Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 1378-1382
Received: 28-07-2018
Accepted: 29-08-2018

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Performance of various rice cultivars under variable nitrogen levels

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Abstract

A field experiment was conducted the Research Farm of College of Post-Graduate Studies, Umiam, Meghalaya during *kharif* season of 2016 following Factorial Randomized Block Design with three replications. The soil of the experimental site was sandy clay loam soil in texture having pH 4.82, organic carbon 3.28%, Available N, P and K was 359.9, 17.6 and 196.4 kg ha^{-1}, respectively. Three rice cultivars (CAU-R1, Shahsarang1 and Lumpnah1) were grown with four nitrogen levels (60, 80, 100 and 120 kg N ha^{-1}) for the study. Shahsarang1 recorded significantly higher plant height over the CAU-R1 and at par with Lumpnah1. Shahsarang1 was significantly more tillers per hill over Lumpnah1 and at par with CAU-R1 at 90 DAT and at harvest. The dry weight of Shahsarang1 showed significant superiority at 90 DAT and at harvest over others. Leaf area and leaf area index of Shahsarang1 was significantly superiority over CAU-R1 at all the stages and at par with Lumpnah1 at 90 DAT. Shahsarang1 recorded maximum panicle length over Lumpnah1 and at par with CAU-R1. Test weight was maximum in CAU-R1 which was significantly higher over Shahsarang1 and at par with Lumpnah1. Highest grain yield and biological yield were obtained from Shahsarang1 which was significantly superior over Lumpnah1 and CAU-R1, Grain yield of CAU-R1 was at par with Shahsarang1. At 30 DAT and 60 DAT, 120 kg N ha^{-1} showed significantly higher leaf area over the 60 and 80 kg N ha^{-1} and at par with 100 kg N ha^{-1}. However, most of the growth parameters had not shown statistically significant difference but increased with each level of nitrogen resulting increase in plant height, tillers hill^{-1}, leaf area, leaf area index and dry matter production, higher values were recorded at 120 kg N ha^{-1} compared to 60 kg N ha^{-1}. Number of filled grain panicle^{-1} was highest at 120 kg N ha^{-1} which was significantly superior over 60 kg N ha^{-1}. However, Nitrogen level 120 kg ha^{-1} at par with 100 and 80 kg N ha^{-1}.

Keywords: Cultivars, rice, nitrogen level

1. Introduction

Rice is the primary food source for about 65% of the world's population and covers an area of 164.7 Mha with annual production of 745.7 Mt grain with average productivity of 4.5 t ha^{-1} (FAO, 2014) [6]. In that, more than 90% of rice is consumed in Asia, where it is a staple food for a majority of the population (Mohanty, 2013) [10]. Globally, India stands first in rice area and second in production after China. In India, rice is cultivated on an area of 44.0 Mha which is the largest among all rice growing countries, annual production is about 106.5 Mt with a productivity of 2.4 t ha^{-1} (DES, 2015) [4]. Rice is the principal food grain crop of the North Eastern hilly region, occupying 3.51 Mha areas and around 5.50 Mt of production with average productivity of 1.57 t ha^{-1}, which is much below the national average of 2.08 tha^{-1} (Ngachan *et al.*, 2011). In Meghalaya, rice area, production and productivity are 1.04 lakh ha, 2.80 lakh tonnes and 2550 kg ha^{-1} (DES, 2015) [4], respectively. The region is net deficient of 1.6 Mt of food grain and about 1 Mt of this deficiency is due to rice alone (Datta *et al*., 2006) [3]. However, a lot of potential exists to make this region self sufficient for meeting its rice requirement through vertical improvement in production. There is no opportunity to increase area under rice and consequently much of the additional rice requirement will have to come from higher average yield on existing land. Clearly, it will require adoption of new technology such as improved management package, high yielding cultivar, higher input use, etc. (Huaqi *et al.*, 2002) [7]. Adoption of location specific high yielding cultivars with optimum plant spacing is among the important management factors to get higher rice yield in the region.

