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Effect of various nutrient management modules on growth and yield traits of high yielding varieties of Rice (*Oryza sativa* L.)

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Abstract
The present investigation was conducted with the objective to know the effect of various nutrient management modules on growth and yield of high yielding varieties of rice (Sarjoo-52 and NDR-359). The study was comprised six treatments of nutrient management modules (a) M_1 -100% RDF of N.P.K (120:60:60kg NPK ha^{-1}), (b) M_2-120% RDF of NPK (150:75:75 kg NPK ha^{-1}), (c) M_3 -150% RDF of N.P.K (180:90:90 kg NPK ha^{-1}), (d) $M_4$100% RDF of NPK (120:60:60 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}, (e) M_5 - 120% RDF of NPK (150:75:75 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} and (f) M_6 -150% RDF of NPK (180:90:90 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}. The present study revealed that the maximum value of number of tillers $hill^{-1}$, plant height (cm), dry matter accumulation (g $plant^{-1}$), days taken to panicle initiation and days taken to physiological maturity were recorded under M_6 - 150% RDF of N.P.K (180:90:90 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} which was significantly superior over rest of the of the nutrient management modules. The application of module M_6 -150% RDF (180:90:90 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} with variety Sarjoo-52 produced maximum growth attributes, grain and straw yield. The study concluded that nutrient management modules M_6 -150% RDF (180:90:90 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} and variety Sarjoo-52 for obtaining maximum yield and productivity of rice.

Key words: Rice varieties, growth attributes, yield.

Introduction
Rice (*Oryza sativa* L.) is a member of poaceae family and is relished as staple food by majority of world's population. In India, rice occupied 45.16 million hectares area with a production of 103.72 million tonnes and average yield 2.7t ha^{-1}(Anonymous, 2013) [1]. Rice is grown in 114 countries across the world on an area about 150 million hectares with annual production of over 525 million tonnes, constituting nearly 11 per cent of the world's cultivated land.

Nitrogen is a 'key' element among essential nutrients and plays vital role in growth as well as development of the plants by virtue of being an integral part of chlorophyll, protein and nucleic acids, deficiency of this element in plant body leads stunted growth, appearance of light green pale yellow colour on the older leaves starting from tips towards the base of the leaf blade. Nitrogen management in rice field is different from other crops because of the continuous sub-emergence of the field results aerobic to anaerobic condition of the root zone. During these process losses of nitrogen take place through leaching and denitrification. Amongst various essential plant nutrients the nitrogen, phosphorus and potassium play a pivotal role for growth and metabolic process in rice plant. Zinc is a secondary plant nutrient which play significant role in increasing production and provide resistance against disease in rice crops.

Besides, major nutrients, Zn are the most important micro-nutrients particularly in our country because most of Indian soil is deficient in these nutrients. Zinc is the essential mineral for IAA synthesis. Zinc deficiency is closely related to the inhibition of RNA synthesis, reduces root and shoots growth and chlorophyll concentration in leaves. Zinc is directly or indirectly required by the several enzymic systems and closely involved in the nitrogen metabolism of plant.

Materials and Methods
The field experiment was conducted during *Kharif* 2013 at Agronomy Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.). Geographically the experimental site is situated at 26.47^0 North latitude and 81.12^0 East longitude with is an elevation of about 113 m. from mean sea level in the Indo Gangatic Plain

Zone of eastern Uttar Pradesh. The climate in this region is humid and characterized with high rainfall (300 cm year^{-1}). The soil is sandy to sandy loam with a pH of 5.05 and 0.72% organic C. Soil low in available N (127.92 kg ha^{-1}), medium in available P (21.59 kg ha^{-1}) and low in available K (122.46 kg ha^{-1}).

The treatment was carried out with 12 treatment combination formed with six nutrient management levels and two varieties in rice which were allocated in factorial RBD with three replications. The six nutrient management modules (a) M_1 - 100% RDF of N.P.K (120:60:60kg NPK ha^{-1}), (b) M_2-120% RDF of NPK (150:75:75 kg NPK ha^{-1}), (c) M_3 -150% RDF of N.P.K (180:90:90 kg NPK ha^{-1}), (d) $M_4$100% RDF of NPK (120:60:60 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}, (e) M_5 - 120% RDF of NPK (150:75:75 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} and (f) M_6 -150% RDF of NPK (180:90:90 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} and two varieties namely NDR-359 and Sarju 52.

