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Nitrogen management on weed growth and yield of *aus* rice cultivars

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ABSTRACT

In this regard, to evaluate the effect of nitrogen management on weed growth and yield of aus rice cultivars an experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period May to August 2019. Three rice cultivars, namely Binadhan-19, BRRI dhan48, and Mulagburu, were used in the experiment, each with five nitrogen levels such as no nitrogen (control), 50% of recommended dose (RD) of nitrogen (30 kg ha^{-1}), 100% of RD of nitrogen (60 kg ha^{-1}), 150% of RD of nitrogen (90 kg ha^{-1}) and application of urea super granule. A randomized complete block design (RCBD) with three replications was used to set up the experiment. BRRI dhan48, had the most weed development, whereas a minimum amount of weed infestation was seen in Binadhan-19. With rising nitrogen levels, weed infestation grew more severe, reaching its peak after USG treatment. Mulagburu and BRRI dhan48 demonstrated the highest weed density and dry weight, respectively, when USG was applied to these varieties. Binadhan-19, on the other hand, displayed the least amount of weed density and dry weight after receiving the control treatment. Both the cultivars and nitrogen management practices had significant impact on all the yield contributing characters and yield of aus rice. Mulagburu, scored better in terms of yield and yield-contributing traits. The best results for almost all parameters especially for grain yield were shown when 150% of the recommended dose of nitrogen (90 kg ha^{-1}) was applied and significant variations were seen for almost all attributes. In the interaction scenario, with the application of 150% of RD of nitrogen (90 kg ha^{-1}), the Mulagburu variety produced the maximum grain yield. Considering all of the facts, it might be adviseable to cultivate the Mulagburu variety in the aus season with 150% of RD nitrogen (90 kg ha^{-1}) to obtain higher grain yield.

Key words: *aus* rice, nitrogen management, weed biomass, grain yield

INTRODUCTION

Rice production plays a vital role in the economy of Bangladesh providing significant contribution to the GDP, employment generation and food availability. The suitability of agro-climatic conditions of Bangladesh for growing rice make it possible to cultivate rice year-round. Bangladesh is now producing 37.61 million tons of rice in total, of which 52.8 % was *boro* rice, 38.4 percent was *aman* rice, and 8.8 percent was *aus* rice (BBS, 2021). About 11.15%, 47.93% and 40.91% of total cropped area are occupied by *aus, aman* and *boro* rice, respectively (BBS, 2021). Both area and yield of *aus* rice are very low compared with other two seasons.

Local *aus* rice is the only source of cash income for many farmers throughout the country except in the south eastern hilly areas. Research works reported earlier emphasized little on the response of the old varieties to management practices. Nowadays several high yielding *aus* rice varieties have been released. The newly innovated paddy variety has opened up a door of enormous prospects for food security.

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Though the climate and soil of Bangladesh are favorable for year-round rice production, but maintaining an increased production of rice will be a challenge especially in the context of decreasing of cultivable rice land with increasing population. Under this situation along with improved cultural management, the use of balanced fertilizer is one of the most important ways for increased crop productivity. Fertilizer is now one of the expensive inputs for crop production in Bangladesh. Among various fertilizers, nitrogenous fertilizer has the strongest influence on the growth and yield of rice. Almost all the soils of Bangladesh are low in organic matter and nitrogen. Among many factors, deficiency of nitrogen element is now considered as major reason for comparatively low yield of rice in Bangladesh. At present the farmers of Bangladesh use increased amount of nitrogen fertilizer to get higher yield. On the other hand, plant growth is seriously hampered when lower dose of nitrogen is applied, which drastically reduce the crop yield (Adhikari *et al.,* 2018). Therefore, it is very much essential to find out optimum level of nitrogenous fertilizer for efficient utilization of nitrogen by the crop plants for reaching maximum production with minimum cost.

There is no doubt that maximum benefit from costly inputs like fertilizer and pesticides in rice can fully be derived when the crop is kept free from weed infestation. In Bangladesh, substantial yield reduction of rice is occurred due to weed infestation and it is estimated that weed infestation reduces the grain by 70-80% in *aus* rice, 30-40% in transplanted *aman* rice and 22-36% in *boro* rice cultivars (Mamun, 1990). Weed infestation is high in *aus* rice field. However, both weed and rice plants compete for nitrogen and in a weed infested field weeds uptake nitrogen more rapidly than rice plant, particularly at high nitrogen levels. It was found that, growth and seed production of *E. crus-galli* increased with increase in nitrogen rate resulting lesser nitrogen availability to the rice plants (Chauhan and Abugho, 2013). Therefore, proper nitrogen management is a key factor for evaluating the effect of nitrogen on weed infestation behavior as well as growth and productivity of *aus* rice. Selection of appropriate amount of nitrogen and the interaction of nitrogen and cultivars may also help in yield improvement by reducing weed infestation. So, efforts and clarification are required to formulate suitable nitrogen management for particular varieties in order to optimize the yield with minimum weed infestation. Therefore, this study was conducted to evaluate the effect of nitrogen management on weed growth and yield performance of *aus* rice.

