ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 47(3): 257-267, September 2022

MORPHOPHYSIOLOGICAL CHANGES OF MUNGBEAN UNDER DIFFERENT WATER REGIMES

A. NAZRAN[1], J. U. AHMED[2], A. J. M. S. KARIM[3]
T. K. GHOSH[4] AND T. HUSNA[5]

Abstract

Drought stress can severely affect crop growth and productivity by altering several physiological processes. This experiment was carried out to explore the drought tolerance ability of four mungbean varieties based on their water relation and performance of some growth parameters. The experiment was conducted in pot at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur from 27th March to 15th May 2017, under a semi-controlled (vinylhouse) condition. Three different water regimes 50 to 60% field capacity (FC), 70 to 80% FC, 90 to100% FC and four mungbean varieties namely BARI Mung-5, BARI Mung-6, BU mug 2, BU mug 4 were used as treatment variable. Among the three water regimes, 50%-60% FC was considered as the severe drought stress. Results indicated significant variations in different traits of both water and growth parameters of the varieties under severe drought stress (50%-60% FC). Among the four mungbean varieties BARI Mung-6 showed superior performance with higher xylem exudation, chlorophyll content, shoot dry matter and lower water uptake capacity at 50%-60% FC (severe drought stress) whereas BU mug 2 showed the lowest performance. Results of this experiment conclude that BARI Mung-6 can be considered as a more water stress tolerant variety than the other three and recommended for cultivation under water limited conditions.

Keywords: Mungbean, xylem exudation, water uptake capacity, chlorophyll and drought stress.

Introduction

Mung bean (*Vigna radiata* L.) is an important pulse consumed all over the world, particularly in the Asian countries like Bangladesh, India, Pakistan, Myanmar, Indonesia, etc. and has been known to be a promising source of protein as high as 19.5 to 28.5%. (Nair and Schreinemachers, 2020). Mungbean covers 11.66% of total pulse cultivated areas in Bangladesh and secures 4th position (BBS, 2019). In Bangladesh, mungbean cultivated area is 41339.68 hectare and average yield is 0.821 ton/ha (BBS, 2019). Mungbean fits easily in the existing cropping pattern due to its short duration, low input needs, minimum care requirement and also it

---

[1]Lecturer, Department of Crop Botany, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706, [2]Rtd. Professor, Department of Crop Botany, BSMRAU, Gazipur-1706, [3]Rtd. Professor, Department of Soil Science, BSMRAU, Gazipur-1706, [4]Professor, Department of Crop Botany, BSMRAU, Gazipur-1706, [5]Lecturer, Department of Crop Botany, Exim Bank Agricultural University Bangladesh, Chapainawabganj-6300.

increases cropping intensity (Ahmed *et al*., 2019). It also fixes atmospheric nitrogen in soil and improves overall soil health and the system productivity (Khan *et al*., 2018). However, the production of mungbean is greatly hampered due to various abiotic and biotic stresses. Among them drought is the major environmental barrier, which can cause moderate to severe yield loss depending on stress duration and severity, and growth stage of mungbean plant as well (Bangar *et al*, 2019). Different morphophysiological processes of mungbean are greatly hampered due to drought stress, which ultimately reduces the grain yield (Baroowa 2016). Drought stress can reduce munbean yield upto 51% to 85.50% (Zare *et al*., 2013). In Bangladesh, drought stress has become a major concern of for limiting mungbean production to a great extent, especially in the northwestern region. However, it is well known that varietal difference is often found in the response to abiotic stresses. In Bangladesh there are several high yielding mungbean varieties available that are popularly grown by the farmers. Hence, it is utmost needed to analyze the extend of altered morphophysiological processes of the popular varieties due to water stress in order to recommend the suitable one for growing in the drought prone area of the country. This study was therefore conducted under a semi-controlled condition to select a suitable variety under water limiting conditions considering the extent of changes of water relation traits and some growth parameters by the stress.

