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EFFECT OF LOW TEMPERATURE AT DIFFERENT GROWTH STAGES ON PHOTOSYNTHESIS, GRAIN GROWTH AND YIELD OF AMAN RICE VARIETIES

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ABSTRACT

Rana MS, Islam MT, Baten MA, Akter MT (2023) Effect of low temperature at different growth stages on photosynthesis, grain growth and yield of aman rice varieties. *Int. J. Expt. Agric*. 13(1), 13-17.

Temperature is one of the most important environmental factors influencing crop growth, development and yield processes. Temperature is becoming the major concern for plant scientists worldwide due to the changing climate. A pot experiment was conducted with five varieties *viz*., Binadhan-4, Binadhan-7, Binadhan-11, Binadhan-12 and Binasail in pot yard and the plant growth chamber at Bangladesh Institute of Nuclear Agriculture, Mymensingh during July to December 2014 to assess the effects of low temperature (20°C) at different growth stages on photosynthesis, grain growth and yield and to find out the variety tolerant to low temperature. Five temperature treatments *viz*., Ambient, 20°C at tillering stage, 20°C at panicle initiation stage, 20°C at booting stage and 20°C at flowering stage were imposed for 7 days at each respective growth stage and then plants were allowed to grow at ambient temperature up to maturity. For grain growth studies two temperature treatments, Ambient and 20°C were applied from fertilization to grain maturity. Ten grains were harvested from selected panicles of three plants of each treatment at 3 days interval starting from fertilization to maturity. During grain growth photosynthetic rate, chlorophyll content of flag leaf and dry weights of those grains were recorded. Photosynthetic rate, chlorophyll content of flag leaf, grain dry matter accumulation, the number of total tillers and effective tillers plant^{-1}, filled and unfilled grains panicle^{-1}, 1000-grain weight and grain yield were significantly affected by temperature treatments. Temperature treatments did not affect the number of total tillers plant^{-1} and panicle length. However, low temperature (20°C) at flowering stage affected grain yield more compared to other temperature treatments and found to be more sensitive. Grain dry matter accumulation gradually increased but photosynthetic rate in flag leaf decreased from fertilization to maturity. The rice varieties achieved physiological maturity at 24 days and chlorophyll content in flag leaves was stable up to 16 days after anthesis. The highest photosynthetic rate, grain dry matter accumulation and grain yield were found in Binadhan-7 under the treatments. So, Binadhan-7 seems to be tolerant to low temperature (20°C) compared to other varieties.

Key words*: rice, low temperature, growth stage, photosynthesis, grain growth, yield*

INTRODUCTION

The sensitivity of rice to low-temperature stress, especially at the reproductive stage, is a primary factor of rice yield fluctuation in cold cultivate region (Guo *et al*. 2022). Changing climate affects growth, yield, and quality of crop varieties (Rawson 1992; Kumar 2020; Moonmoon *et al*. 2022a; Islam 2022). Climate model predicts 33% rice yield decrease in 2100 (Karim *et al*. 2012). The economic yield of a plant depends mainly on leaf photosynthesis. Stomata can function as valves to control the balance of water loss and carbon gain in plants (Huang *et al*. 2021). The climate changes that are currently occurring make it necessary to understand the effects of temperature on photosynthesis. Models based on large-scale observations indicate that, in the absence of agronomic adaptation, the decrease in crop yields can reach 17% for each 1°C increase in the temperature of the growing season (Yamori *et al*. 2014). Boro rice is transplanted in January February and usually faces high temperature (36-39°C) at its reproductive stage in April-May (Islam 2021a). Flowering stage of rice is very important for high temperature (Islam 2011 and Islam 2013). High temperature may cause drying of pollen and stigma and ceasing pollen tube development unsuitable for fertilization. As a result, unfilled grains are produced. High soil moisture can reduce high temperature effect of boro rice at flowering stage (Islam 2021a; Islam 2021b; Islam 2022). In Bangladesh, Boro rice often suffers with high temperature during its reproductive stages in April-May and Aman rice occasionally in September-October. On the other hand, Boro rice usually suffers with low temperature at seedling stage and occasionally Boro and Aman rice at reproductive stage. Cold temperature stress at the young microspore stage enhances and induces partial degradation of proteins in the rice anthers at the trinucleate stage (Imin *et al*. 2004). Aman rice is rain fed cultivated during June-December. It passes through vegetative stage during August to September when rainfall is usually sufficient. The crop suffers from moisture stress when the rainfall usually ceases by the first week of October in Bangladesh. By this time, it passes through reproductive. The total rainfall in September-October is very irregular and often inadequate which fails to meet the evapotranspirational demand of Aman rice consequently develops water stress and affects translocation of assimilates and grain development in rice (Rahman *et al*. 2002; Moonmoon *et al*. 2020b Moonmoon *et al*. 2020c). Rice grain dry weight increased from fertilization to 18-24 days and temperature/water stress decreased the rate of accumulation and finally produced decreased grain weight (Islam and Gretzmacher, 2001; Islam 2010; Hafiz *et al*. 2015; Hazra *et al*. 2016; Moonmoon *et al*. 2020a).

