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Influence of irrigation regimes and mycorrhizal inoculation on the performance of wheat in pot culture

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Abstract

In order to find out the effect of arbuscular mycorrhizal fungi (AMF) and level of irrigation on wheat, an experiment was conducted in the net house of Department of Agronomy, Bangladesh Agricultural University during November 2018 to April 2019. The study included two levels of AMF inoculation (inoculated and non-inoculated) and three levels of irrigation (*viz.*, no irrigation, one irrigation during CRI stage, and two irrigations at tillering and flowering stages respectively). The treatment combinations were applied to two wheat varieties, *viz.*, BARI Gom-25 and BARI Gom-30. The pot experiment was laid out in randomized complete block design (RCBD) with three replications. Commercially available mycorrhizal inoculum (*Gigaspora margarita*) was used to inoculate the plants of respective treatment pots. The performances of these wheat varieties under two AMF inoculation levels (inoculated and non-inoculated) showed that both varieties were significantly affected by AMF inoculation. Though all growth and yield contributing parameters were not significantly affected by AMF application, it was evident that AMF inoculation helped the wheat plants to grow vigorously and produce higher yield. Both wheat varieties showed their best performance under two irrigation treatment but when inoculation was imposed, it gave better performance than non-inoculated pot. The highest yield was recorded with pots which were inoculated with AMF in both wheat varieties. It was observed that in both varieties, irrigation helps wheat to perform better in terms of all parameters in comparison to no irrigation condition, and two irrigations gave better results than that of one irrigation. AMF inoculation gave higher yield in non-irrigated pots in comparison to non-inoculated non-irrigated pots. Inoculation with AMF increased 23% grain yield plant^{-1} compared to the non-inoculated pots. In BARI Gom-25, one irrigation gave statistically similar yield when the crops was AMF inoculated. This results suggest that AMF inoculation can cut the requirement of one irrigation in wheat crop.

Keywords: AMF, irrigation, moisture stress, wheat, *Gigaspora margarita*

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1 Introduction

By 2050, the world population will be about 9.8 billion, which will be 34% higher from today and it is needed to feed another 2.30 billion people with limited resources (UN, 2017). Food production must need to be increased about 70% and to meet this huge demand cereal production will need to increase about 3 billion metric tons from 2.10 billion metric tons today (Hasan et al., 2017). But in a dilemma, the world agriculture in 21st century faces versatile challenges. Lack of irrigation water and drought stress (DS) is one of the major abiotic factors limiting crop growth and yield throughout the world including Bangladesh. Regionally specific winter season drought (hydrological drought) and dry spells during the monsoon (meteorological drought) are a reoccurring concern in Bangladesh (Mustafa et al., 2017). The agriculture and the livelihood of people of the north and north western regions of Bangladesh are heavily impacted by both types of drought. The farmers rely on residual soil moisture (from the monsoon) for wheat and other Rabi crops cultivation. Reduced and uneven rainfall in the drought-prone area led to the drying up of surface water bodies such as ponds, canals, beels, and rivers (Habiba et al., 2012; Mardy et al., 2018).

Wheat (*Triticum aestivum* L.) is one of the most important cereal grains worldwide (second only to rice in importance) in terms of cultivated area, yield, and food production (Johansson et al., 2013; Ma et al., 2020). More than 20% of the total caloric and protein requirement of human comes from wheat and it is the staple food in over 40 countries for approximately 35% of the world's population (Xiang et al., 2009). Wheat production at global level has significantly increased through the years. About 749.5 million tons of wheat were produced on average of 220 million ha with a productivity level of 3.4 t ha^{-1}, a highly significant increase from 1961, which stood at 222 million tons with a productivity level of only 1.2 t ha^{-1} (Tadesse et al., 2019). However, considering the rapid growth of world population, wheat production needs to double by 2050 for ensuring food security (Seleiman, 2019). Further increases in wheat production depend on higher yields rather than an increase in cropping area (Araus et al., 2003). Declining water resources challenge this notion as water availability impacts heavily on crop yields. Moreover, in some regions, crops are often irrigated unsustainably with water drawn from dwindling aquifers (Feng et al., 2007). More than 50% of the area under wheat cultivation is affected by periodic drought (Rajaram, 2001). In major wheat-growing areas of the world, particularly with a Mediterranean climate, mean pan evaporation often surpasses average precipitation especially during grain filling, leading to drought during reproductive and grain-filling phases, which is also known as 'terminal drought' (Savin et al., 2015). Consumption of wheat, regarded as second staple food for Bangladeshi people, now has become an important supplement of rice. Wheat grown over an area of 3.74 million hectare with an annual production of about 1 million metric tons with an average of 2.60 t ha^{-1} in Bangladesh (Jahan and Ahmed, 2018). This production is less than that of the developed countries because about one third of the total area under wheat in Bangladesh falls in the rainfed regions where water stress can limit plant growth and productivity due to very low or no rainfall (Khaliq et al., 1999). In Bangladesh wheat is grown in rabi season (November to March) under rainfed condition. Usually, no significant precipitation takes place during this period. Most of the farmers grow wheat without irrigation due to scarcity of water. As a result, wheat faces drought stress at later stages that reduces grain yield drastically.

