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# EFFECTS OF WATER STRESS ON MORPHO-PHYSIOLOGICAL CHARACTERS AND YIELD OF RICE GENOTYPES

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**ABSTRACT**

Islam MT, Islam MN, Hossain MA, Karim MA (2012) Effects of water stress on morpho-physiological characters and yield of rice genotypes. *Int. J. Sustain. Crop Prod.* 7(1), 6-11.

A pot experiment was carried out at the Bangladesh Institute of Nuclear Agriculture, Mymensingh during aman season from August to November, 2005 to assess the effect of moisture on growth and yield of ten rice genotypes. The ten genotypes included in this study were TNDB-100, BRRIdhan 28, BINAdhan 4, MR-150/11, Ukunmadhu, RM-100/24, RM-100/18. The soil moisture levels were 100% (control), 70% and 40% field capacity (FC). The experiment was laid out in a randomized complete block design with three replications. All the yield and yield contributing characters were the highest at 100% FC and lowest at 40% FC. The highest number of leaves, leaf area, leaf dry weight, stem dry weight, root weight, total dry matter, panicle weight, number of panicle and grain yield were found in RM-100/18. The highest number of leaf, leaf dry weight, root dry weight, stem dry weight, panicle weight, total dry matter, number of panicle and grain yield were found in the treatment combination of RM-100/18 with 100% FC. The highest plant height was recorded in the treatment combination of MR-150/11 with 100% FC.

***Key words: water stress, rice, yield and yield attributes***

## INTRODUCTION

Drought affects every aspects of plant life and inhibits growth, development and productivity and rice is of no exception. The effect of water stress on morpho-physiological characters and yield may vary with variety, degree and duration of stress and growth stage. Several researchers (Islam and Gretzmacher, 2001; Rahman *et al*. 2002) observed that yield losses resulting from water deficit are particularly severe when drought strikes at booting stage. Water stress at or before panicle initiation reduces most potential spikelet number and grain filling rate which decreases grain weight and increases empty grains. Aman rice is generally cultivated under rainfed condition during July to December and faces drought stress occasionally during reproductive stage. However, different cultivars have different ability to respond to drought conditions in terms of growth and development. Therefore, the objectives of this study were to observe the effect of water stress on the rice genotypes and to identify relative water stress tolerant genotype.

## MATERIALS AND METHODS

An experiment was conducted in plastic pots at the pot yard of Crop Physiology Division of Bangladesh Institute of Nuclear Agriculture, Mymensingh during 10 August to 29 November 2005. A total of 180 pots were prepared and their individual weight was recorded (150g). Each pot contained 9 kg of soil. The pot was 21 cm deep with 24 cm diameter at the top. The pots were placed in the polythene sheet. The pots were divided into two groups each had 10 rice genotypes, 3 soil moisture levels and 3 replications. The three soil moisture levels *viz*. 100, 70 and 40% FC were imposed during tillering stage to maturity. Before stress imposition all pots maintained field capacity (100%) level determined though gravimetric method. The 70 and 40% FC were maintained by adding water to the assigned pots with the help of well partitioned weighting balance at two days' interval. The experiment was conducted in randomized complete block design. Soils were fertilized with urea 1.05, TSP 0.87 and MP 0.42 $gpot^{-1}$ corresponding to urea 170, TSP 135 and MP 65 $kgha^{-1}$, respectively. All TSP, MP and one-third of the urea were applied as basal dose. The remaining two-thirds of the urea were applied in two equal splits in each pot at 30 and 50 days after transplanting (DAT). At 60 DAT, plant height, number of tillers, leaves, leaf area, root, stem, leaf dry weight and total dry mater $plant^{-1}$ were recorded. At maturity, plant height, root, stem, leaf, panicle dry weight, total dry matter $plant^{-1}$, number of panicles $plant^{-1}$, panicle length. 1000-grain weight, grain yield $plant^{-1}$ and harvest index (%) were also recorded. The collected data were analyzed with the help of MSTAT computer packages. The mean differences were compared by Duncan's Multiples Range Test (DMRT) at 5% level of significance.