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The yield of rice is an integrated result of various processes including canopy photosynthesis, conversion of assimilates to biomass, and partitioning of assimilates to grains (Jeng *et al*. 2006). Drought stress affects plant growth and development, and ultimately reduces grain yield of rice (Islam *et al*. 1994b; Islam *et al*. 2005a; Islam *et al*. 2005a; Zohora *et al*. 2016; Moonmoon *et al*. 2017; Moonmoon *et al*. 2020b; Moonmoon *et al*. 2022b). Response of rice yield to drought varies with growth stage being most sensitive at booting followed by flowering and or grain filling stage (Islam *et al.* 1994a). The early reproductive growth period, encompassing tetrad-formation stage of miosis (i.e., about 10-15 d prior to heading), was found to be the most sensitive and critical to water deficit resulting in up to 59% grain sterility that caused similar magnitude of yield reduction (Singh *et al*. 2010). As the grain formation progressed further, the early period of grain-filling was found to be more vulnerable to water stress than the late-milk stages (Singh *et al*. 2010). For stress condition, reproductive stages are critical than vegetative stages and booting to early grain filling stages are more critical (Rahman *et al*. 2002; Islam *et al*. 2005b; Moonmoon and Islam, 2017). So, objectives of the study were to assess the effects of low temperature at different growth stages on photosynthesis, grain growth and yield of rice varieties and to find out the variety tolerant to low temperature.

MATERIALS AND METHODS

A pot experiment was conducted with the varieties Binadhan-4, Binadhan-7, Binadhan-11, Binadhan-12 and Biansail in a plant growth chamber at Bangladesh Institute of Nuclear Agriculture (BINA) during June to December, 2014. The following five treatments *viz.* T_0 (ambient temperature), T_1 (20°C attillering stage), T_2 (20°C at panicle initiation stage), T_3 (20°C at booting stage), and T_4 (20°C at flowering stage) were applied for seven days at each respective growth stage and then plants were allowed to grow at ambient temperature up to maturity. The soil for the experiment was collected from BINA campus. The soil was silt loam, organic matter 1.05%, total N 0.07%, available P 14.3 ppm, exchangeable K 0.25 meq. per 100g soil, available S 13.2 and soil pH 6.67. The experiment was laid out on Completely Randomized Design, where each treatment was replicated 3 times. Seedlings were uprooted carefully from the seedbed and bundled with proper care. On 24 July, 2014, 32 days old seedlings were transplanted in the puddle pots. One seedling was transplanted in a pot. Soils were fertilized with urea 1.72 g/pot, TSP 1.06 g/pot, MP 0.215 kg/ha, 0.80 g/pot corresponding to urea 215 kg/ha TSP 180 kg/ha, MP 100 kg/ha, respectively. For grain growth studies two temperature treatments, T_0 (control) and 20^oC were applied from fertilization to grain maturity. Ten grains were harvested from selected panicles of three plants of each treatment at 3 days interval starting from fertilization to maturity. Dry weights of those grains were recorded. Photosynthetic rate were measured using Portable Photosynthetic system (Model: Li-6400XT) and chlorophyll content of flag leaves were measured using SPAD meter (Model: SPAD 502). Grain dry weight grain dry matter accumulation), chlorophyll content (SPAD reading) and photosynthetic rate of flag leaves were measured at 3 days internal from fertilization to maturity. At maturity, three pots were harvested for each treatment. After harvest data were recorded on plant height, number of total, effective and non-effective tillers plant^{-1}, number of filled and unfilled grains panicle^{-1} and grain yield plant^{-1}. The collected data were analyzed statistically following two factor experimental design of CRD by MSTAT computer packages. Duncan's Multiple Range Test was done to compare the means.