Drought is one of the most severe abiotic stress that constraint to plant productivity. Drought is a multidimensional stress and it triggers an array of plant responses ranging from physiological, biochemical to molecular levels (Kaur and Asthir, 2017; Qi et al., 2018; Batool et al., 2019; Seleiman et al., 2021). It hinders photosynthesis, disrupt the structure of enzymes, reduces nutrient uptake and/or transport to the shoot, therefore prompting a hormonal and nutritional imbalance in the plant (Ruiz-Lozano et al., 2015). In addition, drought stress results in osmotic stress that can lead to turgor loss, thereby, leading to inhibition in plant growth and development (Selmar and Kleinwächter, 2013). One of the inevitable consequences of drought stress is an increase in reactive oxygen species (ROS) production in different cellular compartments, namely the chloroplasts and mitochondria (Sharma and Zheng, 2019).

Arbuscular mycorrhizal fungi (AMF) is a group of endotrophic fungi occurring in almost all terrestrial ecosystems and have been reported to form symbiotic associations with many plants including crops (Begum et al., 2019; Qiang-Sheng et al., 2016). AMF have been reported to increase nutrient uptake efficiency by plants, reduce heavy metal toxicity and increase disease resistance (Sarkar et al., 2015a,b, 2016, 2017, 2018; Talukder et al., 2019; Sarkar et al., 2020; Rashid et al., 2021). They also improve soil moisture acquisition by plants and thereby enhance its growth capacity under drought condition (Millar and Bennett, 2016; Yooyongwech et al., 2012). AMF also influence the stress tolerance mechanisms significantly leading to optimization of biochemical changes arising due to physiological modification, osmoregulation, etc. (Wu et al., 2006; Zhang et al., 2010). Therefore, over the past few decades, companies throughout the world have manufactured and commercialized AMF inoculants using either single AMF species or mixtures of AMF species that may include plant-growth-promoting rhizobacteria or other symbiotic and/or biocontrol fungi (Gianinazzi and Vosátka, 2004). The industrial manufacturing of AMF as crop inoculants is relatively new, and, despite practical demonstrations of the efficiency of AMF, and crop producers have been slow to adopt them. Inoculation with effective microorganisms could lead to enhanced crop productivity and higher incomes for farmers.

Based on the above discussion, we hypothesized that AMF inoculation can increase the productivity of wheat crop under drought condition. The Specific objectives of this study was to study the effect of AMF inoculation on the growth of wheat under varying irrigation regimes.

2 Materials and Methods

2.1 Experimental site and duration

The study was conducted in the net house of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh during the period from November 2018 to April 2019. Geographically, the study site was located at 24°43′11.1″N, 90°25′42.2″E and at an altitude of 18 meter above the sea level. The experimental area was located under the subtropical climate, which is specialized by moderately high temperature and heavy rainfall during April to September and low rainfall with moderately low temperature during October to March. The monthly values of maximum, minimum and average temperature (°C), relative humidity (%), and monthly total rainfall (mm) received at the experimental site during the study period were 29.10 °C, 17.75 °C, 23.43 °C, 80.7%, 3.8 mm, respectively.