## RESULTS AND DISCUSSION

Plant height both at 60 DAT and maturity decreased with the decrease in soil moisture levels (Table 1). The results are in agreement with Islam *et al*. (2005a, 2005b) who found decreased plant height in rice under water stress condition. Reduced plant height might be due to inhibition of cell division or cell enlargement by water stress. At 60 DAT, MR-150/11 was the tallest plant with same statistical rank with 150/10, RM-100/24 and RM-100/18. On the contrary, BRRIdhan 28 was the shortest plant. At maturity RM-100/24 was the tallest plant with same statistical rank with Ukunmadhu, MR-150/11 and MR-150/10. Both at 60 DAS and maturity, the tallest plants were observed in MR-150/11 at 100% FC and the shortest in TNDB -100 at 40% FC. Number of tillers was decreased with the decrease in soil moisture levels (Table 1). The maximum number of tillers $plant^{-1}$ was recorded in RM-100/18 with same statistical rack with RM-100/24, Ukunmadhu, MR-150/11, MR-150/10 and TNDB-100 and the minimum was in RD-2586 and BINAdhan 4, All the genotypes showed the maximum number of tillers at 100% FC except BRRIdhan 31, BRRIdhan 28, BINAdhan 4 and RD-2586. The latter three

did not vary in tiller production under different soil moisture levels. Leaf area plant$^{-1}$ decreased with the decrease in moisture levels (Table 1). The results are in conformity with that of Islam *et al*. (2004) who reported decreased leaf area in rice under water stress condition. BINAdhan 4 produced the highest leaf area plant$^{-1}$ and MR-150/10 produced the lowest. Interaction of moisture levels and rice genotypes on leaf area plant$^{-1}$ was not significant.

Table 1. Effect of soil moisture levels on some morpho-physiological attributes of aman rice genotypes

