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EFFECT OF NITROGEN DOSE ON GROWTH, DEVELOPMENT, PRODUCTIVITY AND NUTRIENT USE EFFICIENCY IN RICE (*ORYZA SATIVA* L.) – A REVIEW

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Abstract–Rice is the staple food crop in most of the developing nations. Dry weight of the plant is primarily derived from nitrogenous compounds, which account for about 10% of their total weight. A component of protein, nucleic acid of nucleoproteins, chlorophyll pigment, hormones that regulate metabolism, and a respiratory-energy carrier. This nutrient is crucial for rice production and the building block of cell metabolism. Several workers have reported beneficial effect of applied nitrogen on rice (Kadiyala *et al.*, 2012; Saha *et al.*, 2017; Kumar *et al.*, 2018; Jyothi *et al.*, 2019). Consequently, different nitrogen levels affect rice growth and yield in profound ways. This review paper is an attempt to provide a brief summary of the work done. In this document, researchers discuss the effects of nitrogen dose on rice growth, development, productivity, and nutrient use efficiency.

Plant height

Meena *et al.* (2003) outlined that increase in plant height and enhancement of the vegetative growth in rice hybrid "Proagro 6207 on sandy clay loam, having 0.51 % organic carbon and 186.9kg ha^{-1} available nitrogen is due to higher level of nitrogen. Hossain *et al.* (2008) concluded that the Physiological processes including cell division and cell elongation contributed to plant height increase. Wani *et al.* (2016) and Saha (2017) reported significantly taller plants on 80, 90 kg and 120 kg N ha^{-1} with height of 98.1, 94.1 and 94.7 cm, respectively.

Tiller density

Manzoor *et al.*(2006) at Rice Research Institute, Lahore, Pakistan recorded the effect of nine different level of nitrogen starting from 50 kg to 225 kg N ha^{-1} on rice variety Super Basmati and concluded that the productive tillers hill^{-1} (23.42) surged up to 225 kg N ha^{-1}. Whereas much higher number of tillers were recorded through application of 150 kg N ha^{-1} as reported by Ramesh *et al.* (2009). Similarly, positive response to Nitrogen application has been reported by Shukla *et al.* (2015) at 120 kg N ha^{-1} with effective tillers (238.50 m^{-2}), Kumar *et al.* (2017) at 150 kg/ha (9.25 EBT hill^{-1}) under aerobic condition and Dahipahle and Singh (2018) at 180 kg N ha^{-1} (12.6 EBT hill^{-1}) under puddle soils.

Dry matter accumulation

Maximum dry matter production at physiological maturity was recorded by nitrogen application rate of 180 kg ha^{-1}which was significantly greater to lower N rates as reported by Belder *et al.* (2005). Singh *et al.* (2015) observed that usage of nitrogen doses from 90 to 150 kg N ha^{-1} at all crop growth stage increases the dry matter which might be due to increased photosynthetic efficiency of crop moving to sink. Ronanki *et al.* (2017) observed that with the progressive increase in nitrogen levels and planting densities, total dry matter production improves progressively. Better plant growth was due to higher total dry matter production which resulted in higher dry matter accumulation in leaves and stem at early growth stages and better translocation to ear heads

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during later stages (Prakash *et al.*, 2018).

Dry matter partitioning

Haque and Haque (2016) reported significant outcome of nitrogen on apparent dry matter translocation in rice on clay soil with variety Budhan-1. They further stated that for achieving maximum rice yield, the best photosynthesis activity of flag leaf is needed as 60% - 90% of total carbon in panicle is derived from photosynthesis after heading and rest of photo- assimilates needed for grain is remobilized from vegetative organs. Ronanki *et al.* (2017) observed that 54% to 57% of dry matter partitioning to grain at physiological maturity and the highest accrual of stem, leaf and grain was observed with 300 kg N ha^{-1}and was equivalent with 240 kg N ha^{-1}, 180 kg N ha^{-1}.

Leaf area index

Kadiyala *et al.* (2012) found that temporal curves of LAI improved with the increase in nitrogen level from 0-180 kg N ha^{-1} under both the system of flooded and aerobic culture. Higher LAI (4.58) with 120 kg N ha^{-1} and lowest (2.71) at 80 kg N ha^{-1} was also observed by Amrutha *et al.* (2016). Improvement inmorpho-physiological characteristics of rice is due nitrogen fertilization by increasing rice leaves and roots growth leading to an appropriate higher leaf area index (LAI) at 60 DAT were observed by Ali *et al.* (2017) and concluded that plant communities adjusted their leaves with greater LAI from early stage of growthdue to higher population density. This finding was in conformity with that of Paul *et al.* (2017) and Shome *et al.* (2019).