The crop was fertilised with a uniform dose of 60 kg P_2O_5/ha through single super phosphate, 60 kg K_2O/ha through muriate of potash and half dose of the Nitrogen management as per treatments with organic and inorganic. The number of tiller per hill were counted at 30, 60, 90 DAS and at harvest by placing quadrate at three places in each plot and the plants which come within the quadrate were averaged out to express tiller per hill were counted before harvesting from marked area of one square meter, number of grains panicle^{-1} were five panicles from each plot were taken at random at maturity for counting the number of grains per panicle and averaged values were recorded. After air harvesting and seed were cleaned. The final seed weight was recorded in kg per plot and converted in to t/ha.

Results and Discussion

Effect of different INM modules

Initial plant stand (m^{-2}) did not differ significantly under the influence of nutrient management modules. This might be due to the maintenance of uniform plant population during the transplanting at specific planting space of 20 ×10 cm plant. The result are in close conformity with the finding of Pandey *et al*. (2001) [17] and Geetadevi *et al.* (2009).

Various nutrient management modules (Table-1) significantly influenced the number of tillers hill^{-1}. The highest number of tillers hill^{-1} was recorded under 150% RDF+25 kg $ZnSO_4$ ha^{-1} which was significantly superior over 100% RDF of N.P.K (120:60:60kg NPK ha^{-1}), 120% RDF of N.P.K (150:75:75 kg NPK ha^{-1}), 150% RDF of N.P.K (180:90:90 kg NPK ha^{-1}) and 100% RD of N.P.K (120:60:60kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}but at par with 120% RDF of N.P.K (150:75:75 kg NPK ha^{-1})+25 kg $ZnSO_4$ ha^{-1}. This may be attributed to the fact that 100% RDF alone gives poor tillers, while balanced fertilization provided better atmosphere for tillering. Better tillering under balance fertilization has been also reported by Pandey *et al*. (2001) [17] Geetadevi *et al.* (2009) and Shekara *et al*. (2011) [20] with higher doses of balanced fertilization.

The significantly taller plants were recorded under 150% RDF+25 kg $ZnSO_4$ ha^{-1} at 30, 60, 90, DAT and at harvest which were significantly taller than that of 100% RDF of N.P.K (120:60:60kg NPK ha^{-1}),120% RDF of N.P.K (150:75:75 kg NPK ha^{-1}), 150% RDF of N.P.K (180:90:90 kg NPK ha^{-1}) and 100% RDF of N.P.K (120:60:60kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}but at par with 120% RDF of N.P.K (150:75:75 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}. The results may be attributed to the fact that under 100% RDF give poor growth while optimum doses of balanced fertilization resulted better growth. Similar results have been also reported by Chopra *et al*. (2000) [4] and Meena *et al*. (2003) [16].

Days taken to panicle initiation was influenced significantly by various nutrient management modules. The maximum panicle initiation was recorded with application of 150%RDF+25 kg $ZnSO_4$ ha^{-1} which was significantly superior over 100% RDF of N.P.K (120:60:60kg NPK ha^{-1}), 120% RDF of N.P.K (150:75:75 kg NPK ha^{-1}), 150% RDF of N.P.K (180:90:90 kg NPK ha^{-1}) and 100% RDF of N.P.K (120:60:60kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} but at par with 120% RDF of N.P.K (150:75:75 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}. It may be concluded that better & balanced fertilization resulted better panicle initiation. Malic *et al. (*1998), Fy Quinglim *et al*. (2000), also reported better panicle initiation with higher doses of fertilization.

The days taken to physiological maturity also influence by various nutrient management modules. Application of 150% RDF + 25 kg $ZnSO_4$ ha^{-1} delayed the maturity by 10 days as compared to other nutrient management modules. The delay in days taken maturity may be attributed to better absorption of nitrogen which caused better growth and delayed the developmental phase of the crop. Saker *et al.* (1989), Kola (1997) and Singh (2002) also reported delay maturity with higher doses of fertilization.

All the yield attributing character *viz*., number of ear bearing tillers, number of panicle m^{-2}, panicle length, number of grains panicle^{-1} and test weight were significantly influence under various nutrient management modules

The number of ear bearing tillers m^{-2} was significantly influence by various nutrient management modules. The maximum number of ear bearing tillers m^{-2} (Table-2) was recorded with 150% RDF+25 kg $ZnSO_4$ which was significantly superior over M_1, M_2, M_3 and M_4 but at par with M_5. This might be due to effect of balance fertilization resulted more number of ear bearing tiller .Similar finding have been also reported by Singh *et al*. (2005) [23-24],Tripathi and Jaiswal (2006).

The highest number of panicles m^{-2} were observed with 150% RDF+ 25 kg $ZnSO_4$ ha^{-1} which was significantly superior over other fertility levels. This was mainly due to increase in tillers^{-2} under optimum doses of balanced fertilization which resulted increase in panicles m^2. Similar findings have been also reported by Hollen *et al.* (2008) [11] and Singh *et al.* (2010) [25].