Materials and Method

The experiment was conducted in pot at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur from 27th March to 15th May 2017, under semi-controlled (vinylhouse) condition. Treatment variables were soil moisture levels of 50%-60%, 70%-80%, 90%-100% field capacity (FC) and four mungbean varieties, namely BARI Mung-5, BARI Mung-6, BUmug 2, BUmug 4. The experiment was conducted by following Completely Randomized Design (CRD) with two factors and four replications. Plastic pots of 25 cm length and 20 cm diameter were filled with 9.5 kg silty clay loam soil with 4:1 ratio of soil and cowdung. Soil was fertilized with 0.11 g N, 0.08 g P, 0.10 g K, 0.05 g S, 0.002 g Zn, and 0.001 g B in terms of 50, 80, 40, 59.37,1.25, and 1.38 kg urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid per hectare, respectively. Ten healthy seeds were sown maintaining uniform spacing in each pot on 27th March 2017 and after emergence six healthy plants were kept. Pesticide application and weeding were done according to the requirement.

After full expansion of first trifoliate leaf (12 DAS), irrigation water was maintained for drought imposition up to harvest and to keep three soil moisture status (50%-60%, 70%-80%, 90%-100% field capacity). According to Giriappa, 1988, irrigation requirement was determined by calculating soil moisture (%) at field capacity (MFC), soil moisture (%) before irrigation (MBI) with soil moisture meter, soil bulk density (A) in gcm^{-3}, rooting depth (D) in cm using the following equation: IR= {(MFC - MBI) ÷ 100} × A× D. The method described by Karim *et.al,* (1988). Used in calculating soil bulk density and soil moisture (%) at field capacity.

Xylem exudation rate (XER) was measured at 5 cm above from the base of plant at flowering stage. At first dry cotton, polyethylene piece and thread were weighed. A slanting cut on stem was made with a sharp knife. The weighed cotton was placed on the cut surface, covered and tied with polyethylene piece and thread. The exudation of sap was collected from the stem for 1 hour at normal temperature. The final weight of the cotton with sap was taken. The exudation rate was expressed per hour basis as follows:

XER = {(Weight of cotton+ polyethylene piece+ thread+ Sap) - (Weight of cotton+ polyethylene piece+ thread)} / Time (h)

Water uptake capacity (WUC) was determined from fully expanded uppermost leaves using 30 leaf disks (4.5 mm wide). The leaf disks were soaked in distilled water (100 ml) and kept in the dark for 24 hours after recording the fresh weight. After 24 hr turgid weight were measured. After that leaf disks were oven dried at 70°C for 72 hours and dry weights were recorded. According to Schonfeld *et.al,* (1988) water uptake capacity (WUC) was determined using following formula: WUC = (TW-FW)/ DW. Here, FW = Fresh weight of the leaf disks, DW = Dry weight of the leaf disks and TW = Turgid weight of the leaf disks.

Chlorophyll content was estimated from the fully expanded uppermost leaf samples using the method described by Porra *et.al,* (1989). The fresh leaf sample of 100 mg were taken in small glass vials containing 5 ml of 80% acetone preserved in the dark for 24 hours. Then the absorbance was measured at 663 nm and 646 nm wave length. 80% acetone was used as blank and the result was expressed as mg g^{-1} fresh weight. The formula for computing chlorophyll a, b and total chlorophyll were-

Chlorophyll a (mg g^{-1} fresh weight) = [12.21 (A663) – 2.81 (A646)] × [V/1000 × W]

Chlorophyll b (mg g^{-1} fresh weight) = [20.13 (A646) – 5.03 (A663)] × [V/1000 × W]

Total Chlorophyll (mg g^{-1} fresh weight) = [20.2 (D646) + 8.02 (D663)] × [V/1000 × W]

Where, V = Volume of acetone used (ml), W = Weight of fresh leaf sample in (g).

The data regarding to the water uptake and chlorophyll content were recorded after the appearance of visual symptom of drought stress (30 DAS) and harvested at 50 days after sowing. Then the pods were separated and shoot (stem and leaf) dry weights were recorded by drying for 72 hours at 70°C in drying oven. The relative performance was calculated using the following formula (Asana and Williams 1965):

Relative performance = Variable measured under stressed condition / Variable measured under normal condition.

