Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(3): 1576-1578
Received: 11-03-2020
Accepted: 15-04-2020

Sweta Singh
Department of Soil Science and Agricultural Chemistry, IGKV, Raipur, Chhattisgarh, India

Dr. Sangita Mohanty
Scientist, Soil Science and Microbiology Crop Production Division, National Rice Research Institute, Cuttack, Odisha, India

Dr. Rakesh Banwasi
Scientist, Department of Soil Science and Agricultural Chemistry, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Sweta Singh
Department of Soil Science and Agricultural Chemistry, IGKV, Raipur, Chhattisgarh, India

Nitrogen distribution in plant parts of various rice cultivars under graded nitrogen application

Sweta Singh, Dr. Sangita Mohanty and Dr. Rakesh Banwasi

Abstract
Nitrogen plays an important role in plant growth and development and also the most expensive inputs in agricultural settings. Unutilized nitrogenous fertilizer in agricultural field is one of the causes of environmental pollution now-a-days. In rice based cropping system, utilizes only 30-40% of total applied nitrogen and rest goes to waste thereby creating environmental pollution as well as economic loss. Additionally, the loss of N increases costs, contributes to soil acidification, and causes off-site pollution of the air, groundwater and water bodies. Globally, the current important concern is to face the great challenges of improving nitrogen use efficiency and environmental sustainability. This study reviews current knowledge about technologies for N fertilization with potential to optimize sources and rates of application and reduce its negative effects on the environment. Classic inorganic sources such as urea are the major sources utilized. This experiment was carried out in factorial randomized block design with three replications at Cuttack, Odisha, India during Kharif season of 2017-2018 to asses growth and yield parameters of six rice cultivars (Naveen, Indira, Ratna, Surendra, Birupa and Daya) against six treatments of nitrogen levels (N1:0; N2:40; N3:60; N4:80; N5:100; and N6:150 kgNha^{-1}). Results revealed that Dry matter accumulation increased with N levels up to 150 kg N ha^{-1} in all the cultivars. Whereas, increasing trend of grain yield is favored at higher levels of applied nitrogen in Indira, Surendra and Birupa although it declined at N application levels exceeding 100 kg N ha^{-1} in rest of the cultivars.

Keywords: Maximum tillering (MT), panicle initiation (PI), flowering (FL) stages, physiological maturity (PM) stage, Dry Matter Accumulation

Introduction
Rice is one of the most important staple cereals in human nutrition, consumed by about 75% of the global population providing 30-60% of the calories consumed by them. Nitrogen plays an important role in plant growth and development by being a component of photosynthesis, with about 75% of leaf N associated with chloroplasts, which are physiologically important in dry matter production through photosynthesis (Dalling, 1985) [2]. Nitrogen being a component of photosynthesis contributes to carbohydrate accumulation in culms and leaf sheaths during the pre-heading stage and in grain during the grain-filling stage.

Rice is the major consumer of fertilizer nitrogen and gives high response to applied N. Nitrogen (N) is one of the most yield limiting nutrients in rice production around the world (Samonte *et al*., 2006) [7]. Nitrogen fertilizer is universally accepted as a key component for higher crop yield and optimum economic return. N fertilizer costs comprise an important fraction of total production costs in crops (Tirol-Padre *et al*., 1996) [8]. Plant growth is adversely affected due to deficiency of nitrogen as it restricts the formation of enzymes, chlorophyll and proteins necessary for growth and development. In view of keeping the above important points, a study is planned to conduct a field experiment entitled nitrogen response of different rice cultivars underr graded dose of nitrogenous fertilizers**.**

The pattern of biomass accumulation during different growth stages varies from variety to variety. Therefore, information on the seasonal N uptake pattern and Partioning within the plant part is essential to determine the time and rate of N application. Accumulation and redistribution of N are important processes determining grain yield and grain quality (Hirel *et al*., 2007). It is necessary to investigate the N translocation from pre-anthesis to post-anthesis which provides the major source of grain N.

