); Unan *et al.* (2013); Bridgemohan and Bridgemohan (2014).

Growth regulation treatments also cause significant effect on straw yield. However, these treatments numerically decreased the straw yield than untreated plots because growth regulation treatments reduced the plant height significantly than untreated plots. Similar results opined by Vikash Singh *et al.* (2019) paclobutrazol was effective in shortening the length of the lower internodes which resulted in shorter plants but with increased lodging resistance which in result increases the grain yield as well as straw yield.

Application of fertilizer as per the farmers practice (200 % N) incurred maximum cost of cultivation (Rs. 53801 ha^{-1}) followed by the application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat Chloride with two spray (Rs. 50521 ha^{-1}). Whereas, application of 75 % RDN (112.5 N kg ha^{-1}) + Water spray resulted lowest cost of cultivation (Rs. 47580 ha^{-1}) followed by 100 % RDN (150 N kg ha^{-1}) + Water spray (Rs. 47741 ha^{-1}). Application of different levels of nitrogen and growth retardant has significant influence on gross returns, net returns and benefit-cost ratio of transplanted rice (Table 3). Maximum gross returns (Rs. 143912 ha^{-1}), net returns (Rs. 93391 ha^{-1}) and BC ratio (2.85) was observed with the application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray followed by the application of 125 % RDN (187.5 N kg ha^{-1}) + Mepiquat chloride with two spray (Rs. 135447, Rs. 85087 ha^{-1} and 2.69) Whereas, application of 75 % RDN (112.5 N kg ha^{-1}) + Water spray resulted in lowest gross returns (Rs. 90462, Rs. 42882 ha^{-1} and 1.90).

Economics is the final deciding factor to fix the appropriate dose of nitrogen and growth retardant application so as to recommend the same to the farmers in large scale adoption. Among different components of economics, the treatment with the application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray accounted maximum gross returns (Rs. 143912 ha^{-1}) and cost of cultivation in this particular treatment was less compared to farmers practice because, application of nitrogen level differ with treatment. Whereas highest cost of cultivation found with farmers practice may be due to higher cost involved in the practice of inorganic fertilizers. The lower cost of cultivation was noticed with the application of 75 % RDN (112.5 N kg ha^{-1}) + Water spray (Rs. 47580 ha^{-1}).

Application of 150 % RDN (225 N kg ha^{-1}) + Mepiquat chloride with two spray was found to be economically viable due to its higher yield (6215 kg ha^{-1}) and net returns (Rs. 93391 ha^{-1}) over other treatments. The benefit cost (BC) ratio in this treatment was also more (2.85) as compared to other treatments. Due to different levels of nitrogen and growth retardant application may retard the growth of crop and may helpful to the reduction in lodging per cent and increases the yield of rice results in increases in BC ratio. The lower BC ratio in the treatment with the application of 75 % RDN (112.5 N kg ha^{-1}) + Water spray (1.90) was mainly because of lower yield, which has brought down the advantage of yield obtained in this particular treatment. The next best treatment based on BC ratio (2.69) and net returns (Rs. 85087 ha^{-1}) was application of 125 % RDN (187.5 N kg ha^{-1}) + Mepiquat chloride with two spray. Similar results were also reported by Sultan *et al.* (2007), Singh *et al.* (2012) and Santosh *et al*. (2013).

CONCLUSION

The plant height & lodging per cent have been reduced due to foliar application of mepiquat chloride 5 % Aqueous Solution @ 75 g *a.i.* ha^{-1} (1.5 l ha^{-1}) with two spray (one spray at tillering stage 40 DAT and second spray at panicle initiation stage 80 DAT) along with 150 per cent RDN which resulted in more grain yield and net returns. Further, it can be concluded that the application of mepiquat chloride 5 % AS @ 75 g *a.i.* ha^{-1} (1.5 l ha^{-1}) before panicle initiation (75-80 DAT) on paddy crop found to be safe and effectively reducing the crop lodging and improving the yield and yield components.