Since fertilizer is an expensive and precious input, determination of an appropriate dosage of application that would be both economical and appropriate to enhance productivity and consequent profit of the grower under given situation needs intensive study. At present the world is facing the problem of shortage of major fertilizer nutrients especially Nitrogen. The application of nitrogen fertilizer either in excess or less than optimum rate affects both yield and quality of rice to remarkable extent, hence proper management of crop nutrition is of immense importance. Nitrogen absorbed by rice during the vegetative growth stages contributed in growth during reproduction and grain-filling through translocation (Bufogle *et al.*, 1997; Norman *et al*., 1992) [2, 12]. Nitrogen is very essential for the growth and development of crops. An increase in yield of cereals with increasing rate of nitrogen has been reported earlier (Khan *et al.* 1994) [9]. However, it needs to be explored to determine the desired quantity of nitrogen fertilizer for boosting seed yield per unit area avoiding increase in the cost of production through optimizing the N supply of every newly evolved variety. Keeping in view the importance of N supplies in relation to three different rice cultivars, the present study was therefore designed to find out the performance of rice cultivars in relation to different levels of N.

2. Materials and Method

A field experiment was conducted during *kharif* 2016 on experimental farm of College of Post Graduate Studies, CAU, Umiam, Meghalaya. The soil was sandy clay loam, medium in available N (359.95 kg/ha), P (17.64 kg/ha) and K (196.42 kg/ha), Organic carbon (3.82%) and Readily Soluble Aluminum (3.13 ppm) with acidic in nature of pH 4.82. The experiment was laid out in 2-factorial randomized block design with three replications. The experiment consists of three cultivars (V_1- CAU-R1, V_2- Shahsarang1, V_3- Lumpnah1) and four nitrogen levels (N_1-60, N_2- 80, N_3-100, N_4-120 Kg/ha) having 12 treatment combinations. The cultivars used for studies are high yielding, semi-dwarf, improved variety and tolerance to acidic condition. Shahsarang is developed through selection from the crossing of Mirikrak x Rasi at the ICAR Research complex for NEH Region, Umiam, Meghalaya. This cultivar is non lodging type with moderately resistant to blast, highly resistant to iron toxicity and tolerant to cold and shadow. The sowing of healthy rice seeds in nursery in the first week of July, 2016. The sprouted seeds were taken and sown to the nursery bed. A mixture of soil and FYM (2:1) was used on top of the beds for growing healthy seedlings. Sprouted seed were spread uniformly @100-150 g m^{-2} on the bed. A seed rate of 20 kg ha^{-1} for CAU-R1 and 30 kg ha^{-1} for Shahsarang1 and Lumpnah1 were used for getting sufficient number of seedlings based on the test weight and germination percentage of the cultivars. After twenty one days old seedlings were removed carefully from nursery bed for transplanting in the experimental plots. Two seedlings were transplanted in each hill as per the experimental plan. The overall rainfall received during the cropping period (July-November) was 2204.7 mm. Recommended dose of P and K @ 60: 40 kg ha^{-1} along with different levels of N *viz.*, 60, 80, 100, 120 kg ha^{-1} (full doses of P_2O_5 and K_2O were applied at the time of sowing along with 50% of N and rest 25% of N at active tillering stage and 25% of at panicle initiation stage as top dressing). The nutrients N, P and K were supplied through the chemical fertilizer urea, single super phosphate and murate of potash, respectively. Water maintained near saturation to a thin film maintained from three days after transplanting to active tillering stage. However, sufficient standing water was ensured from panicle initiation to heading stages.

3. Result and Discussion

3.1 Growth and Development

3.1.1 Plant height

Significant variation was recorded in plant height due to cultivars at all dates of observation. Shahsarang1 produced the higher plant height (106.1 cm) at all dates of observation and CAU-R1 produced the shortest plant height (92.5 cm). At 30 DAT, 90 DAT and harvest, Shahsarang1 recorded significantly higher plant height over Lumpnah1 and CAU-R1. At 60 DAT, Shahsarang1 showed significantly higher plant height over CAU-R1 and it was found statistically at par with Lumpnah1. These findings are in line with Jisan *et al.* (2014) [8].

The effect of nitrogen application on plant height was non-significant at all stages of observation, but increased the level of nitrogen plant height was increased. Application of nitrogen increased the plant height and the taller plant height (101.8 cm) was recorded with application of 120 kg N ha^{-1} at all growth stages. This might be due to rapid growth and development of plant cells with adequate nitrogen supply to the growing plants. Secondly adequate supply of nitrogen resulted increase in various metabolic process and performed better mobilization of synthesized carbohydrates in to amino acid and protein, which in turn stimulated the rapid cell division and cell elongation thus, allowed the plant to grow faster. Similar findings were reported by Jisan *et al.,* (2014) [8], Puteh and Mondal, (2014) [15] and Paul *et al.,* (2016) [14].