MATERIALS AND METHODS

Experimental duration and site

The trial was carried out for a period May to August 2019 at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh. The experimental area is located at latitude 24°42′55″N, longitude 90°25′47″E and 19 m above mean sea level having sub-tropical climate characterized by high temperature, high humidity and heavy precipitation during the month from April to September (Kharif season) and scanty precipitation associated with moderately low temperature during the period October to March (Rabi season). The Sonatola soil series of non-calcareous dark grey floodplain soil in the Old Brahmaputra Floodplain (AEZ-9) makes up the soil in the area. The majority of the soils in this series are silty loam, which is dark gray in color, has a pH of 6.8, is poor in organic matter, and has a low degree of overall fertility.

Experimental treatments

The trial included three rice varieties, Binadhan-19, BRRI dhan48, and Mulagburu, as well as five nitrogen levels such as no nitrogen (Control), 50% of recommended dose of nitrogen (30 kg ha^{-1}) (N_1), 100% of recommended dose of nitrogen (60 kg ha^{-1}) (N_2), 150% of recommended dose of nitrogen (90 kg ha^{-1}) (N_3) and application of urea super granule (N_4) @ 1.8 g per 4 hills.

Experimental design and layout

Three replications of the experiment were set up using a randomized complete block design (RCBD). There were total 45(3 x 5 x 3) plots, each measuring 3m x 2m. The distance between plot to plot and replication to replication was 0.75 m and 0.5 m, respectively.

Crop husbandry

The seeds of the *aus* rice varieties, Binadhan-19, BRRI dhan48, and Mulagburu, were procured from BINA, BRRI, and the BAU Genetics and Plant Breeding Field Laboratory. The varieties selected in this experiment were high yielding. Healthy seeds were selected by specific gravity and immersed in water in a bucket for 24 hours. Then the seeds were taken and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours in the nursery bed. Puddling, followed by repeated ploughing and laddering, were used to prepare the seedbed. Whenever it was required, the bed received gentle watering and weeds were removed. No fertilizer was used in the nursery bed. In the first week of May 2019, the experiment's plot was opened using a power tiller and left in the sun for a week. The land was harrowed, ploughed, then cross ploughed many times after one week, then laddered to get a good tilth. A desirable tilth was ultimately achieved for transplanting after weeds and stubbles were cleared. The following fertilizer dose was used in the experimental field as recommended dose: TSP- 90, MoP- 70, gypsum- 60 and zinc sulphate- 10 kg ha^{-1}. Urea as a source of nitrogen was applied as per experimental treatments. Whole amount of TSP, MoP, gypsum and zinc sulphate along with one third (1/3) amount of urea as per treatment was applied as basal dose during final land preparation. Rest amount of urea (1/3+ 1/3) were applied in two installments as top dressing at 20 and 35 days after transplanting (DAT) respectively. Urea super granules (weight 1.8 g per granule) were applied for every four hills at 10 DAT. USG were placed 10 cm below surface using urea super granule placement stick. The nursery bed was made wet by the application of water one day before uprooting of seedlings. The seedlings were uprooted on 18 May 2019 without causing much mechanical injury to the roots and they were immediately transferred to the main field. Transplanting was done with 25 days old seedlings on 18 May 2019. Seedlings were transplanted in lines following line to line distance of 20 cm and hill to hill distance of 15 cm. Irrigation was given in each plot as per requirements. The field was finally dried out 15 days before harvesting. Gap filling was done for all of the plots at 10 days after transplanting (DAT) with the same ages of seedlings from the same source. Plants were infested with rice stem borer and rice hispa to some extent which was successfully controlled by applying Diazinon (60 EC) at tillering and before panicle initiation stage.

The crop was harvested at full maturity. Maturity of crops was determined when 90% of the grains became golden yellow in color. The rice of all the three cultivars was harvested depending upon the maturity of the crop and each plot was harvested manually on 12 August 2019.