Table 1: Plant height (cm) of transplanted rice as influenced by the application of different levels of nitrogen and growth retardant.

Treatments		Plant height (cm)			
		30 DAT	**60 DAT**	**90 DAT**	**At harvest**
T_1	75% RDN (112.5 N kg ha^{-1}) + Water spray	40.4	59.5	85.3	88.0
T_2	100% RDN (150 N kg ha^{-1}) + Water spray	42.5	61.3	86.6	90.6
T_3	125% RDN (187.5 N kg ha^{-1}) + Water spray	42.9	63.3	87.3	92.2
T_4	150% RDN (225 N kg ha^{-1}) + Water spray	44.6	64.2	88.0	93.3
T_5	100% RDN (150 N kg ha^{-1}) + Mepiquat Chloride with One spray	42.7	62.6	81.6	82.3
T_6	125% RDN (187.5 N kg ha^{-1}) + Mepiquat Chloride with One spray	43.4	63.6	82.2	83.1
T_7	150% RDN (225 N kg ha^{-1}) + Mepiquat Chloride with One spray	43.6	64.0	82.6	83.2
T_8	100% RDN (150 N kg ha^{-1}) + Mepiquat Chloride with Two spray	42.6	63.2	80.3	81.0
T_9	125% RDN (187.5 N kg ha^{-1}) + Mepiquat Chloride with Two spray	43.6	63.1	80.9	81.3
T_{10}	150% RDN (225 N kg ha^{-1}) + Mepiquat Chloride with Two spray	44.3	67.5	83.0	84.0
T_{11}	Farmers Practice (200% N)	45.6	73.6	93.6	97.6
S.Em (±)		**1.0**	**1.2**	**1.1**	**0.8**
C.D. at 5 %		**NS**	**3.6**	**3.2**	**2.5**

Note: 1. Recommended P and K is common for all the treatments; **2.** One spray: Mepiquat Chloride spray at tillering stage (40 DAT); Two spray: Mepiquat Chloride spray at tillering stage (40 DAT) and panicle initiation stage (80 DAT); **3.** Mepiquat Chloride 5% Aqueous Solution @ 75 g *a.i* ha^{-1} (1.5 l ha^{-1}); **4.** Water spray (500 l ha^{-1}); **5.** RDF: 150:75:75 N: P_2O_5: K_2O kg ha^{-1}

Table 2: Grain yield, straw yield and harvest index of transplanted rice as influenced by the application of different levels of nitrogen and growth retardant.

Treatments		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index
T_1	75% RDN (112.5 N kg ha^{-1}) + Water spray	3866	5410	0.41
T_2	100% RDN (150 N kg ha^{-1}) + Water spray	4061	5477	0.43
T_3	125% RDN (187.5 N kg ha^{-1}) + Water spray	4466	5737	0.44
T_4	150% RDN (225 N kg ha^{-1}) + Water spray	4683	5830	0.44
T_5	100% RDN (150 N kg ha^{-1}) + Mepiquat Chloride with One spray	4853	5983	0.45
T_6	125% RDN (187.5 N kg ha^{-1}) + Mepiquat Chloride with One spray	5100	6035	0.46
T_7	150% RDN (225 N kg ha^{-1}) + Mepiquat Chloride with One spray	5350	6160	0.46
T_8	100% RDN (150 N kg ha^{-1}) + Mepiquat Chloride with Two spray	5583	6697	0.45
T_9	125% RDN (187.5 N kg ha^{-1}) + Mepiquat Chloride with Two spray	5850	6747	0.46
T_{10}	150% RDN (225 N kg ha^{-1}) + Mepiquat Chloride with Two spray	6215	7182	0.47
T_{11}	Farmers Practice (200% N)	5471	6450	0.45
S.Em (±)		**104**	**95**	**0.01**
C.D. at 5 %		**308**	**280**	**NS**