| Treatment | Plant height (cm) at 60 DAT | Plant Height (cm) at maturity | No. of tillers at 60 DAT | No. of leaves at 60 DAT | Leaf area plant$^{-1}$ (cm$^2$) at 60 DAT |
|---|---|---|---|---|---|
| Moisture level (% FC) | | | | | |
| 100 (Control)($T_0$) | 113.95a | 134.56a | 23.16a | 111.13a | 2203a |
| 70 (($T_1$) | 109.13b | 123.66b | 21.20b | 101.46b | 1791b |
| 40 ($T_2$) | 105.08c | 107.66c | 18.13c | 89.73c | 1459c |
| Genotype | | | | | |
| TNDB-100 ($V_1$) | 85.38e | 89.11f | 23.11a | 104.00bc | 1481ef |
| BRRIdhan 31 ($V_2$) | 91.22d | 105.66b | 19.55c | 85.33e | 2215b |
| BRRIdhan 28 ($V_3$) | 77.94f | 92.66f | 16.00b | 90.55de | 11406fg |
| BINAdhan 4 ($V_4$) | 102.22c | 113.33c | 18.55bcd | 88.00e | 2730a |
| RD-2586 ($V_5$) | 102.22c | 101.00e | 17.77cd | 87.11e | 1684de |
| MR-150/10 ($V_6$) | 127.77a | 142.66ab | 21.11ab | 104.55bc | 1205g |
| MR-150/11 ($V_7$) | 128.33a | 143.77ab | 22.88a | 115.22ab | 1766d |
| Ukunmadhu ($V_8$) | 124.66b | 145.11a | 22.55a | 101.00cd | 1650ef |
| RM-100/24 ($V_9$) | 127.44ab | 146.55a | 22.77a | 113.11ab | 2132bc |
| RM-100/18 ($V_{10}$) | 126.66ab | 139.77b | 24.00a | 118.88a | 1908cd |
| Interaction | | | | | |
| $V_1T_0$ | 9131m | 92.00mno | 27.00a | 114.33a-e | 1903 |
| $V_1T_1$ | 86.33no | 90.33mno | 22.33a-f | 107.66b-g | 1427 |
| $V_1T_2$ | 78.00p | 85.00o | 20.00e-h | 90.00g-l | 1112 |
| $V_2T_0$ | 94.50l | 113.33ij | 21.33a-g | 100.00b-j | 2576 |
| $V_2T_1$ | 91.00lmn | 107.00jk | 20.33b-h | 83.33i-l | 2221 |
| $V_2T_2$ | 88.16mno | 96.66lm | 17.00fgh | 72.66l | 1849 |
| $V_3T_0$ | 84.16o | 98.66lm | 17.00fgh | 99.33e-j | 1591 |
| $V_3T_1$ | 77.00pq | 93.66mn | 15.66gh | 90.66g-l | 1345 |
| $V_3T_2$ | 72.66q | 85.66no | 15.00h | 81.66jkl | 1282 |
| $V_4T_0$ | 104.66hi | 121.33ghi | 20.00e-h | 96.66d-k | 2981 |
| $V_4T_1$ | 101.66ij | 114.66i | 18.33e-h | 91.00f-l | 2747 |
| $V_4T_2$ | 100.33ij | 104.00k | 17.33fgh | 76.33k | 2461 |
| $V_5T_0$ | 107.33h | 114.00ij | 20.00e-h | 100.00d-j | 2359 |
| $V_5T_1$ | 102.33hi | 97.33lm | 18.66e-h | 83.00i-l | 1463 |
| $V_5T_2$ | 97.00jk | 91.66mno | 14.66h | 78.33jkl | 1231 |
| $V_6T_0$ | 127.66cde | 158.33bcd | 23.66a-e | 116.33a-d | 1393 |
| $V_6T_1$ | 128.66bcd | 145.00ef | 21.66a-f | 112.00a-g | 1289 |
| $V_6T_2$ | 127.00c-f | 124.66gh | 18.00d-h | 85.33h-l | 933 |
| $V_7T_0$ | 136.33a | 166.33a | 23.66a-e | 120.00abc | 2204 |
| $V_7T_1$ | 126.00c-f | 147.33ef | 23.66a-e | 116.00a-d | 1746 |
| $V_7T_2$ | 122.66e-g | 117.66hi | 21.33a-g | 109.66a-g | 1348 |
| $V_8T_0$ | 130.33bc | 164.66ab | 26.00ab | 112.00a-g | 1958 |
| $V_8T_1$ | 123.66d-g | 147.00ef | 23.00a-f | 98.66c-j | 1677 |
| $V_8T_2$ | 120.00g | 123.66gh | 18.66e-h | 92.33e-l | 1316 |
| $V_9T_0$ | 133.66ab | 161.00abc | 26.33a | 121.66ab | 2545 |
| $V_9T_1$ | 126.66c-f | 152.00de | 24.33abc | 113.00a-f | 2152 |
| $V_9T_2$ | 122.00fg | 126.66g | 17.66e-h | 104.66b-i | 1700 |
| $V_{10}T_0$ | 129.00bcd | 156.00cd | 26.33a | 131.00a | 2520 |
| $V_{10}T_1$ | 128.00cde | 142.33f | 24.00a-d | 119.33abc | 1844 |
| $V_{10}T_2$ | 123.00fg | 121.00ghi | 21.66a-f | 106.33b-h | 1360 |

In a column figures followed by different letter(s) are statistically significant at 5% level as per DMRT

At 60 DAT and maturity, root dry weight plant$^{-1}$ decreased with the decrease in moisture levels (Table 2). At 60 DAT, BRRIdhan 31, MR-150/11, RM-100/24 and RM-100/18 had higher root dry weights than those of other genotypes. All the genotypes showed the maximum root dry weight at 100% FC except BRRIdhan 31, BINAdhan 4 and RD-2586. At maturity, BRRIdhan 28 had the maximum root dry weight plant$^{-1}$ with same rank with BINAdhan 4, MR-150/10, RM-100/24 and RM-100/18. The lowest root dry weight was found in RD-2586.

Table 2. Effect of soil moisture levels on dry matter distribution in plant parts of aman rice genotypes