Height of individual plant was measured using meter scale from the base at the ground level to the tip of all sampled plants at 20 DAS and 50 DAS. Then change of plant height was measured by deducting the height at 20 DAS from the height gained at 50 DAS.

Statisticx 10 program was utilized for analyzing the collected data with Least Significant Difference (LSD) at 5% level of significance for comparing the treatment means.

Results and Discussion

Xylem Exudation Rate

Xylem exudation rate is known as the flow of sap through the cut end of a stem against the gravitational force. It depends on the available water in soil to be up taken by plant. Xylem exudation rate was greatly interrupted due to water deficit stress in all the four mungbean varieties (Fig 1). Xylem exudation rate was found the highest (1.32 to 2.33 g/hr) at 90% -100% field capacity and it decreased (1.01 to 1.97 g/hr) at 70%-80% field capacity and became lowest (0.76 to 1.58 g/hr) at 50%-60% field capacity. With reducing field capacity, the soil water potential was reduced and as a result the difference of water potential between the soil and the plant root was reduced. This in turn affects to reduce flow rate of xylem exudation. Among the varieties BARI Mug 6 was found to maintain the maximum xylem exudation rate (1.58 g/hr) at the lowest field capacity (50%-60%), while BUmug 2 had the minimum xylem exudation rate (0.76 g/hr) (Fig 1). It indicates that, BARI Mung-6 was able to maintain comparatively better transpiration flow, which might be for its ability to keep higher difference in water potential of soil and leaf. This result is consistent with the report of Islam *et.al,* (2021 and 2022) in mungbean.

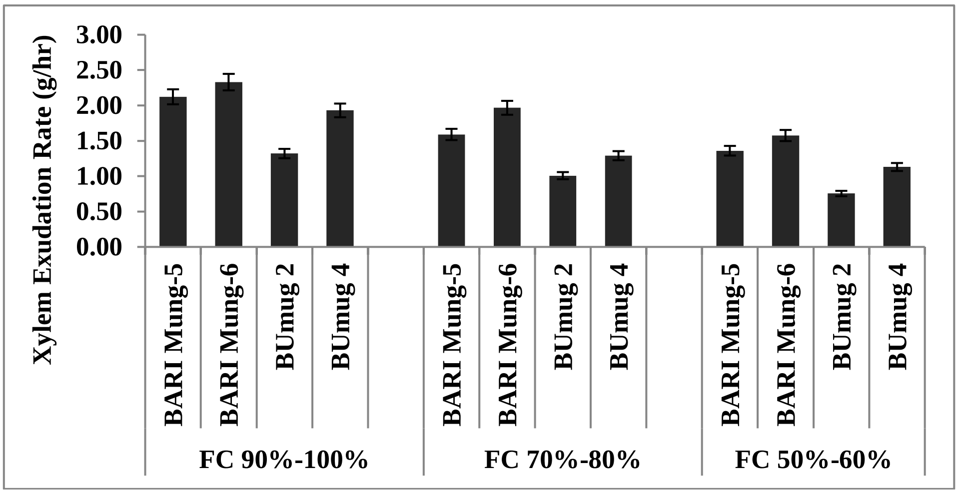

Fig. 1. Xylem Exudation Rate (g/hr) of four mungbean varieties at different levels of field capacity (FC). Bars represent mean ± SE.

