Performance of rice varieties and nitrogen levels under aerobic condition in Eastern Terai

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Abstract

An experiment was conducted for two years (2016 – 2017) to evaluate the performance of rice varieties and nitrogen level under aerobic conditions in the Regional Agriculture Research Station, Tarahara, Sunsari Nepal. The treatments were two varieties of rice (Sukhkhadhan 3 and Sukhkhadhan 6) and five levels of Nitrogen (0, 30, 60, 90 and 120 kg/ha) which was assigned in a split-plot design with three replications. The varieties were treated as the main factor and nitrogen levels were assigned as a sub-plot factor. In both years, the plant height, number of tillers per meter square, panicle number per meter square, panicle length, filled grains, thousand grain weights were recorded. All the recorded values of these paremeters were remarkably same with the application of 120:30:30 $N:P_2O_5:K_2O$ kg/ha and application of 90:30:30 $N:P_2O_5:K_2O$ kg/ha. The grain yields of 3.47 t/ha (2016) and 4.77 t/ha (2017) and straw yields of 7.65 t/ha (2016) and 7.44 t/ha (2017) were recorded with the application of 120:30:30 $N:P_2O_5:K_2O$ kg/ha which found statistically at par with the application of 90:30:30 $N:P_2O_5:K_2O$ kg/ha in both years. Furthermore, grain yield of Sukhkhadhan 3 (3.46 t/ha) remained statistically similar with that of Sukhkhadhan 6 (3.38 t/ha).

Keywords: Direct seeded rice, nitrogen level, varieties

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereals in the world. The rice growing area and production in Nepal are 1.5 million hectares and 5.6 million tons respectively (MOALD, 2018). The population of the country is increasing day by day and horizontal expansion of rice area is not possible due to high population pressure, especially in rice production (Poudel, 2016). Hence, special attention should be given to increase the yield by applying nutrient conserving practice in the soil, use of an optimum dose of nitrogen fertilizer; proper seed rate, high yielding varieties and hybrid varieties (Singh and Singh, 2017). Nutrient management plays an important role whereas nitrogen is the key input for production especially in rice-growing countries including Nepal (Thapa, 2010). According to Tadesse *et al.,* (2020), the 70-80 percent increase in grain yield of rice may be obtained by proper application of nitrogen fertilizer. It is the main nutrient associated with yield in the rice crop, but N rates respond differently to rice type, cultivar, geographic zone and other practices (Bouman *et al.,* 2007). Both lower and higher nitrogen rates are detrimental to crop growth and development. The appropriate nitrogen dose gives a higher yield of the crop and reduced fertilizer cost (Hossain and Islam, 1986). But the dose of nitrogen fertilizer is inappropriate in most cases due to lack of information and over 97 percent of farmers do not follow the recommended dose in developing countries (Hossain *et al.,* 2014). Unfortunately, nitrogen management in direct-seeded rice has received very little attention and management is usually similar to the transplanted method (Chen *et al.,* 2018). Direct-seeded rice is becoming more popular as an alternative to transplanted rice, as it is more profitable when the crop is managed properly. Direct seeding of rice avoids the need for nursery preparation, uprooting of seedlings and transplanting. There has been a rapid shift to the direct seeding method of rice establishment in Asia with 21-22% of the total rice area being dry direct-seeded rice (Gathala *et al.,* 2011). Although a large number of experiments have been carried out to find out the optimum doses of nitrogen in transplanted rice in many places of the world including Nepal, a sufficient number of experiments have not yet been done in direct-seeded rice. Therefore, the experiment was conducted with the objectives to identify the optimum level of nitrogen for obtaining a higher yield from direct-seeded rice.

Materials and Methods

Study site

The study was conducted during two rainy seasons of 2016-2017 A.D at Regional Agriculture Research Station (RARS), Tarahara, Sunsari, Nepal. The climate of the station is sub-tropical and clay loam soil type. It is geographically located at 26º42'16.85" North latitude and 87º16'38.43" East longitude with an elevation of 136 m above mean sea level.