The panicle length was significantly increased by various nutrient management modules. The maximum panicle length was recorded with application of 150% RDF+ 25 kg $ZnSO_4$ ha^{-1} which was significantly longer than other nutrient management modules. The increase in panicle length may be attributed to uptake of nutrient under optimal balanced fertilizer doses which increased the sink size *vis-a-vis* panicle length as compared to sub optimal or unfertilized plots, Pariyani and Naik (2009), Bahmanyar and Manhec (2010) [3] have also reported longer panicles with higher doses of fertilizers.

The number of grains panicle^{-1} significantly influenced by various nutrient management modules. The maximum number of grains panicle^{-1} was found with 150% RDF+ 25 kg $ZnSO_4$ ha^{-1} which was significantly superior over other nutrient management modules. The results may be attributed to the fact that balanced fertilization resulted better growth of root and shoots which resulted higher nutrient uptake and production of photosynthates and its translocation to sink (spikelets) *vis-a-vis* filled grains panicle^{-1}. The results are in agreement with those of Malic *et al.* (1988), Li *et al*. (2009)

[14].

Various nutrient management modules did not influence the test weight was significantly. However, numerically higher and equal weight was registered with 120%RDF +25 kg $ZnSO_4$ kg ha^{-1}. Optimum doses of balanced fertilization resulted increase in photosynthetic efficiency and its translocation towards sink (grains) which resulted heavier grains. Shreemannarayan *et al*. (1993) [22], Dwivedi *et al*. (2006) [8] and Awant *et al*. (2007) have also reported better test weight with higher doeses of fertilizers.

The grain yield was significantly influence by various nutrient management modules. The maximum grain yield of 55.66 q ha^{-1} was recorded with 150% RDF+ 25 kg $ZnSO_4$ ha^{-1} which was at par with100% RDF of N.P.K (120:60:60 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} and 120% RDF of N.P.K (150:75:75 kg NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1}. The results may be attributed to the fact that better & balanced fertilization, resulted optimal availability of nutrients & its uptake resulting better yield attributes *i.e.* sink capacity which ultimately increased grain yield. Similar findings have been also reported by Dwivedi *et al*. (2006) [8] Singh *et al*. (2005) [23-24] Tonmay *et al* (2006) and Updhyay *et al* (2007).

The straw yield was significantly increased with increase in nutrient management modules. The maximum straw yield of 71.47 q ha^{-1} was recorded with 150% RDF + 25 kg $ZnSO_4$ ha^{-1}, which was significantly superior over other nutrient management modules. The optimum doses of balance fertilization increased all the growths characters *viz*. plant height, initial plant stand, tillers hill^{-1}, number of ear bearing tillers (m^{-2}) as well as dry matter production which resulted increase in straw yield Similar findings have been also reported by Jana (2006) [13] and Jana (2009) [12] Tiwana *et al* (1999).

Harvest index is the function of grain yield to the total biological yield (grain + straw). Harvest index was not influenced significantly due to various nutrient management modules. It might be due to proportionate increase in grain and straw yield with increase in nutrient management modules. Similar findings have been also reported by Srivastava and Solanki (1994).

Table 1: Effect of different INM modules on growth attributes and maturity traits of rice varieties

Treatment	Plant height (cm)				Initial plant stand (m^{-2})	No. of tillers hill^{-1}	No. of ear bearing tillers (m^{-2})	Days taken to panicle initiation	Days taken to physiological maturity
	30 DAT	60 DAT	90 DAT	At harvest					
Fertilizer modules									
M_1	52.20	67.50	84.60	93.06	44.20	7.20	271.53	67.10	112.90
M_2	54.52	70.50	88.36	97.20	44.20	7.52	284.11	69.20	116.30
M_3	56.26	72.75	91.18	100.30	44.40	7.76	291.64	71.30	120.40
M_4	59.16	76.60	95.88	105.47	44.50	8.16	306.74	73.40	115.10
M_5	62.06	80.25	100.58	110.64	44.60	8.56	325.40	74.30	118.70
M_6	63.80	82.50	103.40	113.74	44.80	8.80	332.81	77.25	123.30
SEm±	1.49	1.93	2.53	2.84	1.47	0.19	10.55	1.56	1.68
CD at 5%	4.38	5.67	7.44	8.22	NS	0.55	30.96	4.57	4.94
Variety									
V_1	61.48	79.50	99.64	109.60	44.53	8.42	320.96	73.12	122.88
V_2	54.52	70.50	88.36	97.20	44.37	7.52	283.12	71.07	112.68
SEm±	0.86	1.11	1.46	1.61	0.85	0.11	6.09	0.90	0.97
CD at 5%	2.53	3.27	4.25	4.74	NS	0.32	17.87	NS	2.85
V × M	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of different INM modules on yield attributes and yield of rice varieties