CGR, RGR and NAR

Esfahani *et al.* (2006), Singh *et al.* (2009) and Yang *et al.* (2009) reported that crop growth rate at early growth stagewere slow, attained peak at flowering stage and declined towards maturity stage. Slow crop growth rate at earlier stages might be due to lower leaf development which act as a main organ of photosynthesis on which growth rate depends. The highest crop growth rate (33.99 g^{-2}day^{-1}) was obtained at 45 days after transplanting when the crop was fertilized with 100 kg N ha^{-1}. The descending NAR was attributed to less number of leaves at the later stage of crop growth.

Panicle number, length and weight

Kadiyala *et al.* (2012) observed improvement in panicle production with increased N application and more response to incremental rates of N in flooded conditions than aerobic rice treatments. Shukla *et al.* (2015) revealed that 120 kg N ha^{-1} recorded maximum number of effective tillers (238.50 m-2) over 40 kg N ha^{-1} (160.88 m^{-2}) and 80 kg N ha^{-1} (182.37 m^{-2}. Application of 100 kg N ha^{-1} produced significantly higher panicle weight (Patel *et al.*, 2010). Higher availability of N to plants leading to its higher uptake and translocation from vegetative parts to reproductive parts resulting in increased yield attributes which may be the cause behind increase in yield-attributing characters of aerobic rice with the increase in N application (Nayak *et al.*, 2015).

Number of filled grains

Lawal and Lawal (2002) stated that factors like crop genotype, cultivation practices and growing environment affected the number of filled or unfilled grains per panicle. Patel *et al.* (2010) revealed that Application of 100 kg N ha^{-1} produced higher grains (149 panicle^{-1}). Gewaily *et al.* (2018) observed that the number of filled grains per panicle was significantly increased when nitrogen application from 0 to 220 kg N ha-1 was increased. While Hossain *et al.* (2018) observed a lower dose of fertilization (45 kg N ha^{-1}) produced the highest number of grains panicle^{-1} (139.61). Chamely *et al.* (2015) recorded highest number of sterile spikelets (24.85) panicle^{-1} in control (0 kg N ha^{-1}) and the lowest (12.62) panicle^{-1} at 200 kg N ha^{-1}. A similar finding was confirmed by the study ofKumar *et al.* (2017).

Test Weight

Pramanik and Bera (2013) revealed that increase in grain weight can be attributed to an increase in chlorophyll content in leaves at higher nitrogen rates which led to higher photosynthetic rate and ultimately plenty of photosynthates available during grain development which is corroborated by Patel *et al*. (2010). Haque and Haque (2016) opined that less variations among different nitrogen level might be due to the fact that test weight is more of a genetically controlled character as also reported by Kumar *et al.* (2017).

Grain yield

Singh *et al.* (1995) reported that fertilizer application of high N levels reduces rice grain yield but, the response of grain yield to N was linear up to 225 kg N as reported by Shivay and Singh (2003). Rice crop fertilized with 100 kg N ha-1 produced significantly the highest grain yield to the tuned of 6.7 % (5382 kg ha-1) as compared to 75 kg N ha-1 (5045 kg ha-1) (Patel *et al*., 2010). The increase in grain yield at higher nitrogen levels might be due to accumulation of more dry matter and translocation from source to sink (Morteza *et al.,* 2011). Similarly, Kipgen *et al.* (2018) reported the highest grain yield (4.54 t ha-1) with 120 kg N ha-1 which was due to better nutrient uptake leading to higher dry matter production and its translocation to sink leading to increased percent of filled grains and number of panicles m^2.

Straw yield

Shivay and Singh (2003) observed significantly higher straw yield (4.69,6.08,7.03 and 7.87 t ha^{-1}) with increasing level of N (0,75,150 and 225 kg ha^{-1}) which might be due to vigorous plant growth with increasing N level. Pramanik and Bera (2013) also recorded significant increase the straw yield with increase in nitrogen application levels up to 200 kg ha^{-1}. Saha *et al.* (2017) found 90 kg N ha^{-1} producing significantly higher (4.96 t ha^{-1}) straw yield.