| Treatment | Root weight (g) at 60 DAS | Root weight (g) at maturity | Stem weight (g) at 60 DAS | Stem weight (g) at maturity | Leaf weight (g) at 60 DAS | Leaf weight (g) at maturity |
|---|---|---|---|---|---|---|
| Moisture level (% FC) | | | | | | |
| 100 (Control)($T_0$) | 12.05a | 8.44a | 23.12a | 31.47a | 15.10a | 15.81a |
| 70 (($T_1$) | 8.71b | 7.00b | 20.25b | 25.64b | 13.09b | 12.89b |
| 40 ($T_2$) | 7.14c | 5.40c | 17.15c | 17.89c | 10.98c | 10.39c |
| Genotype | | | | | | |
| TNDB-100 ($V_1$) | 8.13cd | 5.58d | 19.67cd | 17.96d | 9.96e | 9.61d |
| BRRIdhan 31 ($V_2$) | 10.7ab | 5.58d | 19.70cd | 17.33d | 13.90d | 11.91c |
| BRRIdhan 28 ($V_3$) | 7.79d | 8.48a | 12.86e | 14.34d | 9.31e | 9.01d |
| BINAdhan 4 ($V_4$) | 9.48bcd | 8.38a | 21.96bc | 29.89bc | 13.29b | 14.28d |
| RD-2586 ($V_5$) | 8.40cd | 3.68c | 18.08d | 14.54d | 9.84e | 8.50d |
| MR-150/10 ($V_6$) | 7.83d | 7.98ab | 20.44bcd | 31.77b | 14.11ab | 14.00b |
| MR-150/11 ($V_7$) | 10.35abc | 7.04bc | 22.97ab | 28.73bc | 15.64ab | 14.66b |
| Ukunmadhu ($V_8$) | 8.22cd | 6.57cd | 19.82cd | 25.48c | 13.80b | 15.28b |
| RM-100/24 ($V_9$) | 10.18abc | 7.88ab | 21.38bc | 36.56a | 14.33ab | 15.68ab |
| RM-100/18 ($V_{10}$) | 11.86a | 8.31ab | 24.87a | 33.40ab | 16.40a | 17.33a |
| Interaction | | | | | | |
| $V_1T_0$ | 11.35a-d | 6.54e-l | 20.99b-i | 21.56f-i | 11.76c-i | 12.36f-k |
| $V_1T_1$ | 7.32d-h | 5.84g-m | 19.97e-j | 18.05hij | 9.73f-i | 9.27k-o |
| $V_1T_2$ | 5.72fgh | 4.37k-n | 18.05g-m | 14.28ij | 8.38g-i | 7.22no |
| $V_2T_0$ | 13.87a | 6.56e-l | 22.62a-h | 20.53g-j | 16.54ab | 13.07e-j |
| $V_2T_1$ | 10.34a-e | 5.68g-m | 21.17b-i | 17.70hij | 14.21a-f | 12.73e-k |
| $V_2T_2$ | 8.06d-h | 4.49j-n | 15.30j-n | 13.77ij | 10.94d-i | 9.92j-n |
| $V_3T_0$ | 9.62b-g | 11.11a | 14.48a-n | 17.18hij | 10.15f-i | 10.26j-n |
| $V_3T_1$ | 7.30d-h | 8.10b-g | 12.77mn | 13.43ij | 9.37ghi | 8.68l-o |
| $V_3T_2$ | 6.45d-h | 6.22f-m | 11.34n | 12.40ij | 8.40hi | 8.10mno |
| $V_4T_0$ | 12.47abc | 10.10ab | 26.24abc | 36.31abc | 15.52a-d | 15.61b-g |
| $V_4T_1$ | 9.13c-h | 8.46b-f | 20.84c-i | 30.16b-e | 13.54a-g | 14.38d-i |
| $V_4T_2$ | 6.85e-h | 6.57e-l | 18.81f-l | 23.21e-h | 10.82e-i | 12.86e-i |
| $V_5T_0$ | 13.45ab | 4.66i-n | 22.74a-h | 18.22hij | 12.52b-h | 11.92h-l |
| $V_5T_1$ | 6.74e-h | 3.98mn | 17.55h-m | 13.73ij | 9.71f-i | 7.38no |
| $V_5T_2$ | 5.02h | 2.42n | 13.94mn | 11.69j | 7.30i | 6.21o |
| $V_6T_0$ | 10.19a-e | 9.52abc | 23.68a-f | 37.83ab | 17.55a | 16.17b-e |
| $V_6T_1$ | 7.82d-h | 8.32b-f | 20.20d-j | 31.85bcd | 13.94a-g | 15.00c-h |
| $V_6T_2$ | 5.48gh | 6.09f-m | 17.46h-m | 25.62d-h | 10.84l-i | 18.85i-m |
| $V_7T_0$ | 13.22abc | 8.78b-e | 25.60a-d | 43.95a | 17.42a | 18.96b |
| $V_7T_1$ | 9.52b-g | 6.86e-j | 23.22a-g | 29.17b-f | 15.5a-d | 13.40d-j |
| $V_7T_2$ | 8.30d-h | 5.49h-m | 20.09d-j | 13.06ij | 13.93a-g | 11.63h-l |
| $V_8T_0$ | 9.72b-f | 8.71b-e | 20.97b-i | 32.42bcd | 14.92a-e | 18.12b-e |
| $V_8T_1$ | 7.84d-h | 6.78e-k | 19.72e-k | 26.92-g | 13.79a-g | 15.53 b-g |
| $V_8T_2$ | 7.12e-h | 4.23h-m | 18.79f-l | 17.10hij | 12.68b-h | 12.19g-k |
| $V_9T_0$ | 12.76abc | 9.01a-e | 26.44ab | 43.98a | 16.69ab | 18.71d |
| $V_9T_1$ | 9.75d-f | 7.49c-h | 22.01a-h | 37.71ab | 14.93a-e | 15.83b-f |
| $V_9T_2$ | 8.03d-h | 7.14c-h | 15.69i-n | 27.99c-g | 11.45d-i | 12.51f-k |
| $V_{10}T_0$ | 13.85a | 9.41a-d | 27.46a | 42.72a | 18.03a | 22.91a |
| $V_{10}T_1$ | 11.34a-d | 8.51b-f | 25.10a-e | 37.68ab | 16.16abc | 16.72bcd |
| $V_{10}T_2$ | 10.40a-e | 7.03d-i | 27.05a-h | 19.80g-j | 15.01a-e | 12.37f-k |