RESULTS AND DISCUSSION

Binadhan-4 produced the longest plants, the highest number of total and effective tillers plant^{-1}, highest number of unfilled grains panicle^{-1} and the lowest yield plant^{-1}(Table 1). Binadhan-7 produced the highest number of unfilled grains panicle^{-1}, the highest 1000-grain weight and the maximum grain yield plant^{-1}. Biandhan-11 produced the shortest plant and the higher number of unfilled grains plant^{-1}. Binadhan-12 produced the highest number of total tiller plant^{-1} and higher yield plant^{-1}. Binasail produced the longest panicle length, the highest number of filled grains panicle^{-1} and the lowest 1000-grain weight. The number of total tillers and effective tillers plant^{-1}, filled and unfilled grains panicle^{-1}, 1000-grain weight and total grain yield were significantly affected by temperature treatments (Table 1). But panicle length was not affected by the temperature treatments. Low temperature (20°C) at flowering stage showed the highest detrimental effect on the filled grains panicle^{-1} and grain yield plant^{-1}. Interaction of temperature treatments and varieties showed significant effect on plant height, number of effective tillers plant^{-1}, filled and unfilled grains panicle^{-1} and grain yield plant^{-1}(Table 2). But interaction effect was not significant on total number of tillers plant^{-1}, panicle length and 1000-grain weight. The highest plant height was found in V_1T_0 (Binadhan-4, at ambient temperature) and the lowest plant height was found in V_3T_2 (Binadhan-11, 20°C at PI stage). The maximum number of tillers plant^{-1} was noticed in V_5T_0 (Binasail at ambient temperature) and the minimum number of tillers plant^{-1} was noticed in V_3T_4 (Binadhan-11, 20°C at flowering stage). The highest number of filled grains panicle^{-1} was observed in V_5T_2 (Binasail, 20°C at PI stage) and the lowest number of filled grains panicle^{-1} was observed in V_4T_4 (Binadhan-12, at flowering stage). The highest number of unfilled grains panicle^{-1} was found in the treatment combination of V_2T_2 (Binadhan-7, 20°C at PI stage) and the lowest number of unfilled grains panicle^{-1} was found in the treatment combination of V_5T_0 (Binasail, at ambient temperature). Binadhan-12 produced the highest grain yield at ambient temperature (T_0), V_1T_2, V_1T_3, V_1T_4 and V_5T_4 produced the least grain yield in different growth stages ofBinadhan-4 and Binasail with 20°C at flowering stage. Low temperature (20°C) at tillering, panicle initiation, booting and grain filling stage affect almost all the yield contributing characters and grain yield of the Aman rice varieties. However, low temperature at flowering stage affected grain yield more compared to other temperature treatments and found to be more critical. Grain dry weight, chlorophyll content and photosynthetic rate significantly decreased with the temperature (20°C) (Table 3). During grain growth period grain dry weight gradually increased but photosynthetic rate in flag leaf decreased from fertilization to maturity. The rice varieties achieved physiological maturity at 24 days after anthesis. Chlorophyll content in flag leaves was stable up to 16 days after anthesis. Binadhan-7 had the highest grain dry matter accumulation and photosynthetic rate. The results agree with Islam 2013; Islam and Arefin, 2022.