3.1.2 Number of tillers per hill

The total tillers $hill^{-1}$ varied significantly due to cultivars at all stages of observation except at 30 DAT. Shahsarang1 recorded maximum number of tillers $hill^{-1}$ which was significantly superior over Lumpnah1 at 60 DAT, 90 DAT and harvest and with CAU-R1 at 60 DAT. However, it was found statistically at par with CAU-R1 at 90 DAT and at harvest. Variation in number of tillers per hill as assessed might be due to varietal characters. Similar findings were also reported by Azarpour *et al.* (2014) [1], Rao *et al*. (2014) [16] and Paul *et al*. (2016) [14].

The total number of tillers increased significantly with an increase in nitrogen fertilizer level at 60 DAT and at harvest. The maximum number of tillers (13.0) was recorded with (120 kg N ha^{-1}) at 60 DAT. This might be due to mutual competition among the plants for light, nutrients and other growth input resulting in mortality of tillers after 60 DAT. The highest tillers $hill^{-1}$ at 60 DAS might be due to higher availability of nutrient which facilitated proper synchronized tillering. These results are in close accordance to those of Paul *et al.,* (2016) [14].

3.1.3 Leaf area and leaf area index

Leaf area varied significantly due to cultivars at different dates of observation. At 30 and 60 DAT, leaf area was found to be highest in Shahsarang1 which was statistically superior over both Lumpnah1 and CAU-R1. At 90 DAT, leaf area was significantly higher in Shahsarang1 over CAU-R1 and was statistically at par with Lumpnah1. LAI differed significantly due to cultivars and Shahsarang1 recorded significantly higher LAI at 30 and 60 DAT over both the varieties *viz*., Lumpnah1 and CAU-R1. At 90 DAT, Shahsarang1 was superior over CAU-R1 and at par with Lumpnah1.

Leaf area and Leaf area index was significantly affected by different levels of nitrogen at various growth stages of crop except 90 DAT. With increasing levels of nitrogen the LAI increased. Application of 120 kg N ha^{-1} recorded significantly higher value of LAI (5.18) at 60 DAT as compared to that observed at 30 DAT. This might be attributed to more number of tillers $hill^{-1}$ and increased plant height, which ultimately increased the size and number of green-leaves due to more favorable utilization of nitrogen and, thus contributed to higher LAI. The LAI was obtained under lower rate of nitrogen which might be due to poor and non-effective root system which resulted in reduced plant height and number of tillers hill^{-1} and led to lower leaf area index. Similar type of result was also reported by Paul *et al*. (2016) [14].

3.1.4 Dry matter production

The dry matter production of Shahsarang1 showed significant superiority at 90 DAT and at harvest stage over both the cultivars *viz*., Lumpnah1 and CAU-R1. At 30 DAT, Shahsarang1 showed significant differences with CAU-R1 while it was found statistically at par with Lumpnah1. Higher content of total dry matter accumulation in Shahsarang1 cultivar was likely due to the higher difference between the total amount of current photosynthesis and plant respiration was than the other cultivars and as a result the surplus of this difference caused further increase in total dry weight of this cultivar compared to the other cultivars (Yang *et al*. 2007) [17].
Nitrogen levels did not show significant difference at any dates of observations.

3.2 Yield attribute and yield

3.2.1 Effective tillers per hill

Cultivars did not show any significant effect on the number of tillers per hill. However, maximum number of panicle per hill was recorded in Shahsarang1 while minimum was recorded in Lumpnah1.
Nitrogen levels did not show any significant difference on number of panicles per hill. Maximum panicle per hill was recorded with nitrogen level of 120 kg ha^{-1} and minimum was recorded with nitrogen level of 60 kg ha^{-1}.

3.2.2 Panicle length

Panicle length varied significantly due to cultivars and Shahsarang1 recorded the longest panicle which was at par with CAU-R1 but significantly longer than the panicle of Lumpnah1. The panicle length was not significantly influenced by nitrogen levels.