2.2 Potting medium

For the pot culture, soil was collected from the field of Agronomy Field Laboratory, BAU. The soil was more or less neutral in reaction (pH 6.7), low in organic matter content (1.29%) and the general fertility level of the soil was low (1% total N, 26 ppm available P and 0.14 me % exchangeable K).

2.3 Preparation of pot and inoculant

No commercially available mycorrhizal inoculum is found. Therefore, to inoculate potting media of respective treatments, AMF spores were applied in the form of a commercial inoculant namely, 'Serakinkon' powder (The Central Glass Company, Tokyo, Japan). The inoculant was composed of 50 *Gigaspora margarita* Becker and Hall (BEG 34) spores per gram powder. The collected soil was mixed with cow dung at 5:1 and was used as potting medium. Chemical fertilizers *viz*. urea, TSP, MP and gypsum were applied @ 10.85, 7.5, 6.0 and 3.4 g 100 g^{-1} soil, respectively. Mycorrhizal inocula were used in the pots where necessary according to the treatment at the rate of 15 g kg^{-1} soil at 3 cm depth of the soil surface and then the soil was saturated with water. Five to six kg of this medium was used per pot (8 L).

2.4 Treatment and experimental design

Two factors were included in the experiment, *viz*., (A) AMF inoculation, and (B) irrigation regimes. AMF had two levels (AMF inoculated and non-inoculated), whereas irrigation regimes had three levels (no irrigation, one irrigation at crown root initiation (CRI) stage, and two irrigations (at CRI stage and flowering stage)). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Two varieties of wheat (BARI Gom-25 and BARI Gom-30) were used in this experiment. Since the assessment of varietal difference was not considered the objective of the experiment, variety was not considered as a factor. Rather, the two sets of similar experiment were conducted with the same setup with two wheat varieties and the results are reported separately.

2.5 Germination test of seed

Wheat seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The seed of each variety were sown in two pots for germination test. The number of sprouted and germinated seeds was counted daily commencing from 1st day till 14th days prior to the commencement of the experiment. After 14 days, final count was done and germination percentage of each day was calculated by the following formula:

$$G = \frac{S_g}{S_T} \times 100 \tag{1}$$

where, G = germination Percentage, S_g = number of seeds germinated, and S_T = total number of seeds set for germination. On an average 85% seeds germinated after 14 days counting.

2.6 Sowing of seeds

Seeds were sown on 20 November 2018. Sowing was done at the rate of 15 seeds per pot. Care was taken to protect the seedlings from birds and rodents up to 20 days after sowing. Protective net was placed around the pots during the protection period.

2.7 Intercultural operations

After germination of seed, only 5-6 plants were kept in each pot. Rest of the plants were removed from the pot. Care were taken while uprooting the plants so that the remaining plants are not injured or affected otherwise. In some pots, there were poor seed germination. Additional seeds were sown in these pots after one week of sowing. Two weddings, one at 20 and the other at 45 days after sowing were done by the help of a nirii. In addition, weeds were removed by hand pulling as and when necessary to keep the pots weed free. Irrigation was given as per the experimental treatment. During the study period (November 2018 to March 2019) the natural monthly total rainfall was 0, 0, 0, 1.2 and 21 mm, respectively. However, during rainfall, the roof of net house was covered with transparent polythene sheet so that no rain water is added to the pots. No infestation of disease and insects were found and hence no control measure was taken.

2.8 Data collection

The leaf greenness was recorded by the help of SPAD 502 Plus Chlorophyll Meter. The leaf greenness was measured in term if SPAD value and it is considered a relative measure of leaf chlorophyll content. At full maturity, the crop was harvested separately pot wise on 01 March and 18 March 2019 for BARI Gom-25 and BARI Gom-30, respectively. The harvested crop of each pot was bundled and separately tagged and brought to the clean threshing floor. The bundles were sun dried, threshed and then the grains were cleaned. The grain yield was taken plot wise and converted to grain yield per plant. Before harvesting five plants from each pot were randomly selected and tagged with labels. The labelled plants were uprooted carefully so that no root is left in the soil.

2.9 Data analysis and visualization

The recorded data were statistically analyzed using open source statistical environment 'R' (R Core Team, 2021). For the Analysis of Variance (ANOVA) were conducted using 'agricolae' package of 'R'. The differences among treatment means were adjudged by Tukey's post hoc test. Plots presenting growth and yield of maize were prepared by 'ggplot2' library (Wickham, 2016) of 'R'.