Table 1. Yield and yield attributes of Aman rice under low temperature (20°C) at tillering, PI, booting and flowering stages

Treatments	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield plant^{-1} (g)
Varieties								
Binadhan-4 (V_1)	147a	11a	9a	14	50e	18a	18d	9c
Binadhan-7 (V_2)	133b	10b	7c	23	63c	21a	30a	14a
Binadhan-11 (V_3)	81e	11a	8b	33	68b	20a	24c	13b
Binadhan-12 (V_4)	88d	12a	8b	21	55d	10b	27b	13ab
Binasail (V_5)	92c	11a	8b	24	83a	11b	14e	10c
Temperature								
Ambient (T_0)	112a	12	10a	27	66b	8d	24a	16a
20°C at tillaring stage (T_1)	108b	11	8b	19	72a	13c	23b	13b
20°C at PI stage (T_2)	105b	11	7b	18	65c	22a	23b	11c
20°C at booting stage (T_3)	108b	11	7b	19	64d	17b	23b	10d
20°C at flowering stage (T_4)	108b	11	8b	32	51e	21a	23b	9e

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT.

Table 2. Interaction effects of low temperature and variety on yield and yield attributes

Treatments	Plant height (cm)	Total tillers plant^{-1} (no.)	Effective tillers plant^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield plant^{-1} (g)
V_1 T_0	159a	12	11.6a	24	61k	9hij	19	13gh
V_1 T_1	149b	11	9.3bc	13	54o	20cdef	18	10lm
V_1 T_2	142bcd	11	9bcd	11	48q	24bcd	18	7n
V_1T_3	144bc	11	9.6b	11	43t	16efg	18	7n
V_1 T_4	143bcd	11	9bcd	11	44s	21cde	18	7n
V_2 T_0	137cde	9	9bcd	30	66i	15fgh	31	17b
V_2 T_1	136de	10	8.3bcd	21	62j	18defg	30	16cd
V_2 T_2	130ef	10	7.3bcd	21	59l	30a	30	13gh
V_2 T_3	128f	10	7d	23	67h	16efg	30	14fg
V_2 T_4	133ef	10	7d	22	60l	27ab	31	12hi
V_3 T_0	85hij	13	12a	25	58m	8ijk	24	17bc
V_3 T_1	80jk	12	7d	15	92c	15fgh	23	14ef
V_3 T_2	75k	12	7.3cd	14	68g	28ab	24	12ij
V_3 T_3	82ijk	11	7.3cd	20	76e	24bcd	24	11jk
V_3 T_4	85hij	9	8.6bcd	88	47r	24abc	24	9m
V_4 T_0	86hij	12	9.3bc	28	71f	4jk	29	19a
V_4 T_1	85hij	12	9.6b	19	58m	8ijk	27	15de
V_4 T_2	86hij	12	8.6bcd	18	50p	13ghi	27	11ij
V_4 T_3	91gh	12	7.3cd	18	56n	12ghi	27	11jkl
V_4 T_4	90ghi	12	9.3bc	20	43t	14fgh	26	10klm
V_5 T_0	95g	12	11.6a	30	77e	3k	15	13gh
V_5 T_1	91gh	11	8.3bcd	24	95b	5jk	14	11j
V_5 T_2	92gh	11	7d	25	102a	16efg	14	10lm
V_5 T_3	95g	11	7.3cd	21	78d	17efg	14	8n
V_5 T_4	90ghi	12	8.3bcd	18	62j	16efg	14	7n

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT.
Where, V_1= Binadhan-4, V_2= Binadhan-7, V_3= Binadhan-11, V_4= Binadhan-12 and V_5= Binasail rice varieties.
T_0= Ambient temperature, T_1= 20°C attillering stage, T_2= 20°C at panicle initiation stage, T_3= 20°C at booting stage, T_4= 20°C at flowering stage.

Table 3. Effect of temperature on grain dry weight, chlorophyll content and photosynthetic rate of flag leaf during grain filling period of Aman rice genotypes

Treatments	**Grain dry wt. grain^{-1} (mg)**	**SPAD reading (chlorophyll)**	**Pn (μmolCO_2m-^{2}s-^{1})**
Ambient	16a	37a	21a
Temperature stress (20ºC)	15b	35b	12b
Varieties			
Binadhan-4	17b	39a	17b
Binadhan-7	20a	37b	22a
Binadhan-11	15d	36b	16c
Binadhan-12	16c	37b	16b
Binasail	8e	31c	14d
Days after anthesis			
0	2g	38a	21a
4	4f	37a	19b
8	11e	37ab	18c
12	17d	36ab	17d
16	19c	36ab	16e
20	21b	35b	15f
24	24a	35b	14g
28	23a	34b	14h

Values having common letter(s) in a column do not differ significantly at 5% level as per DMRT. Where, Pn= Photosynthetic rate (μmolCO_2m-^{2}s-^{1}).