In a column figures followed by different letter(s) are statistically significant at 5% level as per DMRT

The maximum root dry weight plant$^{-1}$ was recorded in BRRIdhan28 at 100% FC with same rank with BINAdhan 4, MR-150/10, RM-100/24 and RM-100/18. The genotype TNDB-100 and BRRIdhan 31 showed the lowest root dry weight at 40% FC. Stem dry weight both at 60 DAT and maturity, decreased with decreasing soil moisture levels (Table 2). The highest stem dry weight plant$^{-1}$ was recorded in RM-100/18 with same statistical rank with MR-150/11. The lowest stem dry weight plant$^{-1}$ was noticed in BRRIdhan 28. All the genotypes produced maximum stem dry weight at 100% FC except Ukunmadhu. At maturity, stem dry weight was the highest in RM-100/18. The genotype RM-100/24 showed the maximum stem dry weight at 100% FC with same rank with that of 70% FC, with RM-100/18 at 70 and100% FC and BINAdhan 4 at 100% FC. Leaf dry weight at 60 DAT decreased with the decrease in soil moisture levels (Table 2). At 60 DAT, the highest leaf area plant$^{-1}$ was recorded in RM-100/18 with same rank with RM-100/24, Ukunmadhu, MR-150/11 and MR-

150/10. All the genotypes showed the maximum leaf dry weight at 100% FC except TNDB-100, BRRIdhan 28 and RD-2586. At maturity, RM-100/18 had the highest leaf dry weight with same rank with RM-100/24. The lowest leaf dry weight was recorded in RD-2586. RM-100/18 showed the maximum leaf dry weight at 100% FC. The results are in agreement with those of Islam *et al*. (1994a, 1994b) who reported decreased dry mass of root, leaf and stem in rice genotypes under water stress condition.

Panicle dry weight/plant decreased with the decrease in soil moisture levels (Table 3). RM-100/18, RM-100/24 and BRRIdhan 31 showed higher panicle dry weights than that of other genotypes.