3 Results and Discussion

3.1 Plant height

Plant height of wheat was significantly affected by AMF inoculation, irrigation management and their interaction in both varieties (Tables 1 and 2, Fig. 1). AMF inoculation two irrigation and combination of AMF × two irrigation produced the tallest plants in both cases. However, it is noticeable from Fig. 1 that one irrigation produced similar plant stature when it was inoculated with AMF. Previous researcher (Sarwar et al., 2010; Gao et al., 2020) have reported that plant height of wheat increases with soil moisture levels. Millar and Bennett (2016) and Yooyongwech et al. (2012) reported that AMF inoculated plants have better soil moisture uptake efficiency under moisture deficit condition. Therefore, similar plant height with both one and two irrigation under AMF inoculation agrees with previous works.

3.2 Flag leaf area

Flag leaf area was not significantly affected by AMF inoculation in both wheat varieties (Table 1). However, irrigation regimes and its interaction with AMF inoculation had significant effect on the same (Table 2, Fig. 1). Flag leaf area is an important yield determining trait (Simón, 1999) and it has osmoregulaiton function under saline and drought condition (Farouk, 2011). Flag leaf area increased numerically with the frequency of irrigation and the it attained 39.83 cm^2 with two irrigation. However, in both varieties, both one and two irrigation had statistically similar impact on it irrespective of AMF inoculaiton (Fig. 1). Inoue et al. (2004) reported that flag leaf area of some wheat varieties decreases under soil moisture deficit condition.

3.3 SPAD value

The chlorophyll meter (or SPAD meter) is a simple, portable diagnostic tool that measures leaf greenness, i.e., the relative chlorophyll concentration in leaves. Compared with traditional destructive methods, this method provides substantial savings in time, space, and resources (Barutcular et al., 2016). Wang et al. (2009) reported a direct relation between soil moisture status and chlorophyll content of maize leaves. In our study, the effects of AMF inoculaiton and irrigation regimes on SPAD value was variety-specific. For example, SPAD value was significantly affected by AMF inoculation in BARI Gom-25, whereas it was not affected in BARI Gom-30 (Table 1). For irrigation regimes, BARI Gom-25 was not affected, however, BARI Gom-30 was significantly affected and SPAD value increased with the frequency of irrigation. It reached 39.83 with two irrigation, whereas in control (no irrigation), the value was 22.67 (Table 2). Any combination of irrigation frequency (one or two) and AMF inoculation gave statistically similar SPAD values and they were significantly higher than AMF0 × no irrigation in both wheat varieties (Fig. 1).

3.4 Ratio of shoot and root dry weights

Under drought condition, plants allocate more photosynthates to the root system for capturing more soil moisture (Nejad, 2011; Xu et al., 2015). Thus, root weight increases and shoot to root (SW-RW) ratio decreases in moisture deficit condition (Pace et al., 1999). Therefore, shoot dry weight to root dry weight ratio is considered an indicator for soil moisture status

Table 1. Effect of arbuscular mycorrhizal fungi (AMF) on growth characters of wheat cv. BARI Gom-25 and BARI Gom-30

Treatment	Plant height (cm)	Flag leaf area (cm^2)	SPAD value	SW-RW ratio
BARI Gom-25				
AMF0	52.71 ± 7.98	31.39 ± 8.31	42.43 ± 4.89	11.54 ± 3.98
AMF1	59.58 ± 4.99	35.99 ± 7.59	48.02 ± 3.31	15.55 ± 6.22
Sig. level	0.43*	0.238 ^{NS}	0.011*	0.122 ^{NS}
BARI Gom-30				
AMF0	61.16 ± 5.23	31.96 ± 9.62	42.20 ± 5.17	9.04 ± 3.49
AMF1	67.73 ± 4.57	35.48 ± 7.89	46.12 ± 4.12	13.28 ± 2.87
Sig. level	0.049*	0.408 ^{NS}	0.094 ^{NS}	0.012*

AMF0 = AMF non-inoculated, AMF1 = AMF inoculated; SW-RW ratio: ratio of shoot and root weights; Values are mean ± standard deviation. NS: treatment means are not significantly different at P = 0.05; * designates treatment means are significantly different at P = 0.05