Data collection

Weed density was calculated with the help of a quadrate of size 25 cm^2. The quadrate was placed randomly in each plot and the weeds inside the quadrate was counted by species and then converted to number m^{-2}. After counting the weed density, the weeds inside each quadrate were uprooted and cleaned. To determine dry matter the sample weeds were first air dried for 6-8 hours. Then the weed samples were packed in labelled brown paper bag and dried in the oven at 80 °C for 72 hrs until constant weight was reached. After oven drying, the weed samples were weighed by using electric balance. Five hills (excluding border rows and central 1 m^2 area) were randomly selected from each plot and uprooted manually from the ground level for recording yield contributing data of aus rice such as plant height (cm), number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, length of panicle (cm), number of sterile spikelets $panicle^{-1}$, number of grains $panicle^{-1}$ and 1000-grain weight (g). After sampling the whole plot was harvested. After sampling for recording grain and straw yield per plot, crops of central $1m^2$ (1m × 1m) were harvested. Then the harvested crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. The grains were cleaned and dried to a moisture content of 14%. Straws were sun dried properly. Final grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}.

Statistical analysis

Data concerning weed growth, yield and yield contributing characters of *aus* rice were compiled and tabulated in proper form for statistical analyses. Analysis of variance was done with the help of MSTAT-C computer package program. The mean differences among the treatments were adjudged by Duncan Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Weed species infested in the experimental plots

Eleven weed species belonging to four families infested the experimental field. Among the 11 species of weeds five of them were grasses, two of them were broad leaves and four of them were sedges. The important weeds of the experimental plots were *Echinochloa crus-galli* (L.) P. Beauv., *Panicum repens* L., *Cyperus rotundus* L., *Leersia hexandra* Sw., *Cynodon dactylon* (L.) Pers., *Monochoria vaginalis* (Sw.) Willd., *Cyperus difformis* L., *Scirpus juncoides* Roxb., *Eichhornia crassipes* and *Digitaria sanguinalis* (L.) Scop. Local name, scientific name, family, morphological type and life cycle of the weed in the experimental plot have been presented in Table 1. Bari *et al.* (1995) noted a greater range of variability in the case of weed infestation in *aus* rice at various transplanting dates. They saw that there were 28 species of weeds in the field, of which 15 were annuals and 13 were perennials. Rahman *et al.* (2007) reported that important weed species that infested *aus* rice were Angta (*Panicum repens* L.), Durba (*Cynodon dactylon* L.), Shusnishak (*Marsilea crenata* C.) and Panilong (*Ludwigin prostrata* Roxb.).

Table 1. Infested weed species in the experimental plots

SL No.	Local name	Scientific name	Family	Morphology type	Life cycle
1	Shama	*Echinochloa crus-galli* (L.) P. Beauv.	Poaceae	Grass	Annual
2	Mutha	*Cyperus rotundus* L.	Cyperaceae	Sedge	Perennial
3	Angta	*Panicum repens* L.	Poaceae	Grass	Perennial
4	Chesra	*Scirpus juncoides* Roxb.	Cyperaceae	Sedge	Perennial
5	Durba	*Cynodon dactylon* (L.) Pers.	Poaceae	Grass	Perennial
6	Shuhni	*Marsile aquadrifolia* L.	Marsiliaceae	Broadleaf	Perennial
7	Joina	*Fimbristylis miliacea* (L.) Vahl.	Cyperaceae	Sedge	Annual
8	Sabujnakful	*Cyperus deformis* L.	Cyperaceae	Sedge	Annual
9	Angulighas	*Digitaria sanguinalis* (L.) Scop.	Poaceae	Grass	Annual
10	Panikachu	*Monocghoria vaginalis* (Sw.) Willd.	Pontederiaceae	Broadleaf	Perennial
11	Arail	*Leersia hexandra* Sw.	Poaceae	Grass	Perennial

Effect of cultivar on weed density and weed dry weight

The varietal effect had non-significant effect on weed density and dry weight. Numerically, the highest weed density (28.00 m^{-2}) was documented in BRRI dhan48 which was near identical to Mulagburu (26.33 m^{-2}) while the lowest weed density (24.73 m^{-2}) was found in Binadhan-19 (Figure 1). In BRRI dhan48, the weed dry weight was determined to be the greatest (3.18 g m^{-2}), and in Binadhan-19 the lowest (2.87 g m^{-2}) (Figure 2). The variety Binadhan-19 might have allelopathic effect which inhibited the germination and growth of weed seedlings and ultimately reduced weed dry weight (Alam *et al.,* 2018).