Materials and Methods
The experiment was conducted during Kharif season 2017 to assess nitrogen response of rice cultivars under graded nitrogen doses. The seven rice cultivars were grown with six nitrogen levels i.e. 0, 40, 60, 80, 100, 150 kg N ha^{-1} in a factorial randomized block design replicated three times.

Plant samples were collected at maximum tillering (MT), panicle initiation (PI) and flowering (FL) stages of crop by cutting above ground plant parts from the base of six representative hill samples in each plot. Collected plant samples were properly cleaned by washing in distilled water and oven dried at 70 °C till constant weight was attained and the oven dry weight of samples was expressed as dry matter accumulation in t ha^{-1}.

Rice grain and straw yields were determined at physiological maturity (PM) stage. The fresh weight of total bundle, straw and grain were recorded, and a part of the grain and straw sample was used to determine moisture content by oven drying method. The moisture content was used to convert fresh weight to dry weight and grain yield was expressed in t ha^{-1} at 14% moisture content. To determine dry matter accumulation and yield components (Panicle Number, No of filled grain per panicle and thousand grain weight) 10 randomly selected sample hills (excluding two boarder rows on each side of the plot) were taken out. After counting number of panicle, grains from panicle were manually removed and filled and unfiled grains (chaff) in each panicle were counted separately. The dry matter accumulated was determined by drying all the above ground plant parts (straw, filled and unfilled grains, and rachis) at 70◦C to a constant weight.

Result and Discussion

Data pertaining to number of tillers m^{-2} at MT stage of rice were given in Table 1 and Figure 1. Number of tillers m^{-2} of rice increased with increasing N level, the highest tiller number was observed at N level 150 kg ha^{-1} in all the varieties. Average number of tiller m-^{2} across the N dose was highest for Birupa (349) and lowest for Indira (272). Growth promoting effect of N on plant can be explained on the basis of the fact that N supply increases the number and size of meristematic cells which leads to formation of new shoots (Lawlor DW, 2002). Furthermore, N application is known to increase the levels of cytokinin which affects cell wall extensibility (Arnold *et al.*, 2006). Since N plays significant role in the cell division, enlargement and production of tissues supply of higher level of N could possibly have positive effect on growth characteristics particularly tiller numbers (Haque and Haque, 2009) [5]. The lower tiller number was due to the failure in competition for nitrogen at lower level and increase death of the tillers due to mutual shading (Fageria *et al.*, 1997).

Table 1: Tillers per m^{-2} at maximum tillering stage of different cultivars

SN	Treatment	N doses (kg ha-1)						
	Varieties(V)	**0**	**40**	**60**	**80**	**100**	**150**	**mean**
	Naveen	182	248	264	314	347	380	289
	Indira	182	215	248	281	330	380	272
	Ratna	215	248	248	314	380	446	308
	Surendra	231	264	314	347	380	413	325
	Birupa	215	281	314	396	429	462	349
	Daya	215	281	314	363	396	413	330
		V	**N**	**VxN**				
	CD (P=0.05)	19.8	18.3	23.9				
	SE(m)+	6.91	6.39	16.9				