CONCLUSION

Photosynthetic rate, chlorophyll content of flag leaf, grain dry matter accumulation, the number of total tillers and effective tillers plant^{-1}, filled and unfilled grains panicle^{-1}, 1000-grain weight and grain yield of the rice varieties were significantly affected by temperature treatments. Low temperature (20°C) at flowering stage affected grain yield more compared to other temperature treatments. Grain dry matter accumulation gradually increased but photosynthetic rate in flag leaf decreased from fertilization to maturity. The rice varieties achieved physiological maturity at 24 days and chlorophyll content in flag leaves was stable up to 16 days after anthesis. The highest photosynthetic rate, grain dry matter accumulation and grain yield were found in Binadhan-7 under the treatments. So, Binadhan-7 seems to be tolerant to low temperature (20°C) compared to other varieties.

REFERENCES

Guo Z, Cai L, Liu C (2022) Low-temperature stress affects reactive oxygen species, osmotic adjustment substances, and antioxidants in rice (*Oryza sativa* L.) at the reproductive stage. *Sci Rep* 12: 6224. https://doi.org/10.1038/s41598-022-10420-8

Hafiz MA, Islam MT, Karim MA (2015) Grain growth and yield performance of aromatic rice genotypes under different soil moisture regimes. *Int. J. Sustain. Crop Prod.* 10(2), 44-47.

Hazra P, Islam MT, Das GC (2016) Effect of high temperature on some physiological parameters of grain growth and yield of boro rice varieties. *J. Biosci. Agric. Res.* 7(1), 600–607.

Huang G, Yang Y, Zhu L, Peng S, Li Y (2021) Temperature responses of photosynthesis and stomatal conductance in rice and wheat plants. https://doi.org/10.1016/j.agrformet.2021.108322

Imin N, Kerim T, Rolfe BG, Weinman JJ (2004) Effect of early cold stress on the maturation of rice anthers. *Proteomics*. 4, 1873–1882. DOI 10.1002/pmic.200300738

Islam MT (2010) Photosynthesis, conductance, transpiration, water use efficiency and grain growth of high yielding rice varieties under water stress. *Int. J. Expt. Agric.* 1(2), 1-4.

Islam MT (2011) Effect of temperature on photosynthesis, yield attributes and yield of aromatic rice genotypes. *Int. J. Sustain Crop Prod.*, 6(1), 14-16.

Islam MT (2013) Photosynthesis, chlorophyll stability and grain growth of aromatic rice genotypes under high temperature. *Bangladesh J. Nuclear Agric.*, 27-28:9-14.

Islam MT (2021a) Water stress tolerance in hybrid rice. *Intl. J. Sustain. Crop Prod.*, 16(2), 1-3.

Islam MT (2021b) High soil moisture at flowering stage of boro rice varieties reduces high temperature effect. *Int. J. Expt. Agric.* 11(2), 11-14.

Islam MT (2022) Effect of high temperature on photosynthesis, stomatal conductance, transpiration and yield of boro rice varieties under different soil moisture regimes. *Bangladesh J. Nuclear Agric.* 36(1), 65-72.

Islam MT, Arefin KS (2022) Photosynthesis, chlorophyll flouroscence, stomatal conductance, transpiration, water use efficiency and yield of aman rice genotypes under high temperature at different growth stages. *Int. J. Sustain. Crop Prod.* 17(1), 22-26.

Islam MT, Gretzmacher R (2001) Grain growth pattern and yield performance of some transplanted aman rice cultivars in relation to moisture stress. *Bangladesh J. Nuclear Agric.* 16&17: 21-28.