Table 3. Effect of soil moisture level on panicle dry weight and total dry matter of aman rice genotypes

| Treatment | Panicle weight (g) at maturity | Total dry matter (g) at 60 DAT | Total dry matter (g) at maturity |
|---|---|---|---|
| Moisture level (% FC) | | | |
| 100 (Control)($T_0$) | 27.79a | 55.28a | 83.70a |
| 70 (($T_1$) | 19.23b | 42.06b | 64.69b |
| 40 ($T_2$) | 6.05c | 35.28c | 39.88c |
| Genotype | | | |
| TNDB-100 ($V_1$) | 15.45cd | 37.77de | 49.07cd |
| BRRIdhan 31 ($V_2$) | 20.05abc | 44.36bc | 54.88c |
| BRRIdhan 28 ($V_3$) | 13.54d | 29.97f | 45.11d |
| BINAdhan 4 ($V_4$) | 17.91a-d | 44.75bc | 70.53b |
| RD-2586 ($V_5$) | 16.68bcd | 36.33e | 43.43b |
| MR-150/10 ($V_6$) | 16.34bcd | 42.39cd | 70.10b |
| MR-150/11 ($V_7$) | 16.83bcd | 48.96ab | 67.26b |
| Ukunmadhu ($V_8$) | 17.09bcd | 41.85cde | 64.43b |
| RM-100/24 ($V_9$) | 20.89ab | 45.90bc | 81.01a |
| RM-100/18 ($V_{10}$) | 22.03a | 53.14a | 81.74a |
| Interaction | | | |
| $V_1T_0$ | 21.96d-h | 44.11e-j | 62.43ghi |
| $V_1T_1$ | 14.61g-j | 37.04g-m | 47.78i-l |
| $V_1T_2$ | 9.79i-l | 32.16klm | 37.01lm |
| $V_2T_0$ | 30.48abc | 53.04a-d | 70.65fg |
| $V_2T_1$ | 17.20e-i | 45.37b-l | 53.32h-k |
| $V_2T_2$ | 12.48ijk | 34.31i-m | 40.66klm |
| $V_3T_0$ | 25.14b-e | 34.26i-m | 63.71gh |
| $V_3T_1$ | 9.20i-l | 29.44lm | 38.60klm |
| $V_3T_2$ | 6.28kl | 36.20m | 33.02lm |
| $V_4T_0$ | 31.30ab | 54.24abc | 93.29bc |
| $V_4T_1$ | 16.73f-i | 43.51e-k | 69.75fg |
| $V_4T_2$ | 5.91kl | 36.49h-m | 48.56h-l |
| $V_5T_0$ | 26.52bcd | 48.72a-f | 61.33g-j |
| $V_5T_1$ | 16.21ghi | 34.01j-m | 41.31klm |
| $V_5T_2$ | 7.31jkl | 26.26m | 27.64m |
| $V_6T_0$ | 23.18b-g | 51.42a-e | 86.71cd |
| $V_6T_1$ | 21.81d-h | 41.96d-k | 76.99d-g |
| $V_6T_2$ | 4.03l | 33.79j-m | 46.61jkl |
| $V_7T_0$ | 24.52b-f | 56.24ab | 96.19bc |
| $V_7T_1$ | 23.26b-g | 48.32a-g | 72.70efg |
| $V_7T_2$ | 2.72l | 42.33d-k | 32.91lm |
| $V_8T_0$ | 25.52bcd | 45.61b-i | 84.77e-f |
| $V_8T_1$ | 22.25e-h | 41.35e-k | 71.49efg |
| $V_8T_2$ | 3.51l | 38.00f-l | 37.04lm |
| $V_9T_0$ | 34.37a | 55.84ab | 106.06ab |
| $V_9T_1$ | 22.50e-h | 46.69b-h | 83.54ef |
| $V_9T_2$ | 5.79kl | 35.17i-m | 83.44h-k |
| $V_{10}T_0$ | 34.87a | 59.33a | 111.87a |
| $V_{10}T_1$ | 28.49a-d | 52.61a-e | 91.41bcd |
| $V_{10}T_2$ | 2.72l | 47.47b-h | 41.93klm |

In a column figures followed by different letter(s) are statistically significant at 5% level as per DMRT

The genotype RM-100/18 showed the maximum panicle dry weight at 100% FC with same rank with RM-100/24, BINAdhan 4 and BRRIdhan 31 at 100% FC. Total dry matter both at 60 DAT and maturity decreased with decreasing soil moisture levels (Table 3). At 60 DAT, RM-100/18 produced the highest total dry matter with same rank with MR-150/11. The lowest total dry matter/plant was found in BRRIdhan 28. All the

genotypes showed the maximum total dry matter/plant at 100% FC except TNDB-100, BRRIdhan 28 and Ukunmadhu. At maturity, the maximum total dry matter/plant was recorded in RM-100/18 with same rank with RM-100/24**.** The minimum total dry matter was recorded in BRRIdhan 28 with same rank with TNDB-2586. The genotype RM-100/18 produced the maximum total dry matter plant$^{-1}$ at 100% FC with same rank with RM-100/24. The results are in conformity with those of Islam *et al.* (2005a, 2005b), who observed varietal differences in root, leaf stem dry mass and total biomass production under different soil moisture regimes.