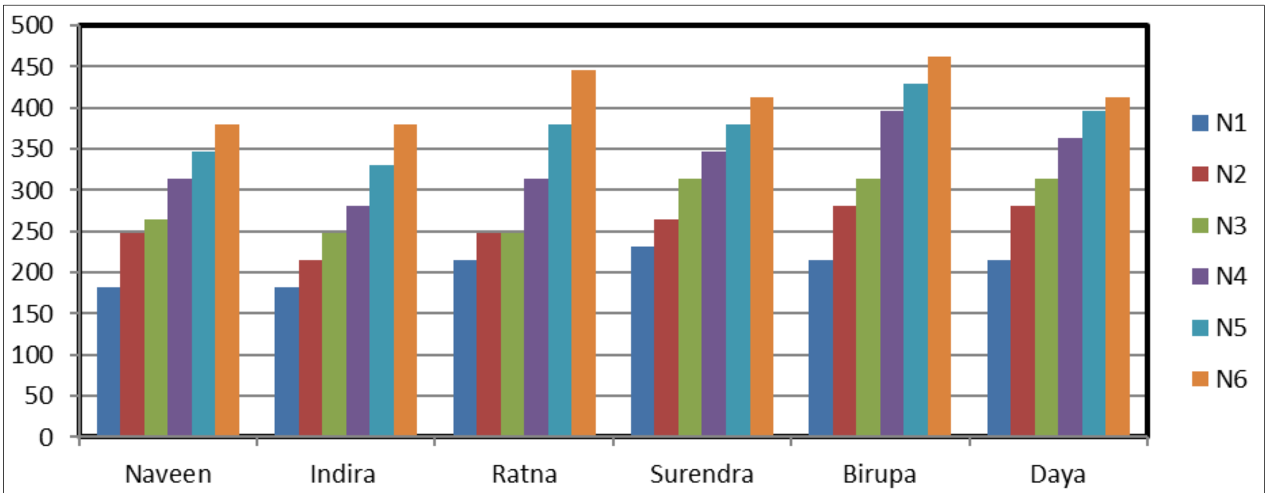

Fig 1: Number of tillers m^{-2} at maximum tillering stage influenced by different N levels in various rice cultivars

Dry Matter Accumulation in different cultivars at all growth stages under as affected by N level are presented in figures 2. Dry matter production by rice plants increased progressively with the advancement of growth stages and reached peak at maturity. N application had a positive effect on DMA in different cultivars at all growth stages. DMA at MT ranged across the cultivars 0.35 to 1.12 t ha-1 among which the highest was observed in Naveen. While in PI stage range across the cultivars is 1.99 to 3.68 t ha-1 among which Naveen is highest. At FL stage, range across the variety is 4.76 to 7.42 t ha-1 and the highest recorded in Birupa. At GF stage, range across the variety is 6.59 to 9.79 t ha-1 and the highest recorded in Birupa. At Maturity stage, range across the variety is 8.67 to 10.94 t ha-1 and the highest recorded in Birupa. During vegetative stage high level of N can enhance dry matter content by producing higher photo-assimilates through enhanced photosynthesis, which is distributed to reproductive organ (Dordas CA and Sioulas C, 2008; Azarpour *et al.*, 2014) [3, 1]. Application of nitrogen leads to significant difference in the pattern of partitioning of dry matter of rice at all the growth stages whereas low nitrogen fertilizer levels triggers allocation of low dry matter to all the plant parts (Haque and Haque, 2009) [5]. Nitrogen availability, uptake and translocation affects basic physiological functions associated with biomass production (Below *et al.*, 1985; Kaizzi *et al.*, 2012) [2]. Nitrogen influences production of biomass and grain through its effect on photosynthetic capacity and photosynthetic activity (Dreccer *et al.*, 2000, Muchow *et al.*, 1988) [4], development and maintenance of sink capacity i.e the number and size grain (Miralles *et al.*, 1998)