Effect of nitrogen management on weed density and dry weight

Weed density was significantly affected by different nitrogen management. The highest weed density (30.89 m^{-2}) was found with the application of USG which was statistically identical to 150% nitrogen of recommended dose (90 kg ha^{-1}) (29.78 m^{-2}). The lowest weed density (21.44 m^{-2}) was found in control treatment (Figure 3). It might be because there was less nitrogen available to the weeds in the control area where the lowest weed density was found. In a similar way, N_4 (application of urea super granules) treatment had the largest weed dry weight (3.65 g m^{-2}), and it was statistically equivalent to N_3 (150% of RD of nitrogen) (90 kg ha^{-1}) (3.40 g m^{-2}). Whilst, in N_0 (no nitrogen), the lowest weed dry weight (2.31 g m^{-2}) was discovered (Figure 4). Due to variations in nitrogen management, Nandan *et al.* (2018) also noted variation in weed dry weight. Nitrogenous fertilizer affects weed management and where nitrogenous fertilizer is applied, weed absorbs more nutrients than rice and competitive ability of weed becomes more than rice. In the present study, weeds in control (no nitrogen) plots got less nitrogen to absorb and weed dry weight was the lowest in control plots.

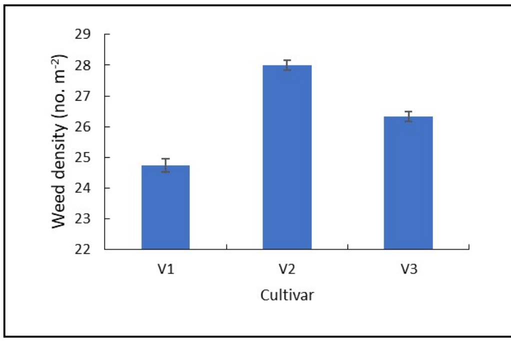

Figure 1. Effect of variety on weed density. Here, V1 = Binadhan-19, V2 = BRRI dhan48, V3 = Mulagburu

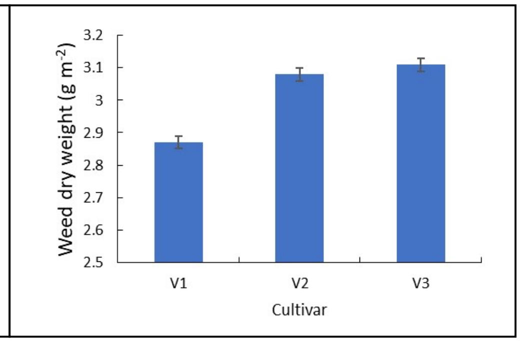

Figure 2. Effect of variety on weed dry weight. Here, V1 = Binadhan-19, V2 = BRRI dhan48, V3 = Mulagburu

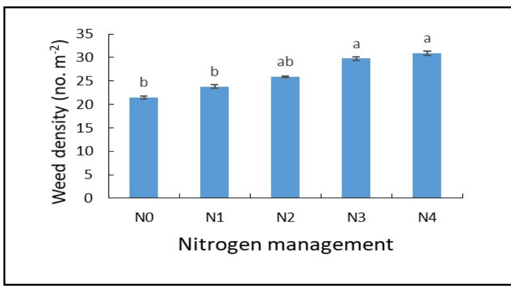

Figure 3. Effect of nitrogen management on weed density, Here, N0 = No nitrogen (Control), N1= 50% of RD of nitrogen (30 kg ha-1), N2 = 100% of RD of nitrogen (60 kg ha-1), N3 = 150% of RD of nitrogen (90 kg ha-1) and N4 = Application of urea super granule @ 1.8 g per 4 hills; Bars indicate standard error (±SE); Same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly

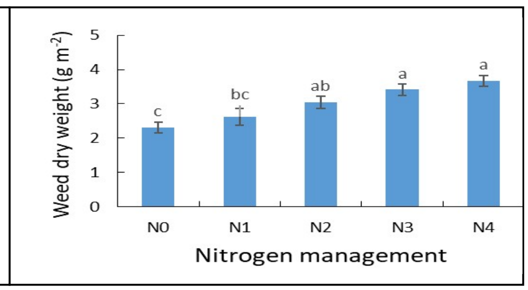

Figure 4. Effect of nitrogen management on weed dry weight, Here, N_0 = No nitrogen (Control), N_1= 50% of RD of nitrogen (30 kg ha^{-1}), N_2 = 100% of RD of nitrogen (60 kg ha^{-1}), N_3 = 150% of RD of nitrogen (90 kg ha^{-1}) and N_4 = Application of urea super granule @ 1.8 g per 4 hills; Bars indicate standard error (±SE); Same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly

Interaction effect of cultivar and nitrogen management on weed density and dry weight