Note: 1. Recommended P and K is common for all the treatments; **2.** One spray: Mepiquat Chloride spray at tillering stage (40 DAT); Two spray: Mepiquat Chloride spray at tillering stage (40 DAT) and panicle initiation stage (80 DAT); **3.** Mepiquat Chloride 5% Aqueous Solution @ 75 g *a.i* ha^{-1} (1.5 l ha^{-1}); **4.** Water spray (500 l ha^{-1}); **5.** RDF: 150:75:75 N: P_2O_5: K_2O kg ha^{-1}

Table 3: Economics of transplanted rice as influenced by the application of different levels of nitrogen and growth retardant.

Treatments		Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
T_1	75% RDN (112.5 N kg ha^{-1}) + Water spray	47580	90462	42882	1.90
T_2	100% RDN (150 N kg ha^{-1}) + Water spray	47741	94819	47079	1.99
T_3	125% RDN (187.5 N kg ha^{-1}) + Water spray	47902	103989	56088	2.17
T_4	150% RDN (225 N kg ha^{-1}) + Water spray	48063	108856	60793	2.26
T_5	100% RDN (150 N kg ha^{-1}) + Mepiquat Chloride with One spray	48845	112749	63905	2.31
T_6	125% RDN (187.5 N kg ha^{-1}) + Mepiquat Chloride with One spray	49006	118235	69230	2.41
T_7	150% RDN (225 N kg ha^{-1}) + Mepiquat Chloride with One spray	49167	123860	74693	2.51
T_8	100% RDN (150 N kg ha^{-1}) + Mepiquat Chloride with Two spray	50199	129523	79324	2.58
T_9	125% RDN (187.5 N kg ha^{-1}) + Mepiquat Chloride with Two spray	50360	135447	85087	2.69
T_{10}	150% RDN (225 N kg ha^{-1}) + Mepiquat Chloride with Two spray	50521	143912	93391	2.85
T_{11}	Farmers Practice (200% N)	53801	126812	73011	2.36
S.Em (±)			2283	2283	0.05
C.D. at 5 %			6735	6735	0.14

Note: 1. Recommended P and K is common for all the treatments; **2.** One spray: Mepiquat Chloride spray at tillering stage (40 DAT); Two spray: Mepiquat Chloride spray at tillering stage (40 DAT) and panicle initiation stage (80 DAT); **3.** Mepiquat Chloride 5% Aqueous Solution @ 75 g *a.i* ha^{-1} (1.5 l ha^{-1}); **4.** Water spray (500 l ha^{-1}); **5.** RDF: 150:75:75 N: P_2O_5: K_2O kg ha^{-1}

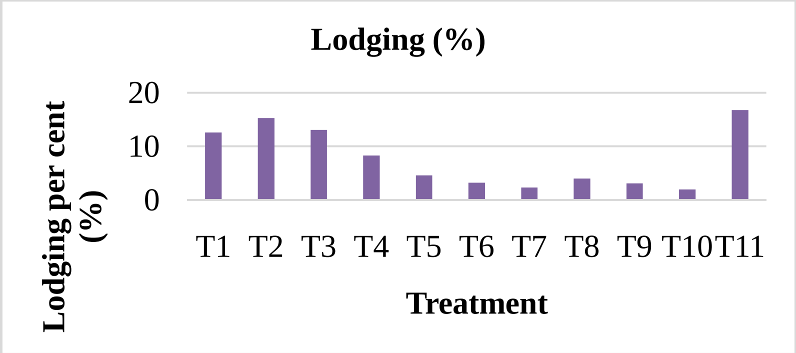

Fig. 1. Lodging per cent of transplanted rice as influenced by the application of different levels of nitrogen and growth retardant.

FUTURE SCOPE

Need to study the effect of different anti-lodging plant growth regulators on transplanted rice to reduce the lodging per cent and also effect of growth retardant (Mepiquat chloride) on the physiology of rice plant.

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Conflict of Interest. None.

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