Experimental design

The experimental plot was designed in a split-plot with three replications. The main plot included two drought-tolerant varieties (Sukhkhadhan-3 and Sukhkhadhan-6) with 5 fertilizer levels as sub-plot (0:30:30 $N:P_2O_5:K_2O$ kg/ha, 30:30:30 $N:P_2O_5:K_2O$ kg/ha, 60:30:30 $N:P_2O_5:K_2O$ kg/ha, 90:30:30 $N:P_2O_5:K_2O$ kg/ha and 120:30:30 $N:P_2O_5:K_2O$ kg/ha). Nitrogen was provided through urea and DAP, Phosphorus was applied through DAP and the source of potassium as MOP. The full dose of phosphorus and potassium and half dose of N was applied at the time of land preparation. The remaining half dose of N was applied in two splits.

Seed preparation and sowing

The seed was pre-soaked for 24 hours and incubated for 36 hours before seeding. The same pre-germinated seeds were sown in continuous lines with the row spacing of 25cm on the first week of July 2016 and 2017 respectively. The land was well prepared by 2-3 tillage and well leveled. The treatments sub-plot size was 10 m^2 and seed rate of 40 kg seed/ha was used.

Weed control

All intercultural operations such as weed control and irrigation were applied as needed. Pendimethalin @ 1000 ml a.i /ha was applied to control grasses and sedges in the initial stages of crop followed by one hand weeding and bispyribac sodium salt 20 a.i. g/ha were applied after one month of planting in all the treatments.

Data recording

During the experimentation, the data were recorded in such a way as average plant height was measured from the base of the stem up to the longest panicle tip in randomly selected 10 hills in each plot. To determine the effective tillers/m^2, only the panicle bearing tillers were counted from the 4th sample hills and its average was expressed in tillers or panicle m^{-2}. Days to flowering were determined when 50% of the hills in each plot had reached anthesis. Days to maturity were determined when 80% of the hills in each treatment were matured. Panicles after maturity were hand-threshed and the filled and unfilled grains were separated. Total numbers of filled grains and empty grains per panicle were counted and expressed in grain filling %. Grain and straw yields were determined from the harvested area of 1 m^2 marked in the middle of each sub-plot to avoid the border effect in each plot. Grain samples were harvested, dried and adjusted to a moisture content of 14% for determining thousand grain weight (TGW) and yield. The straw was sun dried, weighed and expressed in t/ha.

Data analysis

The data collected were analyzed using STAR software and compared among the different treatments. Treatment means were compared using the least significant difference (LSD) tests and compared at $p \leq 0.05$ level of significance.

Results and Discussions

Climatic condition during experimentation

In two consecutive years, the monsoon started from May to September, but the rainfall pattern was unevenly distributed in 2017 with lower rainfall (1899.2 mm) as compared to 2016 (2262.40 mm) within the entire experimentation (from May to October). The rainfall highly fluctuated in August and September in both years but in 2016, the highest rainfall recorded was 590.5 mm which was quite similar to June (589 mm). In the case of 2017, the highest rainfall was recorded as 918.2 mm in August, which was higher than in other months. This intense rainfall did not damage the crop because it already attained panicle initial stage (90 days after sowing) that favored growth and development of the crop. However, late rainfall in 2016 did not favor the proper germination of the crop so the optimum population wasn't obtained. Similarly, the maximum temperature ranged from 31.03 to 33.59 °C and minimum temperature from 21.32 to 25.75°C during the crop growing season in the year 2016 (Figure 1 and 2) but the maximum temperature ranged slightly higher (32.8 to 34.3°C) in 2017. In both years, the maximum temperature reached above 34°C in August or September and the minimum was recorded below 22°C in October.