Table 2. Effect of irrigation management on growth characters of wheat cv. BARI Gom-25 and BARI Gom-30

Treatment	Plant height (cm)	Flag leaf area (cm^2)	SPAD value	SW-RW ratio
BARI Gom-25				
M0	50.28 ± 7.43	24.06 ± 4.40	41.92 ± 6.09	8.96 ± 3.28
M1	55.79 ± 5.12	38.44 ± 3.96	46.47 ± 3.81	14.10 ± 2.65
M2	62.37 ± 3.86	38.56 ± 4.46	47.30 ± 3.48	17.57 ± 6.24
Sig. level	0.007**	<0.001**	0.127 ^{NS}	0.012*
BARI Gom-30				
M0	58.79 ± 6.33	22.67 ± 3.73	39.77 ± 4.49	9.35 ± 3.63
M1	63.29 ± 5.52	38.66 ± 3.77	44.02 ± 2.91	11.69 ± 3.49
M2	71.26 ± 7.06	39.83 ± 3.16	48.70 ± 2.68	12.43 ± 4.17
Sig. level	0.012*	<0.001**	<0.001**	0.36 ^{NS}

M0 = no irrigation, M1 = one irrigation, and M2 = two irrigation; SW-RW ratio: ratio of shoot and root weights; Values are mean ± standard deviation. NS: treatment means are not significantly different at P = 0.05; ** and * designate treatment means are significantly different at P = 0.01 and P = 0.05, respectively.

Table 3. Effect of arbuscular mycorrhizal fungi (AMF) on yield contributing characters and yields of wheat cv. BARI Gom-25 and BARI Gom-30

Treatment	Grains ear^{-1}	WTG (g)	Grain yield (g $plant^{-1}$)	Straw yield (g $plant^{-1}$)
BARI Gom-25				
AMF0	13.72 ± 4.60	45.86 ± 1.63	0.63 ± 0.23	4.45 ± 1.09
AMF1	17.89 ± 4.18	46.05 ± 1.58	0.82 ± 0.18	4.64 ± 0.98
Sig. level	0.061 ^{NS}	0.803 ^{NS}	0.07 ^{NS}	0.7 ^{NS}
BARI Gom-30				
AMF0	15.48 ± 4.14	43.47 ± 1.14	0.67 ± 0.19	3.82 ± 0.72
AMF1	18.54 ± 4.40	44.8 ± 1.11	0.83 ± 0.20	4.52 ± 0.77
Sig. level	0.148 ^{NS}	0.022*	0.107 ^{NS}	0.064 ^{NS}

AMF0 = AMF non-inoculated, AMF1 = AMF inoculated; WTG: weight of 1000 grains; Values are mean ± standard deviation. NS: treatment means are not significantly different at P = 0.05; * designates treatment means are significantly different at P = 0.05

Table 4. Effect of irrigation management on yield contributing characters and yields of wheat cv. BARI Gom-25 and BARI Gom-30

Treatment	Grains ear^{-1}	WTG (g)	Grain yield (g $plant^{-1}$)	Straw yield (g $plant^{-1}$)
BARI Gom-25				
M0	12.47 ± 2.29	45.23 ± 1.52	0.56 ± 0.10	3.45 ± 0.43
M1	15.56 ± 4.20	46.56 ± 1.72	0.72 ± 0.19	4.79 ± 0.81
M2	19.39 ± 5.07	46.08 ± 1.38	0.89 ± 0.24	5.39 ± 0.50
Sig. level	0.030*	0.344 ^{NS}	0.025*	<0.001*
BARI Gom-30				
M0	13.53 ± 3.14	43.87 ± 1.67	0.59 ± 0.14	3.78 ± 0.74
M1	16.53 ± 1.26	44.30 ± 0.94	0.73 ± 0.06	4.34 ± 0.74
M2	20.97 ± 4.66	44.24 ± 1.35	0.93 ± 0.22	4.38 ± 0.93
Sig. level	0.005**	0.844 ^{NS}	0.007**	0.385 ^{NS}

M0 = no irrigation, M1 = one irrigation, and M2 = two irrigation; WTG: weight of 1000 grains; Values are mean ± standard deviation. NS: treatment means are not significantly different at P = 0.05; ** and * designate treatment means are significantly different at P = 0.01 and P = 0.05, respectively.