Cultivars and various nitrogen management strategies had no discernible impact on weed density and dry weight. Numerically, the highest weed density (33.00 m^{-2}) was found from V_2N_4 (application of urea super granule with BRRI dhan48) and the lowest weed density (20.667 m^{-2}) was found from V_1N_0 (no nitrogen on Binadhan-19) and V_3N_0 (no nitrogen on Mulagburu) (Figure 5). The highest weed dry weight (g m^{-2}) (3.84 g m^{-2}) was observed in V_3N_4 (application of urea super granule on Mulagburu) while the lowest weed dry weight (2.277 g m^{-2}) was noticed in V_3N_0 (no nitrogen on Mulagburu) (Figure 6). Nitrogenous fertilizer affects weed management and where nitrogenous fertilizer is applied, weed absorbs more nutrients than rice and competitive ability of weed becomes more than rice. In the present study, control (no nitrogen) plots' weed got less nitrogen to absorb and weed dry weight was the lowest in these plots. On the other hand, tall stature plant exerts higher competitive ability to suppress weed (Dimaano *et al.,* 2017). Probably for this reason Mulagburu rice variety with no nitrogen applied plots had lowest weed dry weight.

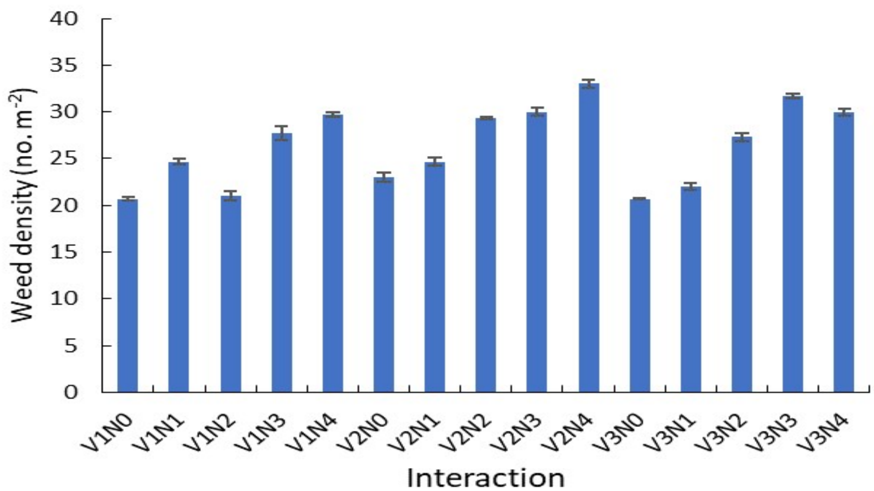

Figure 5. Weed density (number m^{-2}) as influenced by interaction effect of cultivar and level of nitrogen
V1 = Binadhan-19, V2 = BRRI dhan48, V3 = Mulagburu

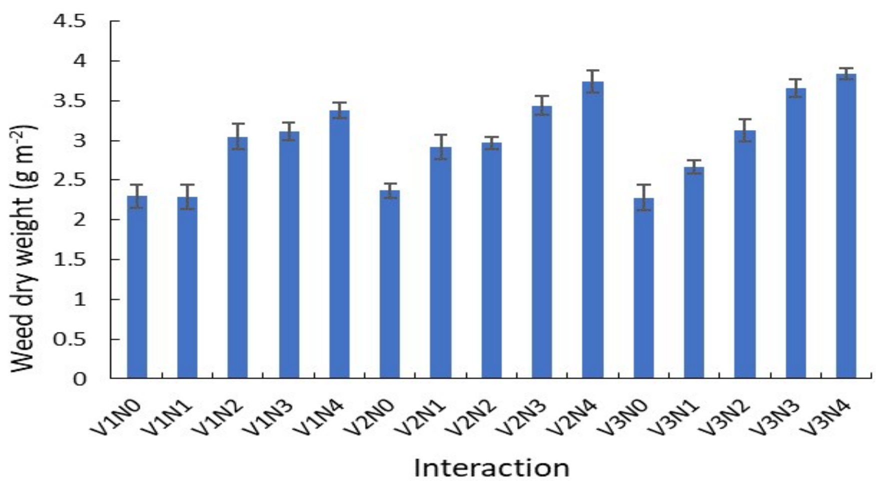

Figure 6. Weed dry weight (g m^{-2}) as influenced by interaction effect of cultivar and level of nitrogen
V_1 = Binadhan-19, V_2 = BRRI dhan48, V_3 = Mulagburu
N_0 = No nitrogen (Control), N_1= 50% of RD of nitrogen (30 kg ha^{-1}), N_2 = 100% of RD of nitrogen (60 kg ha^{-1}), N_3 = 150% of RD of nitrogen (90 kg ha^{-1}) and N_4 = Application of urea super granule @ 1.8 g per 4 hills; Bars indicate standard error (±SE)