Table 1. Growth parameters influenced due to different dose of fertilizer and varieties for DSR at Regional Agricultural Research Station Tarahara, Sunsari, Nepal during wet season 2016 and 2017

Treatments	Plant height (cm)		Panicle length (cm)		Panicle no. /m^2	
	2016	2017	2016	2017	2016	2017
Variety						
Sukhkhadhan 3	103.61^{b}	100.9	22.27	22.8	205.46	257.7
Sukhkhadhan 6	115.00^{a}	110.8	23.05	23.0	208.66	234.7
LSD (P<0.05)	6.12	ns	ns	ns	ns	ns
Fertilizer ($N:P_2O_5:K_2O$ kg/ha)						
0:30:30	105.26^{b}	98.0^{c}	21.99^{b}	21.1^{c}	202.16	214.2^{b}
30:30:30	105.26^{b}	105.0^{b}	22.31^{ab}	22.3^{bc}	210.50	238.0^{ab}
60:30:30	107.96^{ab}	106.2^{ab}	22.39^{ab}	22.9^{abc}	220.83	245.8^{ab}
90:30:30	110.03^{ab}	108.7^{ab}	22.82^{ab}	23.6^{ab}	200.83	261.5^{a}
120:30:30	117.76^{a}	111.2^{a}	23.79^{a}	24.6^{a}	201.00	271.7^{a}
LSD (P<0.05)	9.68	5.54	1.41	1.9	ns	31.9
CV, %	0.85	4.28	5.07	6.89	22.26	10.59

Note: *Treatment means followed by same letter(s) in the column are not significantly different among each other based on DMRT at 0.05. ns= non-significant*

Table 1 showed that the plant height and number of panicle length were significantly higher with the increasing dose of fertilizers in both consecutive years. The plant height was highest (117.8 cm) with the application of 120:30:30 $N:P_2O_5:K_2O$ kg/ha which was at par with 90:30:30 and 60:30:30 $N:P_2O_5:K_2O$ kg/ha on both consecutive years. Likewise, the panicle number per meter square and panicle length were recorded as 271.7 and 24.6 with the application of 120:30:30 $N:P_2O_5:K_2O$ kg/ha which was statistically at par with the application of 90:30:30 $N:P_2O_5:K_2O$ kg/ha. Similar results were also obtained by Singh *et al.,* (2014); Mahajan and Timsina (2011); Gala *et al.,* (2011) and Dongarwar *et al.,* (2015) who reported that the increasing amount of nitrogen considerably improves the vegetative growth of rice. Furthermore, the panicle per meter square was non-significant with the increasing dose of nitrogen fertilizer. It might be due to the lodging of the crop at a later stage. Similar findings reported by Lacerda *et al.,* (2016) because nitrogen can make plants more susceptible to lodging. Likewise, the plant height, panicle per meter square and panicle length were non-significant among the varieties but the plant height of Sukhkhadhan-6 was around 12 cm higher than Sukhkhadhan-3 in both years.

Table 2. Growth parameters influenced due to different dose of fertilizer and varieties for DSR at Regional Agricultural Research Station Tarahara, Sunsari, Nepal during wet season 2016 and 2017

Treatments	Filled grains panicle		Grain filling %		TGW (g)	
	2016	2017	2016	2017	2016	2017
Variety						
Sukhkhadhan 3	87.42^{a}	77.7	89.99^{a}	87.9	21.76	21.9^{b}
Sukhkhadhan 6	75.98^{b}	82.9	77.57^{b}	84.7	24.24	24.1^{a}
LSD (P<0.05)	9.925	ns	3.885	ns	ns	0.96
Fertilizer ($N:P_2O_5:K_2O$ kg/ha)						
0:30:30	70.80^{c}	69.6	83.83	85.5	22.61	22.4
30:30:30	77.96^{bc}	78.4	84.14	85.8	22.73	22.8
60:30:30	79.63^{b}	79.9	82.51	85.9	22.97	23.2
90:30:30	81.36^{b}	86.6	82.35	86.5	22.29	23.2
120:30:30	98.76^{a}	86.9	86.08	87.7	24.40	23.4
LSD (P<0.05)	15.69	ns	ns	ns	ns	ns
CV, %	15.74	16.24	5.99	3.29	26.78	2.57

Note: *Treatment means followed by same letter(s) in the column are not significantly different among each other based on DMRT at 0.05. ns= non-significant*

Grain filling percentage and thousand grain weights were non-significantly differed among the doses of fertilizers; however, all these were significant among the varieties. The filled grain was significantly higher by 15.5 and 16.0 % in Sukhkhadhan 3 in the first year but non-significant in the second year. Likewise, the thousand grain weight was significantly higher by 10.0 % in Sukhkhadhan 6 for the second year but non-significant in the first year.