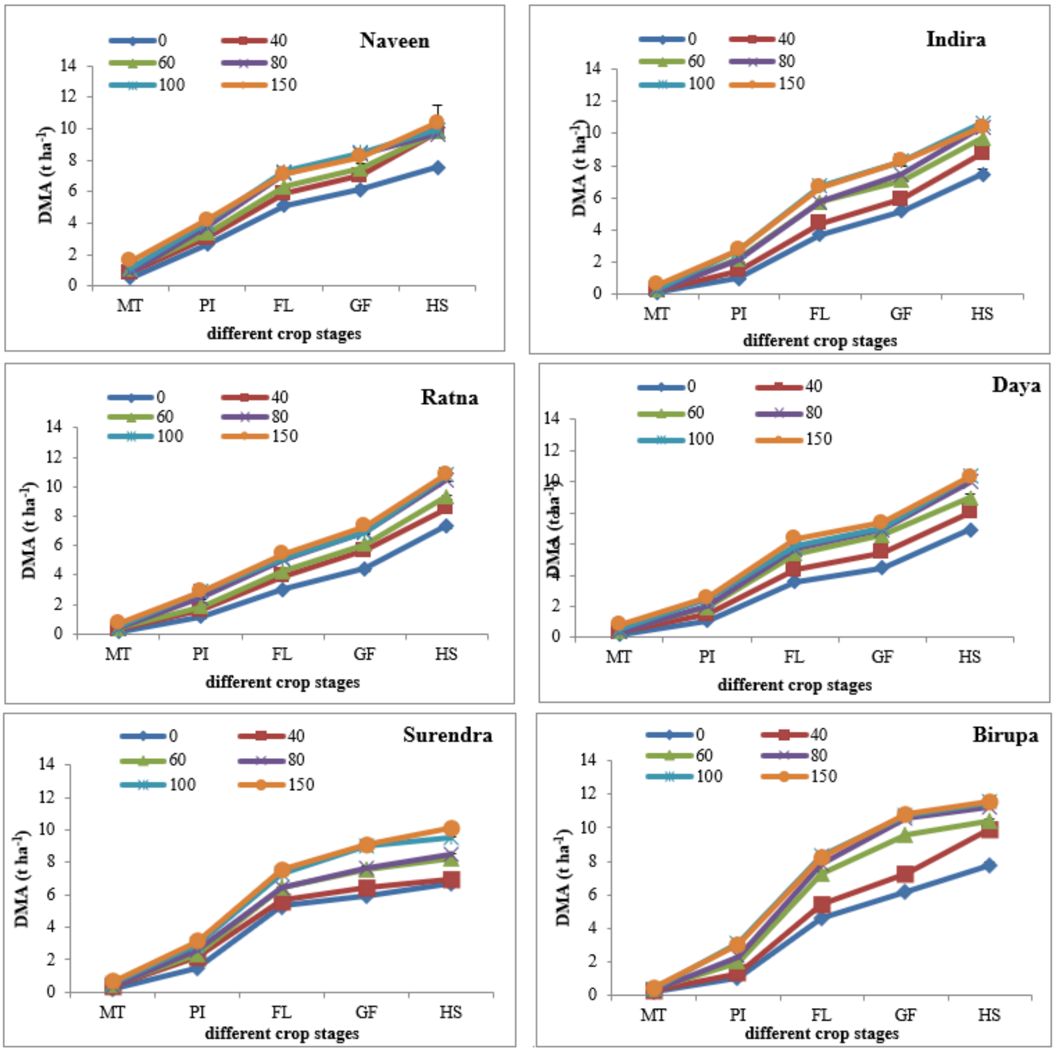

Fig 2: Dry matter accumulation among all the seven varieties in different N doses at crop growth stages

Conclusion

It may be concluded from our findings that crop growth of the different rice cultivars were significantly influenced by different N level of nitrogen fertilizer. Supply of higher level of N shows positive effect on growth characteristics. Whereas, increasing trend of yield and yield attributing characters is favoured at higher levels of applied nitrogen in Indira, Surendra and Birupa although it declined at N application levels exceeding 100 kg N ha^{-1} in rest of the cultivars. The cultivars giving higher grain yield even at higher N levels are known to be efficient cultivars due to greater sink capacity, larger rates of post anthesis growth, N uptake and remobilization. In contrast, cultivars giving lower grain yield at higher N levels are known to be inefficient cultivars can be due to the application of excess nitrogen is not effectively utilized by the crop and the rate of production was less per unit of N application.

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