Number of panicles plant$^{-1}$ decreased with the decrease in soil moisture levels (Table 4). The genotypes TNDB-100, BINAdhan 4, RD-2586, RM-100/24 and RM-100/18 produced higher number of panicles plant$^{-1}$. RM-100/18 produced the highest number of pods/plant at 100% FC with same rank with TNDB-100 at 100% FC.

Table 4. Effect of soil moisture levels on yield and yield attributes of aman rice genotypes

| Treatment | No. of panicles plant$^{-1}$ | Panicle length (cm) | 1000-grain weight (g) | Grain yield (g) plant$^{-1}$ | Harvest index (%) |
|---|---|---|---|---|---|
| Moisture level (% FC) | | | | | |
| 100 (Control)($T_0$) | 17.53a | 23.93a | 18.76a | 21.94a | 26.92a |
| 70 (($T_1$) | 14.50b | 22.09b | 17.56b | 14.18b | 21.89b |
| 40 ($T_2$) | 8.00c | 19.92c | 13.90c | 2.98c | 10.54c |
| Genotype | | | | | |
| TNDB-100 ($V_1$) | 15.66a | 20.8de | 20.93c | 11.93bcd | 22.94c |
| BRRIdhan 31 ($V_2$) | 9.44c | 23.68a | 23.11b | 14.71abc | 25.32ab |
| BRRIdhan 28 ($V_3$) | 11.66bc | 22.92ab | 23.36b | 9.09d | 17.75bc |
| BINAdhan 4 ($V_4$) | 14.22ab | 21.84bc | 23.66b | 12.84a-d | 16.28bc |
| RD-2586 ($V_5$) | 16.55a | 19.42e | 25.55a | 12.26bcd | 33.64a |
| MR-150/10 ($V_6$) | 12.55b | 22.41abc | 9.57d | 11.45cd | 14.05c |
| MR-150/11 ($V_7$) | 11.66bc | 22.29bc | 10.57d | 12.10bcd | 15.33bc |
| Ukunmadhu ($V_8$) | 12.44b | 23.0ab | 9.91d | 13.03a-d | 17.84bc |
| RM-100/24 ($V_9$) | 14.00ab | 22.70b | 10.48d | 16.10ab | 17.42bc |
| RM-100/18 ($V_{10}$) | 15.22a | 21.16cd | 10.24d | 16.85a | 17.24bc |
| Interaction | | | | | |
| $V_1T_0$ | 21.33ab | 21.38g-j | 22.53de | 18.40c-g | 29.24ab |
| $V_1T_1$ | 14.66c-h | 20.38ijk | 21.80e | 12.59ghi | 26.29abc |
| $V_1T_2$ | 11.00 f-k | 19.38jkl | 18.46f | 4.80jk | 13.28b-f |
| $V_2T_0$ | 11.33e-j | 24.99abc | 25.60abc | 24.03a-d | 33.87a |
| $V_2T_1$ | 9.66ijk | 23.66a-g | 24.13cde | 13.19f-i | 24.66a-d |
| $V_2T_2$ | 7.33i-m | 22.38e-i | 19.60f | 6.92ijk | 17.43a-f |
| $V_3T_0$ | 13.33d-i | 25.11ab | 25.86abc | 18.49c-g | 28.90abc |
| $V_3T_1$ | 11.33e-j | 22.61e-i | 24.76bcd | 5.35jk | 13.89b-f |
| $V_3T_2$ | 10.33g-k | 21.05h-k | 19.46f | 3.45jk | 10.47e-f |
| $V_4T_0$ | 17.00bcd | 23.05b-h | 26.53abc | 24.95abc | 26.67abc |
| $V_4T_1$ | 15.66c-f | 21.71f-j | 25.00bc | 10.04hij | 14.80b-f |
| $V_4T_2$ | 10.00h-k | 20.77 h-k | 19.46f | 3.54jk | 7.38d-f |
| $V_5T_0$ | 18.66bc | 20.99h-k | 27.73a | 21.62a-e | 35.68a |
| $V_5T_1$ | 17.00bcd | 19.77jkl | 26.93ab | 12.46ghi | 29.62ab |
| $V_5T_2$ | 13.33d-i | 17.49l | 22.00e | 2.65jk | 35.63a |
| $V_6T_0$ | 16.33cd | 24.24a-e | 11.46gh | 17.82c-g | 20.40a-f |
| $V_6T_1$ | 15.00c-g | 22.83b-h | 10.13ghi | 15.40e-h | 20.28a-f |
| $V_6T_2$ | 6.33 klm | 20.17ijk | 7.13j | 1.13k | 2.46f |
| $V_7T_0$ | 18.00bcd | 24.94a-d | 12.20g | 19.56b-g | 20.23a-f |
| $V_7T_1$ | 13.66d-i | 22.99b-h | 10.53ghi | 15.00e-h | 20.52a-f |
| $V_7T_2$ | 3.33m | 18.94k | 9.00hij11.93g | 1.75k | 5.25ef |
| $V_8T_0$ | 16.33cd | 25.83a | 10.66ghi | 20.71a-f | 24.62a-d |
| $V_8T_1$ | 14.33 e-i | 22.55d-i | 7.13j | 27.09ab | 23.85a-d |
| $V_8T_2$ | 6.66 j-m | 20.66h-k | 11.86g | 1.30k | 5.04ef |
| $V_9T_0$ | 18.00bcd | 24.77a-e | 11.20gh | 27.56ab | 25.96abc |
| $V_9T_1$ | 16.00cde | 23.77a-g | 8.40ij | 18.07e-g | 21.59a-e |
| $V_9T_2$ | 8.00jkl | 19.55jkl | 11.93g | 2.69jk | 4.71ef |
| $V_{10}T_0$ | 25.00a | 23.99a-f | 10.46ghi | 29.33a | 23.61a-d |
| $V_{10}T_1$ | 17.00bcd | 20.66h-k | 8.33y | 22.66a-e | 24.37a-d |
| $V_{10}T_2$ | 3.66lm | 18.82k | | 1.55k | 3.74ef |