(Bacher et al., 2021; Xu et al., 2015). The effects of AMF inoculaiton and irrigation regimes on SW-RW ratio was variety-specific. SW-RW ratio was significantly affected by AMF inoculation in BARI Gom-25, whereas it was not affected in BARI Gom-30 (Table 1). For irrigation regimes, BARI Gom-25 was not affected, however, BARI Gom-30 was significantly affected and SW-RW ratio value increased with the frequency of irrigation (Table 2). One or two irrigation and AMF inoculation gave statistically similar RW-SW ratio values and they were significantly higher than AMF0 × no irrigation in both wheat varieties (Fig. 1). The lowest number of grains were found in plots no irrigation and no AMF inoculaiton in both varieties.

3.5 Number of filled grains ear^{-1}

Number of grains ear^{-1} was not significantly affected by AMF inoculation in both wheat varieties (Table 3). However, irrigation regimes and its interaction with AMF inoculation had significant effect on the same (Table 4, Fig. 1). Highest number of grains ear^{-1} (BARI Gom-25:19.39 and BARI Gom-30:21.39) were recorded under two irrigation condition.

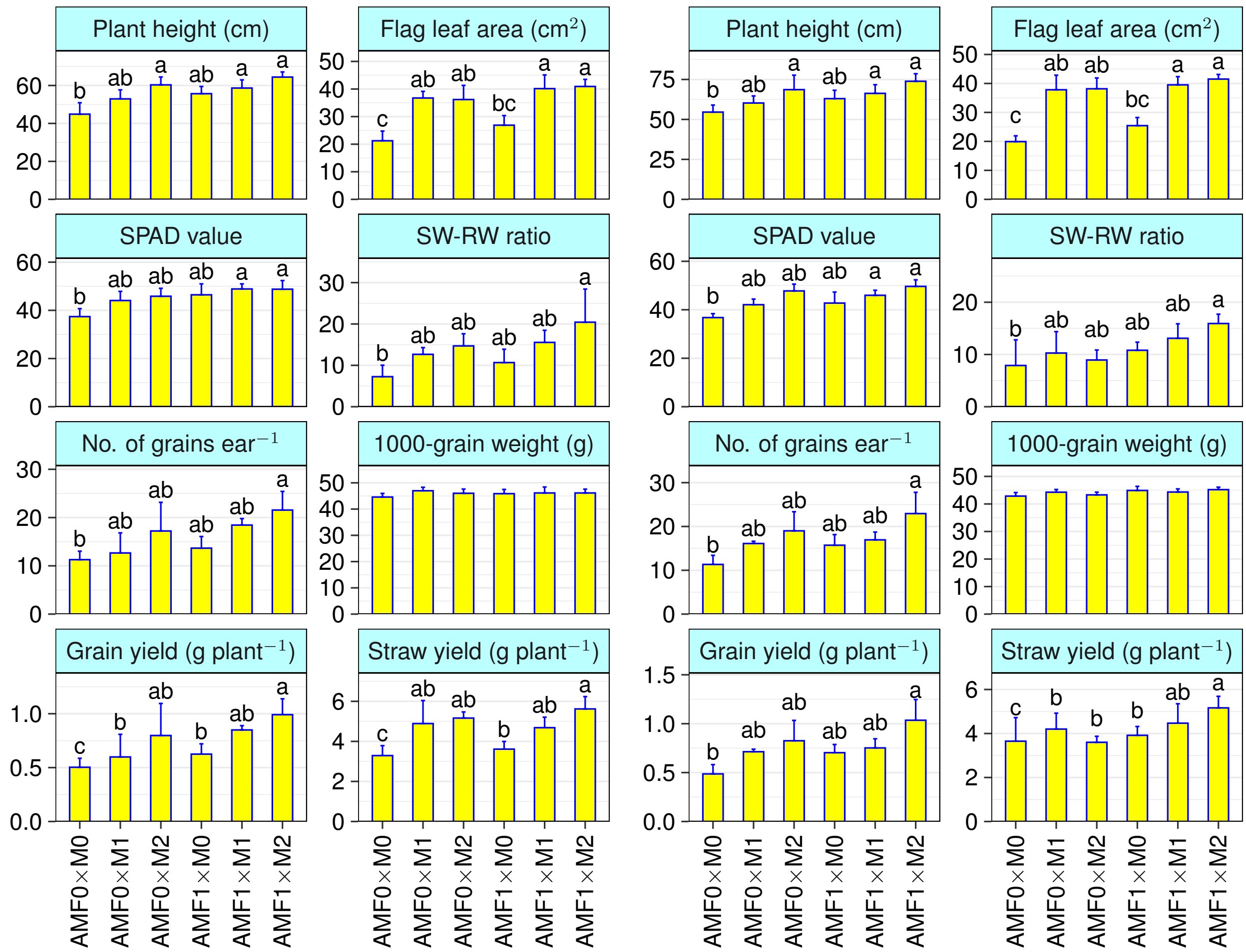
3.6 Weight of 1000 grains

Thousand grain weight of rice did not differ significantly due to AMF inoculation and irrigation management nor their interaction at 5% level of significance (Tables 3 and 4, Fig. 1). Previous studies reported that drought condition affects 1000-grain weight of wheat and reduces grain yield Denčić et al. (2000); Houshmand et al. (2014). On the other hands, some other researchers have found no significant difference in 1000-grain weight of wheat under stress condition (Taheri, 2011).

3.7 Grain yield

Grain yield of wheat was significantly affected by AMF inoculation (Table 3), irrigation regimes (Table 4) and their interaction (Fig. 1) for both varieties. AMF inoculation gave 23% higher yield in BARI Gom-25 and 19% higher yield in BARI Gom-30 over their non-inoculated treatments. In both varieties, irrigation frequency increased grain yield (Table 4). However, when considered the interaction effect of AMF inoculaiton and irrigation management, non-inoculated × non-irrigated pots produced the lowest grain yield in both varieties (Fig. 1).