Islam MT, Hossain MA, Islam MT (2005a) Effect of soil moisture on morpho-physiological and yield attributes of boro rice genotypes. *J. Bangladesh Soc. Agric. Sci. Technol.*, 2(3&4), 81-84.

Islam MT, Islam MT, Salam MA (1994b) Growth and yield performance of some rice genotypes under different soil moisture regimes. *Bangladesh J. Train.Devt.*, 7(2), 57-62.

Islam MT, Khan MEH, Islam MT (2005b) Grain growth pattern and yield attributes of boro rice genotypes under soil moisture stress. *J. Bangladesh Soc. Agric. Sci. Technol*., 2(3&4), 25-28.

Islam MT, Salam MA, Kauser M (1994a) Effect of water stress at different growth stages of rice on yield components and yield. *Progress. Agric*., 5(2), 151-156.

Islam Z, Islam MT, Islam MO (2005c) Effect of soil moisture on dry matter production and yield of boro rice under pot culture conditions. *Bangladesh J. Crop Sci*., 16(1), 37-43.

Jeng TL, Tseng TH, Wang CS, Chen CL, Sung JM (2006) Yield and grain uniformity in contrasting rice genotypes suitable for different growth environments. *Field Crops Res*., 99: 59-66.

Karim MR, Ishikawa M, Ikeda M, Islam MT (2012) Climate change model predicts 33% rice yield decrease in 2100 in Bangladesh. *Agron. Sustain*. Dev., DOI 10.1007/s13593-012-0096-7

Kumar S (2020) Abiotic stresses and their effects on plant growth, yield and nutritional quality of agricultural produce. *Int. J. Sci. Food Agric.* 4(4), 367-378.

Moonmoon S, Fakir MSA, Islam MT (2017) Effect of drought stress on grain dry weight, photosynthesis and chlorophyll in six rice genotypes. *Sch J Agric Vet Sci*., 4(1), 13-17.

Moonmoon S, Fakir MSA, Islam MT (2020a) Assimilation of grain on yield and yield attributes of rice (*Oryza sativa* L.) genotypes under drought stress. *Fourrages*. 241(3), 85-98.

Moonmoon S, Fakir MSA, Islam MT (2020b) Effect of drought on morphology and dry matter partitioning at panicle stage in rice genotypes. Fourrages. 242(6), 19-30.

Moonmoon S, Fakir MSA, Islam MT (2020c) Modulation of morpho-physiology in rice at early tillering stage under drought stress. Role of photosynthates. *Fourrages.* 242(4), 19-37.

Moonmoon S, Fakir MSA, Islam MT (2022a) Biochemical traits at reproductive stages in six rice genotypes under drought stress. *Biotechnol*. 21(1), 15-21.

Moonmoon S, Fakir MSA, Islam MT (2022a) Effect of drought on physiological traits at reproductive stage in six rice genotypes (*Oryza sativa* L.). *Res. J. Bot*. 17(1), 11-17.

Moonmoon S, Islam MT (2017) Effect of drought stress at different growth stages on yield and yield components of six rice (*Oryza sativa* L.) genotypes. *Fundam Appl Agric*., 2(3), 285-289.

Rahman MT, Islam MT, Islam MO (2002) Effect of water stress at different growth stages on yield and yield contributing characters of transplanted aman rice. *Pakistan J. Biol. Sci*., 5(2), 169-172.

Rawson HM (1992) Plant responses to temperature under conditions of elevated CO_2.*Aust J. Bot*. 40: 473-490.

Singh S, Singh TN, Chauhan JS (2010) Productivity of hybrid rice. 1. Vernubility to water stress of reproductive development and inhibition of RuBisCO enzyme in upper leaves as major constraints to yield. *J. New Seeds*. 11(4), 328-355.

Yamori W, Hikosaka K, Way DA (2014) Temperature response of photosynthesis in C3, C4, and CAM plants: temperature acclimation and temperature adaptation. *Photosynthesis Res.* 119: 101-117.

Zohora FT, Islam MT, Baten MA (2016) Drought tolerance of NERICA rice mutants. *Int. J. Sustain. Crop Prod.*, 11(11), 4-8.