In a column figures followed by different letter(s) are statistically significant at 5% level as per DMRT

Panicle length decreased with decreasing soil moisture levels. Reduced panicle length might be due to inhibition of cell division or cell enlargement by water stress. BRRIdhan 31 had the longest panicle with same rank with BRRIdhan 28, MR-150/10, Ukunmadhu and RM-100/18. The shortest panicle was found in RD-2586 with same rank with TNDB-100. All the genotypes had the maximum panicle length at 100% FC except TNDB-100 and BINAdhan 4. Thousand grain weight decreased with the decrease in soil moisture levels (Table 4). The highest 1000-grain weight was recorded in RD-2586 and the lowest in MR-150/10 with same rank with MR-150/11, Ukunmadhu, RM-100/24 and RM-100/18. BRRIdhan 31, BRRIdhan 28, BINAdhan 4 and RD-2586 showed the maximum 1000-grain weight at 100% FC and RD-2586 at 70% FC. Grain yield plant$^{-1}$ decreased with the decrease in soil moisture levels (Table 4). Decreased grain yield under water stress might be due to less photosynthesis and insufficient translocation. The genotype RM-100/18 produced the highest grain yield plant$^{-1}$ with same rank with BRRIdhan 31, BINAdhan 4, Ukunmadhu and RM-100/18. Harvest index also decreased with decreasing soil moisture levels. RD-2586 produced the maximum harvest index with same rank with BRRIdhan 31. Other genotypes had statistically similar grain yield plant$^{-1}$. All the genotypes showed maximum grain yield at 100% FC. The results are in agreement with those of Islam (2000), Rahman *et al*. (2002 and Choudhury *et al*. (2004) who reported decreased yield and yield attributes under water stress condition.

## CONCLUSION

All the morpho-physiological attributes studied and yield decreased with the decrease in soil moisture levels. RM-100/18 showed the best performance among the genotypes.

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