Harvest index

Shukla *et al.* (2015) found a nitrogen dose of 120 kg N ha^{-1} exhibiting the maximum harvest index (34.84%). Saha *et al.* (2017) also reported higher (44.80) value of harvest index at 90 kg N ha^{-1} followed by 60 kg N ha^{-1} (40.80 %) and 30 kg N/ha (36.80%). But, the harvest index of aerobic rice did not differed significantly with different levels of nitrogen (Hebbal Narayan *et al.,* 2017).

Nutrient uptake

Shivay and Singh (2003) reported that production of higher amount of biomass due to higher level of nitrogen significantly increases the grain, straw and total N uptake by rice. Zaidi and Tripathi (2007) from three years average data reported that total N uptake of 123.11 kg ha^{-1} was the highest under 150 kg N ha^{-1}application with an additional uptake of 78.46, 34.42 and 22.95 Kg N ha^{-1} over 0, 50 and 100 Kg N ha^{-1}, respectively. Jyothi *et al.* (2019) from their two years study on clay loam soil low in organic carbon, available nitrogen and medium in available P and K concluded that N, P and K at harvest was the highest at 210 kg N ha^{-1} closely followed by N @ 150 $kgha^{-1}$. Greater absorption of nitrogen by rice crop occurs due to proportionately increased pool of available nitrogen at the root zone. Higher root proliferation and vigorous seedling growth and their foraging ability may be due to significant increase in P uptake at higher nitrogen levels which helps in augmenting phosphorus uptake from soil.

Nitrogen-use efficiency

Relationship between the total nitrogen inputs compared to nitrogen output which is expressed using different variables described as Nitrogen use efficiency. Very low efficiency of the urea-N in rice culture is found, generally around 30-40%, in some cases even further low, as reported by several workers (Cao *et al.*, 1984; Choudhury *et al.,* 2002). Shivay and Singh (2003) showed significant effect of nitrogen levels on agronomic nitrogen-use efficiency (NUE), apparent N recovery (%), nitrogen-efficiency ratio (NER) and physiological efficiency index of nitrogen (PEIN). Due to leaching and de nitrification losses at highest level of nitrogen, Agronomic NUE and apparent N recovery declined significantly as reported by Sunita Devi *et al.* (2019). Zaidi and Tripathi (2007) observed that agronomical efficiency improved significantly with increase in the dose of N up to 100 Kg ha^{-1}. The results are in conformity with the findings of Sharma *et al.* (2007) who also reported a strong positive relationship between apparent recovery efficiency of nitrogen and nitrogen levels.

Economics (Net return and B:C ratio)

Shukla *et al.* (2015) reported that crop fertilized with 120 kg N ha^{-1}had higher B:C ratio (2.27)over 40 kg N ha^{-1} (1.81)and 80 kg N ha^{-1} (2.00). Similar findings were also observed by Singh *et al.* (2017) that among the different nitrogen levels, the maximum benefit: cost ratio of 2.34 can be recorded with the application of 120 kg N ha^{-1} over 180, 60 and 0 kg N ha^{-1}. Maximum gross return (Rs.79307.50 ha^{-1}), net return (Rs.52314.96 ha^{-1}) and benefit: cost ratio (1.94) at 60 kg $Nha^{-1}$was reported by Sunita Devi *et al.* (2019).

Correlation and path coefficient analysis

An important criterion for understanding the biological yield is information on character association with yield and among themselves. Correlation and path coefficient help in identifying such direct and indirect effects (Prakash *et al.* 2018). Ramkrishnan *et al.* (2006) reported that the grains $panicle^{-1}$ and spikelet fertility are positively correlated with seed yield and also among themselves. Sadeghi (2011) also found positive and significant correlation between grains $panicle^{-1}$, days to maturity, panicle weight, the number of productive tillers, days to flowering, plant height panicle length, flag leaf width and flag leaf length indicating the importance of these characters for yield improvement. Ratna *et al.* (2015) recorded the highest positive direct effect of number of filled spikelets panicle^{-1} on grain yield followed by 1000-seed weight and days to 50% flowering.

CONCLUSION

In the highlights of above scientific description about effect of nitrogen from different technical aspects, we are giving conclusion that optimum dose of nitrogen can significantly improve the growth, development, productivity of rice along with higher returns, benefit cost ratio, nutrient use efficiency which is very site specific.

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