Water Uptake Capacity

Water uptake capacity (WUC) quantifies the capacity of plants to reach turgid condition by absorbing water per unit of dry weight. Lower value of WUC indicates better water uptake capacity of a plant. Water uptake capacity (WUC) was recorded 2.43to 3.44% at 50%-60% field capacity, 1.70 to 2.33% at 70% - 80% field capacity and 1.15 to 1.63% at 90%-100% field capacity (Table 1). A higher WUC indicated that plants were subjected to a greater degree of moisture stress as these plants would absorb a greater amount of water to reach turgid weight, which is consistent with the report by Sangakkara *et.al,* (1996). The level of WUC was found to differ among the varieties of mungbean (Table 1). At the lowest field capacity (50%-60%), BARI Mug 6 was found to maintain the minimum WUC (2.43%) while BU mug 2 had the maximum WUC (3.44%) (Table 1). At drought stress condition (50%-60% FC), it indicated that BARI Mung-6 was able to maintain water level very close to the turgid level among the four mungbean varieties. Results were also reported that the tolerant varieties possessed the lowest WUC under drought stress compared to other varieties. (Islam *et.al,* 2022).

Table 1. Water uptake capacity (WUC) of four mungbean varieties under three variable water regimes

Variety	Water Uptake Capacity		
	FC of 90%-100%	FC of 70%-80%	FC of 50%-60%
BARI Mung-5	1.32 i	1.99 f	2.75 c
BARI Mung-6	1.15 j	1.70 g	2.43 d
BUmug 2	1.63 g	2.33 d	3.44 a
BUmug 4	1.47 h	2.16 e	3.24 b
CV%		4.48	

Means along both rows and columns followed by the same letter (s) did not differ significantly at 5% level of probability.

Chlorophyll Content

Chlorophyll content was reduced significantly under water deficit condition, imposed in terms of variable field capacity (Table 2). The chlorophyll-a content in the treatments with the lowest field capacity (50% - 60%) was 1.30 mg/g FW in BARI Mung-6 whereas in high field capacity (90 % - 100%) it was 1.40 mg/g FW. Chlorophyll-b content in BARI Mung-6 was 1.10 mg/g FW at 90 % - 100% field capacity and that was reduced to 1.01 mg/g FW at 50% - 60% field capacity in BARI Mung-6. At both the field capacity (90%-100% & 50%-60%), BUmug 2 showed lower amount of chlorophyll-a (1.27 to 1.10 mg/g FW) and chlorophyll-b content (1.01 to 0.97 mg/g FW). It might be due to genetic variation of varieties. On the other hand the decrease of chlorophyll content under water deficit condition can be attributed to the sensitivity of this pigment to increasing environmental stresses, especially to drought and salinity (Sing *et.al,* 2021).

Table 2. Chlorophyll content of four mungbean varieties under three variable water regimes

Variety	Chlorophyll a (mg/g fresh weight)			Chlorophyll b (mg/g fresh weight)			Total Chlorophyll (mg/g fresh weight)		
	FC of 90%-100%	FC of 70%-80%	FC of 50%-60%	FC of 90%-100%	FC of 70%-80%	FC of 50%-60%	FC of 90%-100%	FC of 70%-80%	FC of 50%-60%
BARI Mung-5	1.38 a	1.24 d	1.21 de	1.05 b	1.01 cde	0.99 ef	1.71 b	1.60 d	1.52 e
BARI Mung-6	1.40 a	1.35 b	1.30 c	1.10 a	1.03 bc	1.01 cde	1.75 a	1.68 bc	1.65 c
BUmug 2	1.27 c	1.16 f	1.10 g	1.01 cde	0.99 ef	0.97 f	1.60 d	1.49 e	1.39 f
BUmug 4	1.37 ab	1.22 de	1.19 e	1.03 bcd	1.00 de	0.98 ef	1.68 bc	1.57 d	1.48 e
CV		1.87			2.18			1.60	

Means along both rows and columns followed by the same letter (s) did not differ significantly at 5% level of probability.

As such, in treatment with the lower field capacity (50%-60%), BARI Mug 6 was found to maintain the higher level of chlorophyll-a, chlorophyll-b and total chlorophyll content (1.30, 1.01 and 1.65 mg/g FW respectively) while BUmug 2 had the lower level of chlorophyll a, chlorophyll b and total chlorophyll content (1.10, 0.97 and 1.39 mg/g FW respectively). Similar result is also recorded by Islam *et.al*, (2022). This result indicates that at water deficit condition, BARI Mung-6 was able to reduce chlorophyll degradation most efficiently among all the four mungbean varieties.