3.2.3 Number of filled grain per panicle

Cultivars had no significant difference on number of filled grains per panicle. However, Shahsarang1 recorded highest filled grains followed by CAU-R1 and Lumpnah1.
Nitrogen levels showed significant effect on number of filled grains per panicle. At of 120 kg N ha^{-1}, highest number of filled grains panicle^{-1} was recorded which was significantly superior to that obtained at 60 kg N ha^{-1}. However, it was found that filled grains per panicle were at par for 120, 100 and 80 kg N ha^{-1}.

3.2.4 Total number of grains per panicle

Cultivars did not vary significantly for total number of grains per panicle. However, cultivar Shahsarang1 recorded higher grains per panicle than the other cultivars CAU-R1 and Lumpnah1. Nitrogen levels showed significant effect on the total number of grains per panicle. Application of 120 kg N ha^{-1} recorded maximum number of grains per panicle which was significantly superior over 80 and 60 kg N ha^{-1} and at par with 100 kg N ha^{-1}. Application of 100 kg N ha^{-1} also showed significantly higher numbers of grains per panicle over 60 kg N ha^{-1} and at par with 80 kg N ha^{-1}. Filled grains panicle^{-1} affected favourably due to levels and split application of nitrogen. This finding corroborates the finding of Devi and Sumathi (2011) [5] and Puteh and Mondal, (2014) [15].

3.2.5 Test weight

Cultivars had significant effect on test weight of rice. Maximum test weight was recorded in CAU-R1 which was significantly higher over the test weight recorded in Shahsarang1. Test weight of CAU-R1 and Lumpnah1 was at par.
Nitrogen levels did not show any significant difference on test weight of rice, though it increased in N levels from 60 kg ha^{-1} to 120 kg ha^{-1}.

3.2.6 Grain yield

Grain yield varied significantly in different rice cultivars. Highest grain yield was obtained from Shahsarang1 (4,074 kg ha-1) which was significantly more that Lumpnah1 (3,479 kg ha^{-1}) and statistically at par with CAU-R1 (3,747 kg ha^{-1}). The yield potential of any cultivar shows its ability to produce more number of effective tillers per hill and grain per panicle. Higher number of grains per hill generally is the component associated with yield improvement in most of the crops including rice. Shahsarang1 produced significantly maximum panicles length and test weight. Shahsarang1 produced significantly higher yield over Lumpnah1 and at par with CAU-R1. This was possible as number of filled grains per hill that is an integrated function of number of panicles per hill and filled grains per panicle, has more bearing on deciding grain yield per hill than the test weight. The maximum value of yield attribute in Shahsarang1 was probably due to its genetic potential over the other two cultivars to maintain higher growth rate for producing more dry matter per hill and translocate most of this dry matter towards grain as measured in terms of various growth parameters and harvest index. Similar results also reported by Patel, (2000) [13] and Jisan *et al.* (2014) [8].
Nitrogen levels also showed significant effect on grain yield of rice. Highest yield was recorded at 120 kg N ha^{-1} (3,999 kg ha^{-1}) which was significantly higher than 60 kg N ha^{-1} and was at par with 80 and 100 kg N ha^{-1}. N level of 100 kg N ha^{-1} also showed significant superiority over the 60 kg N ha^{-1} and at par with 80 kg N ha^{-1}.

3.2.7 Straw yield

Straw yield showed significant difference due to cultivars. Highest straw yield was obtained from Shahsarang1 (6,754 kg ha^{-1}) which was significantly more over Lumpnah1 (5,903. kg ha^{-1}) and CAU-R1 (5,790 kg ha^{-1}).
However, nitrogen levels showed no significant difference in straw yield of rice. Maximum straw yield (6,249 kg ha^{-1}) was reported from 120 kg N ha^{-1} and minimum (5,943 kg ha^{-1}) was obtained from 60 kg N ha^{-1}.

3.2.8 Above ground biomass

Cultivars brought significant difference on above ground biomass of rice. Highest above ground biomass was recorded in Shahsarang1 (10,854 kg ha^{-1}) which was significantly superior over CAU-R1 (9,537 kg ha^{-1}) followed by Lumpnah1 (9,383 kg ha^{-1}), respectively.
Above ground biomass showed significant effect due to nitrogen levels. Maximum above ground biomass (10,248 kg ha^{-1}) was recorded at 120 kg N ha^{-1} which was significantly superior over the 60 kg N ha^{-1} and it was found statistically at par with 80 and 100 kg N ha^{-1}.