Table 2. Effect of cultivar on the yield and yield components of *aus* rice

Cultivar	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains Panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
Binadhan-19	73.07b*	8.80b	6.73b	18.4b	59.07b	14.33c	22.58c	2.24b	3.07b	41.91
BRRI dhan48	73.93b	9.26ab	7.20b	17.73b	54.53b	18.13b	24.50a	2.05b	2.76b	42.55
Mulagburu	91.60a	10.07a	8.25a	22.93a	110.10a	21.13a	23.55b	2.89a	3.80a	42.96
Level of significance	0.001	0.014	0.001	0.001	0.001	0.001	0.001	0.001	0.001	NS
CV (%)	4.92	11.88	14.40	6.82	10.72	6.79	0.80	21.72	19.67	9.26

*In a column, figure with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)

Effect of cultivar on the yield and yield components of *aus* rice

With the exception of harvest index, all yield and yield contributing variables considerably varied due to varietal influence (Table 2). The Mulagburu plant had the greatest plant height (73.93 cm) which was statistically distinct from the other two varieties. The study's findings about variation in plant height may be related to the genetic variations among the varieties. This outcome is in line with the findings of Alam *et al.* (2012), who also stated that the cultivars had varying plant height. The maximum number of total tillers hill^{-1} (10.07) was identified in Mulagburu, which was statistically close to BRRI dhan48 (9.26), while the lowest (8.8) was discovered in Binadhan-19. For the production of rice, tillering is a crucial quality (Badshah *et al.,* 2014). Mahamud *et al.* (2013) observed that the number of total tillers hill^{-1} differed amongst the varieties. Mulagburu likewise provided the largest number of effective tillers hill^{-1} (8.25), whereas Binadhan-19 provided the lowest number (6.73). Chamely *et al.* (2015) also discovered differences in the number of effective tillers hill^{-1} across the varieties. The genetic diversity of the variety, which may be modified by inheritance, may be the cause of the variances in generating effective tillers hill^{-1}. The Mulagburu variety in this case produced the longest panicle (22.93 cm), which was statistically different from the other two varieties, Binadhan-19 (18.4 cm) and BRRI dhan48 (17.73 cm). The genetic composition of the many types may be the cause of this. From Mulagburu, the greatest number of grain panicle^{-1} was found (110.10). The BRRI dhan48, which was statistically equivalent to Binadhan-19 (59.07), yielded the fewest grains panicle^{-1} (54.53). According to BRRI (1994), variety had a substantial impact on the quantity of grains panicle^{-1}, which is mostly determined by heredity. Similar results were also reported in several rice varieties by Pooniya *et al.* (2012). The highest number of sterile spikelets panicle^{-1} (21.13) was obtained from Mulagburu whereas the lowest (14.33) was obtained from Binadhan-19. Alam (2013) stated that number of sterile spikelets panicle^{-1} showed significant relation with varieties. The maximum 1000-grain weight (24.50 g) was identified in BRRI dhan48, and the lowest (22.58 g) was discovered in Binadhan-19. Roy *et al.* (2014) found variations in 1000-grain weight due to morphological and varietal diversity. Impa *et al.* (2013) conducted an experiment and noted that the weight of 1000-grain differed with the cultivars. In terms of grain yield, Mulagburu produced the maximum amount (2.89 t ha^{-1}), while BRRI dhan48 produced the least amount (2.05 t ha^{-1}). These fluctuations were in line with Mohammad *et al.* (2014), who asserted that variations in grain yield might result from changes in the genetic composition of the cultivars. The highest straw yield (3.80 t ha^{-1}) was obtained from Mulagburu. The lowest straw yield (2.76 t ha^{-1}) was obtained from BRRI dhan48 and it was significantly identical to Binadhan-19 (3.07 t ha^{-1}) (Table 2). Variation in straw yield was also reported by Gawali *et al.* (2015) and this was might be due to genetic heredity of the cultivars.