Table 3. Growth parameters influenced due to different doses of fertilizer and varieties for DSR at Regional Agricultural Research Station Tarahara, Sunsari, Nepal during wet season 2016 and 2017

	Straw yield (t/ha)		Harvest index (HI)		Grain yield (t/ha)		
Variety	2016	2017	2016	2017	2016	2017	Pooled
Sukhkhadhan	4.92^{b}	5.87	0.385	0.41^{a}	2.96	3.96	3.46
Sukhkhadhan	7.84^{a}	7.57	0.291	0.33^{b}	3.14	3.61	3.38
LSD (P<0.05)	1.09	ns	0.042	0.07	ns	ns	ns
Fertilizer ($N:P_2O_5:K_2O$ kg/ha)							
0:30:30	5.64^{b}	5.71^{c}	0.330	0.34	2.57^{d}	2.76^{d}	2.66^{d}
30:30:30	5.77^{b}	6.45^{b}	0.336	0.36	2.59^{c}	3.47^{c}	3.03^{cd}
60:30:30	6.06^{ab}	6.74^{ab}	0.363	0.36	3.24^{b}	3.65^{bc}	3.44^{bc}
90:30:30	6.79^{ab}	7.24^{a}	0.343	0.38	3.37^{ab}	4.29^{ab}	3.83^{ab}
120:30:30	7.65^{a}	7.44^{a}	0.321	0.40	3.47^{a}	4.77^{a}	4.12^{a}
LSD (P<0.05)	1.72	0.63	ns	ns	0.691	0.70	0.47
CV,%	22.01	8.43	15.10	12.85	18.50	15.07	16.58

Note: *Treatment means followed by same letter(s) in the column are not significantly different among each other based on DMRT at 0.05. ns= non-significant*

The grain yield and straw yield significantly differed due to the nitrogen level but the harvest index was non-significant among the treatments on both consecutive years. The pooled data analysis showed that the higher grain yield (4.12 t/ha) was recorded by the application of 120:30:30 $N:P_2O_5:K_2O$ kg/ha which was statistically at par with the application of 90:30:30 $N:P_2O_5:K_2O$ kg/ha (3.83 t/ha). Similarly, the straw yield was also recorded higher (7.65 and 7.44 t/ha) by the application of 120:30:30 N: $P_2O_5:K_2O$ kg/ha which was statistically at par with the application of 90:30:30 N: $P_2O_5:K_2O$ kg/ha (6.79 &7.24 t/ha) respectively. Similar results were also obtained by Sharma *et al.* (2007) who reported that application of 120 N kg/ha gave significantly higher grain and straw yields over 40 N kg/ha. Similarly, the application of 120 N kg/ha significantly increased the grain yield of rice as compared to the lower (60 N kg/ha) and higher doses (180 N kg/ha) (Xiang-long *et al.*, 2007 and Huang *et al.*, 2008). However, the grain yield and straw yield were non-significant among the varieties in both consecutive years. But the harvest index was significantly higher by 21.2 % in Sukhkhadhan-3 over the Sukhkhadhan-6 during 2017.

Conclusion

The application of 120:30:30 and 90:30:30 $N:P_2O_5:K_2O$ kg/ha performed similarly but comparatively 120:30:30 $N:P_2O_5:K_2O$ kg/ha had higher plant height, more effective tillers per meter square, thousand grains weight, panicle weight, panicle length and grain yield under the direct-seeded condition in both years.

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