3.2.9 Harvest index

Harvest index in rice showed non-significant difference due to cultivars. Harvest index was found maximum in CAU-R1 (39.3%) and minimum in Lumpnah1 (37.0%).
Nitrogen levels also did not show any significant difference

on harvest index of rice. Harvest index was maximum in 120 kg N ha^{-1} (39.2%) and lowest (37.0%) in 60 kg N ha^{-1}.

4. Conclusions
Based on the results, the following conclusions can be drawn
1. Among three rice cultivars, performance of Shahsarang1 in terms of growth and yield was superior under N fertilization.
2. Nitrogen influenced the grain yield and above ground biomass yield. Highest grain and above ground biomass yield were recorded at 120 kg N ha^{-1}. It was also observed the improving of yield and yield attributes with the increase in N levels.

4.1 Future line of research thrust
In view of findings of present investigation, following future lines of research thrust may be suggested.
This was first year of study; it may be continued along with the some more treatments like increase in the levels of nitrogen fertilizer.

Table 1: Effect of rice cultivars under various nitrogen levels on growth parameter of rice

Treatments	Plant height (DAT)				No. of Tillers per hill (DAT)				Leaf area (cm^2) (DAT)			LAI (DAT)		
Cultivars	30	60	90	harvest	30	60	90	harvest	30	60	90	30	60	90
CAU-R1	42.9	65.7	92.3	92.5	10.3	11.7	10.0	9.8	722.5	1107.2	924.8	2.4	3.7	3.1
Shahsarang1	55.6	74.9	104.6	106.1	10.4	12.7	10.4	10.0	866.3	1687.1	1297.6	2.9	5.6	4.3
Lumpnah1	50.0	70.8	98.9	100.9	10.3	11.3	9.3	9.0	752.4	1447.7	1297.6	2.5	4.8	4.2
CD(P=0.05)	4.4	4.5	4.5	4.7	NS	0.9	1.1	0.8	48.7	214.8	181.7	0.16	0.72	0.61
N levels (kg/ha)														
60	46.8	67.9	67.9	98.1	9.7	10.9	9.4	9.2	623.1	1106.9	1103.5	2.1	3.7	3.7
80	49.8	69.4	69.4	99.1	10.5	11.4	9.8	9.6	683.5	1463.7	1159.9	2.3	4.9	3.9
100	50.0	71.5	71.5	100.3	10.4	12.2	9.8	9.7	883.9	1530.3	1179.9	3.0	5.2	3.9
120	51.4	73.2	73.1	101.8	10.5	13.0	10.7	10.4	931.2	1555.2	1185.1	3.1	5.1	4.0
CD(P=0.05)	NS	NS	NS	NS	NS	1.1	NS	1.0	56.2	248.0	NS	0.19	0.83	NS

Table 2: Effect of rice cultivars under various nitrogen levels on yield attribute and yield

Treatments	Dry wt. hill (g $hill^{-1}$) (DAT)				Effective tillers $hill^{-1}$	Panicle length (cm)	Filled grains $panicle^{-1}$	Total no. of grains $panicle^{-1}$	Test wt. (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	HI (%)
Cultivars	30	60	90	harvest									
CAU-R1	2.5	16.1	33.0	45.9	10.0	23.6	112.6	131.8	25.6	3747	5790	9537	39.3
Shahsarang1	5.0	18.7	38.1	53.0	10.3	25.8	114.0	134.7	24.2	4074	6755	10829	37.8
Lumpnah1	3.5	16.6	33.3	46.8	10.0	22.7	111.3	128.4	24.7	3479	5903	9383	37.0
CD(P=0.05)	1.91	NS	3.51	4.48	NS	0.97	NS	NS	0.90	299.2	492.4	606.3	NS
N levels (kg/ha)													
60	3.1	16.1	33.4	46.4	9.9	23.4	105.6	124.8	24.6	3478	5943	9421	37.0
80	3.5	16.9	34.5	48.3	9.9	23.8	112.7	130.2	24.7	3741	6191	9932	37.5
100	4.0	17.7	35.4	49.4	10.0	24.4	115.5	133.5	24.8	3850	6214	10064	38.3
120	4.1	18.0	35.9	50.1	10.6	24.6	116.7	138.0	25.3	3999	6249	10248	39.2
CD(P=0.05)	NS	NS	NS	NS	NS	NS	5.57	6.41	NS	345.5	NS	593.0	NS

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