Table 3. Effect of level of nitrogen on the yield and yield components of *aus* rice

Level of N	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains Panicle^{-1} (cm)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
N_0	75.44c*	8.11d	5.77c	18.67b	65.67b	15.44c	23.42b	1.68c	2.43c	40.82
N_1	77.67bc	8.66cd	6.77b	19.33ab	76.56a	18.78ab	23.59ab	2.13bc	2.93bc	42.16
N_2	79.44ab	9.22bc	7.64b	19.89a	77.89a	19.11a	23.71a	2.53ab	3.39ab	42.35
N_3	82.67a	11.11a	9.22a	20.22a	75.56a	18.22ab	23.52b	2.97a	3.75a	44.32
N_4	82.44a	9.77b	7.55b	20.33a	77.11a	17.78b	23.47b	2.66a	3.56ab	42.72
Level of sig.	0.001	0.001	0.001	NS	0.017	0.001	0.02	0.001	0.001	NS
CV (%)	4.92	11.88	14.40	6.82	10.72	6.79	0.80	21.72	19.67	9.26

*In a column, figure with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); NS = Not significant

N_0 = No nitrogen (Control), N_1= 50% of RD of nitrogen (30 kg ha^{-1}), N_2 = 100% of RD of nitrogen (60 kg ha^{-1}), N_3 = 150% of RD of nitrogen (90 kg ha^{-1}) and N_4 = Application of Urea Super Granule @ 1.8 g per 4 hills

Effect of nitrogen management on the yield and yield components of *aus* rice

Significant variation was noticed in all the yield parameters due to different nitrogen management except panicle length and harvest index (Table 3). The tallest plant (82.67 cm) was obtained from N_3 (150% of recommended dose of nitrogen) (90 kg ha^{-1}) whereas the shortest plant (75.44 cm) was obtained from N_0 (no nitrogen). Nitrogen fertilizer boosts plant development, lengthens internodes, and increases their number, all of which contribute to a progressive increase in plant height that is why it makes plants grow taller. Additionally, Malik *et al.* (2014) found that nitrogen management had a favorable impact on plant height. The nitrogen source that produced the most total tillers hill^{-1} (11.11) was N_3 (150% nitrogen of the required dose) (90 kg ha^{-1}), while the nitrogen source that produced the least (1.11%) was N_0 (on nitrogen). The number of total tillers hill^{-1} increased as a result of nitrogen management, according to Salem *et al.* (2011). The N_3 (150% nitrogen of recommended dose) (90 kg ha^{-1}) yielded the maximum number of effective tillers hill^{-1} (9.22), whereas the N_0 (no nitrogen) yielded the lowest (5.77). Adequacy of nitrogen from nitrogen fertilizer probably favored the cellular activity during tiller formation and development, which led to increased number of effective tillers hill^{-1}. Ahmed *et al.* (2005) also reported that number of effective tillers hill^{-1} increased with the better management of nitrogen. Increased N absorption had great role in increasing number of tillers (Yoshida *et al.,* 1972). The highest number of grains panicle^{-1} (75.56) was obtained from N_3 (150% of RD of nitrogen (90 kg ha^{-1}) and the lowest (65.67) was found in control treatment. Hossain *et al*. (2010) reported variation in number of grains panicle^{-1} due to different nitrogen management. In terms of the number of sterile spikelets panicle^{-1}, N_2 (100% of RD of nitrogen) (60 kg ha^{-1}) produced the maximum number (19.11), while N_0 (no nitrogen) produced the lowest number (15.44). The maximum 1000-grain weight (23.71 g) was produced by N_2 (100% of RD of nitrogen) (60 kg ha^{-1}), which was statistically equivalent to N_1 (50% of RD of nitrogen) (30 kg ha^{-1}). This possibly happened due to the uptake of N by root of the rice plant that influenced the photosynthesis process and subsequently storage of starch in sink cell such as grain (Sarker *et al*., 2020). Hossain and Islam (2008) also reported the variation in 1000-grain weight due to the more availability of N in soil. Chaturvedi (2005) observed that N play important role in increasing protein percentage, which in turn increased the grain weight.

The maximum grain yield (2.97 t ha^{-1}) was achieved from N_3 (150% nitrogen of recommended dosage) (90 kg ha^{-1}), which was identical to N_4 (application of USG) (2.66 t ha^{-1}) while the lowest grain yield (1.68 t ha^{-1}) was discovered in the control treatment. The highest grain yield was obtained from 150% of recommended dose of nitrogen due to highest number of total and effective tillers $hill^{-1}$, longest panicle and highest number of grains $panicle^{-1}$ in this treatment. Similar results were found elsewhere (Qurashi *et al*., 2013). The highest straw yield (3.75 t ha^{-1}) was also obtained from N_3 (150% nitrogen of recommended dose) (90 kg ha^{-1}) which was near identical to N_4 (application of USG) (3.56 t ha^{-1}) and N_2 (application of 100% of RD of N) (3.39 t ha^{-1}). The lowest straw yield (2.43 t ha^{-1}) was obtained from N_0 (no nitrogen) (Table 3). Nitrogen fertilization induced rice plant vegetative growth in terms of plant height and total tillers $hill^{-1}$, which ultimately led to an increase in straw yield (Mishra *et al*., 2003).