In BARI Gom-25, the highest grain yield (0.99 g $plant^{-1}$) was observed when the pots were inoculated with AMF and irrigated two times. However, one irrigation gave statistically similar yield when the crops was AMF inoculated. Almost similar pattern of result was observed in BARI Gom-30. However, though AMF inoculation was beneficial, it was noticed that irrespective of AMF inoculation, BARI Gom-30 could produce statistically similar grain yield in both one and two irrigation. BARI Gom-30 is a drought tolerant variety. Its drought tolerance may attributed to this kind of result. Overall, our results suggest that AMF inoculation can cut the requirement of one irrigation in wheat crop. These results can be supported by the observations of ield contributing characters (SPAD value, flag leaf area, number of grains ear^{-1}) of wheat presented in previous sections. Our results are in agreement with previous researchers (Celebi et al., 2010; Bacher et al., 2021; Biel et al., 2021; Leventis et al., 2021) who reported increased yield of AMF inoculated cereal and vegetation crops under deficit soil moisture condition.



(a) BARI Gom-25 **(b)** BARI Gom-30

Figure 1. Effects of interaction between arbuscular mycorrhizal fungi (AMF) inoculation and irrigation management on growth and yield contributing characters, and yields of wheat cv. BARI Gom-25 and BARI Gom-30. AMF0 = AMF non-inoculated, AMF1 = AMF inoculated, M0 = no irrigation, M1 = one irrigation, and M2 = two irrigation, SW-RW ratio = ratio of shoot and root weights

3.8 Straw yield

Straw yield did not differ significantly due to AMF inoculation for neither of the wheat varieties (Table 3). Irrigation significantly affected the straw yield of BARI Gom-25, however, BARI Gom-30 was not affected by the same (Table 4). The interaction of the factors affected the straw yield of both varieties significantly (Fig. 1). The highest straw yield (5.73 g plant^{-1}) was observed with two irrigation when the crop was AMF inoculated in BARI Gom-25. In BARI Gom-30, both irrigation regimes with AMF inoculation gave similar straw yield.

4 Conclusion

The results of this study suggest that the yield of wheat increases with the frequency of irrigation. Though AMF inoculation cannot be an alternative to irrigation under moisture deficit condition, it can reduce the frequency of irrigation. Therefore, AMF can be used in wheat under drought condition.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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