Treatment	No. of panicle (m^{-2})	Length of panicle (cm)	No. of grain panicle^{-1}	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Fertilizer modules							
M_1	271.53	20.74	189.00	23.50	45.54	61.35	42.58
M_2	284.11	21.62	195.49	23.60	47.56	61.48	43.08
M_3	291.64	22.31	203.70	23.61	49.08	61.83	43.46
M_4	306.74	23.46	214.20	23.89	51.61	61.93	44.41
M_5	325.40	24.61	224.70	24.18	54.14	67.91	45.02
M_6	332.81	25.30	231.00	24.38	55.66	71.47	45.51
SEm±	10.55	0.78	6.55	0.42	1.66	1.60	1.03
CD at 5%	30.96	2.29	19.23	NS	4.89	4.71	NS
Variety							
V_1	320.96	23.69	216.30	24.47	52.12	66.26	44.02
V_2	283.12	22.31	203.06	23.24	49.08	62.40	44.0
SEm±	6.09	0.45	3.78	0.24	0.96	0.92	0.60
CD at 5%	17.87	1.32	11.10	0.71	2.82	2.72	1.76
V × M	NS	NS	NS	NS	NS	NS	NS

Performance of high yielding varieties

Initial plant stand (m^{-2}) did not differ significantly under the influence of variety. This might be due to the maintenance of uniform plant population during the transplanting at specific planting distance of 20 ×10 cm plant. The result are in close conformity with the finding of Pandey *et al*. (2001) [17] and Geetadevi *et al.* (2009).

The number of tillers hill^{-1} was influenced by various varieties. Sorjoo-52 produced significantly higher number of tillers hill^{-1} over NDR-359. This may be attributed to better growth of roots which resulted better nutrient uptake and better tillering. Desmukh *et al.* (1988) and Tunga and Nayak (2000) [29] also reported significant variation in tillers hill m^{-1} in different varieties.

The high yielding rice variety Sarjoo-52 produced significantly taller plants than NDR-359 at all growth stages *viz.*, 30, 60, 90 DAT and at harvest. This was due to genetic behavior of the variety. Similar finding have been also reported by Wang Haiqin (2007).

Higher yielding variety of rice showed significant variation in dry matter production. Maximum dry matter accumulation was recorded by Sarjoo-52 which was significantly superior over NDR-359 at all growth stages. The result may attributed to the fact that balanced fertilization result better root and shoot development which resulted in higher accumulation of photosynthats and nutrient uptake increasing dry matter production reported by Guo *et al*.(2001) [10].

High yielding rice variety Sarjoo-52 took significantly higher number of days for maturity as compared to NDR-359. This may be attributed to genetic behavior of the variety Sarjoo-52 and NDR-359. Findings are in conformity with of Deshpande *et al.* (2002) [6].

Sarjoo-52 produced significantly highest number of panicles m^{-2} which was significantly superior over NDR-359. This was mainly due to better tillering capacity of Sarjoo-52. Significant variations in tillering of high yield in varieties have been also reported by Shekara *et al.* (2001).

The different varieties influenced the length of panicle significantly. The largest panicles were recorded by Sarjoo-52 which were significantly superior over NDR-359. The results may be attributed to better root and shoot growth which resulted better sink development. Ramesh *et al.* (2007) and Du *et al.* (2009) [7] also reported variation in panicle length of various varieties under test.

The different varieties influenced the number of grains panicle^{-1} and the highest number of grains panicle^{-1} was found with Sarjoo-52 which was significantly superior over those of NDR-359. This may be due to the fact the variety which shown better photosynthetic ability, produced larger panicles as well as higher number of grains panicle^{-1}. The results are in line with those of Singh *et al.* (2010) [25]. Various varieties significantly varied in test weight, the maximum test weight was recorded by Sarjoo-52 which was significantly superior over NDR-359. Mishra and Abidi (2006) also reported variation in test weight in various rice varieties and inbred varieties. The different rice varieties influenced the grain yield significantly. The highest grain yield of 55.66 q ha^{-1} was recorded by Sarjoo-52 which was significantly superior over NDR-359. The increase in yield may be attributed to increase in all yield attributing characters which resulted increase in grain yield. The results are line with those of Verma (2004) [31]. The different varieties also influenced the straw yield significantly. The highest straw yield of 71.47 q ha^{-1} was recorded by Sarjoo-52, which was significantly superior over NDR-359.This may be due to higher tillering capacity and dry matter production with Sarjoo-52 which have positive correlation with straw yield. Similar results have been also reported by Singh *et al.* (2005) [23-24] and Hommene *et al.* (2008).

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