Interaction effect of cultivar and nitrogen management on the yield and yield components of *aus* rice

Except for sterile spikelets $panicle^{-1}$, none of the yield and yield-contributing traits were significantly affected by the interaction between variety and nitrogen management. Numerically the highest number of effective tillers $hill^{-1}$ (8.00) was obtained from V_1N_3 (application of 150% nitrogen of recommended dose (90 kg ha^{-1}) on Binadhan-19) and V_1N_4 (application of USG on Binadhan-19) and the lowest number of effective tillers $hill^{-1}$ (5.67) was obtained from V_1N_0 (no nitrogen with Binadhan-19) and V_3N_2 (100% of RD of nitrogen on Mulagburu). The highest number of sterile spikelets $panicle^{-1}$ (22.67) was documented in V_3N_2 (application of 100% of recommended dose of nitrogen (60 kg ha^{-1}) on Mulagburu). The lowest number of sterile spikelets $panicle^{-1}$ (8.33) was obtained from V_1N_0 (no nitrogen on Binadhan-19). Numerically the highest grain yield (3.49 t ha^{-1}) was produced by Mulagburu with 150% of RD of nitrogen whereas the lowest grain yield (1.48 t ha^{-1}) was produced by BRRI dhan48 with control treatment (Table 4).

Table 4. Interaction effect of cultivar and level of nitrogen on the yield and yield components of *aus* rice

Interaction (V × N)	Plant height (cm)	Total tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no)	Sterile spikelets $panicle^{-1}$ (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
V_1N_0	70.00	7.33	5.67	17.66	42.00	8.33e*	22.57	1.58	2.19	41.90
V_1N_1	72.00	8.67	6.00	17.32	66.33	16.00cd	22.43	1.93	2.75	41.29
V_1N_2	73.33	8.00	6.00	19.00	65.66	15.00d	22.76	2.33	3.31	40.04
V_1N_3	75.67	10.00	8.00	19.33	61.00	16.33cd	22.63	2.95	3.80	44.11
V_1N_4	74.33	10.33	8.00	18.65	60.33	16.00cd	22.50	2.44	3.34	42.08
V_2N_0	68.67	8.67	6.33	16.66	48.66	17.33c	24.40	1.48	2.48	37.77
V_2N_1	70.33	8.33	6.00	17.31	51.66	19.67b	24.71	1.82	2.35	43.81
V_2N_2	73.33	9.33	6.33	17.67	55.65	19.67b	24.73	2.18	2.81	43.51
V_2N_3	78.66	12.33	9.67	18.33	58.01	17.33c	24.36	2.49	3.15	44.23
V_2N_4	78.66	9.33	6.33	18.65	58.66	16.67cd	24.30	2.30	3.03	43.45
V_3N_0	87.68	9.67	6.33	21.66	106.33	20.67ab	23.32	2.00	2.63	42.69
V_3N_1	90.65	9.67	6.33	23.32	111.66	20.67ab	23.63	2.65	3.71	41.40
V_3N_2	91.66	9.67	5.67	23.00	112.32	22.67a	23.63	3.08	4.06	43.50
V_3N_3	93.66	10.33	7.67	23.00	107.65	21.00ab	23.56	3.49	4.30	44.62
V_3N_4	94.33	10.00	7.33	23.66	112.32	20.67ab	23.60	3.26	4.34	42.62
Level of sig.	NS	NS	NS	NS	NS	0.01	NS	NS	NS	NS
CV (%)	4.92	11.88	14.40	6.82	10.72	6.79	0.80	21.72	19.67	9.26

*****In a column, figure with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); NS = Not significant

V_1 = Binadhan-19, V_2 = BRRI dhan48, V_3 = Mulagburu

N_0 = No nitrogen (Control), N_1= 50% of RD of nitrogen (30 kg ha^{-1}), N_2 = 100% of RD of nitrogen (60 kg ha^{-1}), N_3 = 150% of RD of nitrogen (90 kg ha^{-1}) and N_4 = Application of urea super granule @ 1.8 g per 4 hills

CONCLUSION

From the weed infestation results it may be concluded that weed infestation increases with the increasing in nitrogen level. Rice cultivar Mulagburu with 150% of the recommended dose of nitrogen (90 kg ha^{-1}) produced the highest yield of *aus* rice. So, in this experiment, to develop new protocol in nitrogen management practices with the Mulagburu variety and the application of 150% of recommended dose of nitrogen (90 kg ha^{-1}) might be recommended. But further studies at different agro-ecological zones might be required to confirm the results of the present study.

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