Shoot Dry Weight

Field capacity with different soil water status had a profound effect on total shoot dry weight. Shoot weight was found higher at 100%-90% field capacity (7.98 to 13.82 g/plant), which decreased to 5.19 to 10.86 g/plant at 70%-80% field capacity and lowest at 50%-60% field capacity 2.38 to 5.76 g/plant (Fig 2.a) in all the mungbean varieties. The highest shoot dry weight was recorded in BARI Mung-6 i.e. 5.76 g/plant under drought stress condition (50%-60% field capacity) while BUmug 2 was recorded with lowest shoot weight 1.93 g/plant. Imtiaz *et.al*, (2020) and Prakash *et.al*, (2017) also found dry weight reduction in water stress condition. Relative shoot dry weight at 50%-60% and 70%-80% field capacity was also higher in BARI Mung-6 (0.42 and 0.79 respectively) compare to that of BUmug 2 (0.30 and 0.65 respectively) (Fig. 2.b). This result indicated that among all the four mungbean varieties BARI Mung-6 was most competent to accumulate dry matter under drought stress condition.

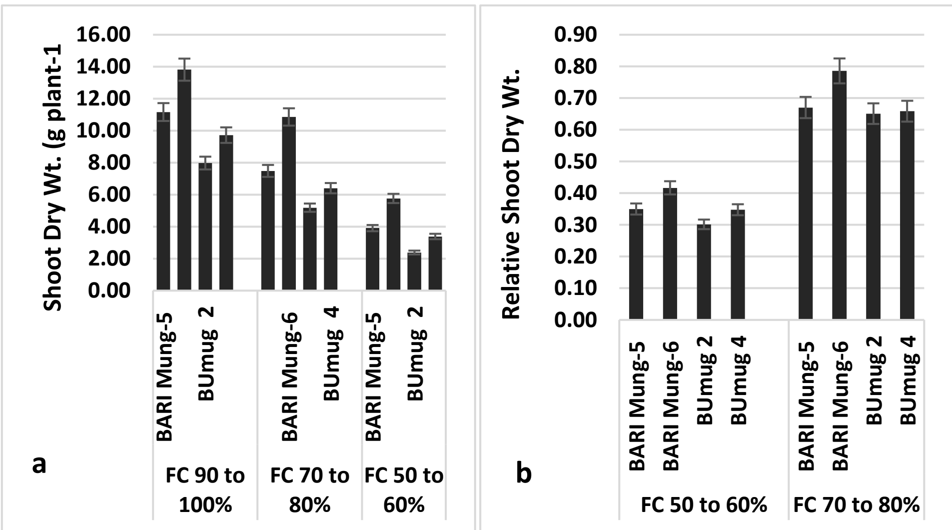

Fig 2. Shoot dry weight (g/plant) (a) at three different levels of water regime and relative shoot dry weight (b) at 50-60% and 70%-80% field capacity compared to 90-100% FC of four mungbean varieties. Bars represent mean ±SE.

Plant Height Change

Plant height was affected adversely by the water deficit stress, imposed in term of variable field capacity. Irrespective of mungbean varieties, increasing rate of plant height was found higher at 90%-100% field capacity with a range of 5.10 to 5.96 (cm/month). Increasing rate of plant height was decreased (3.52 to 5.46 cm/month) when field capacity at 70%-80%. Then at 50%-60% field capacity increasing rate of plant height was found the lowest (2.67 to 4.47 cm/month) (Fig. 3). According to Bangar *et.al,* (2019), drought reduced plant height of mungbean in both vegetative and reproductive stage. Among the four mungbean varieties BARI Mung-6 was recorded with maximum Increase of plant height (4.47 cm/month) compare to that of BUmug 2 (2.67 cm/month) under drought stress condition (50%-60% field capacity) (Fig 3). The result indicated that BARI Mung-6 was able to maintain higher turgidity due to its higher water uptake capacity and xylem exudation rate, which ultimately helped it to had higher plant height among all the four mungbean varieties.

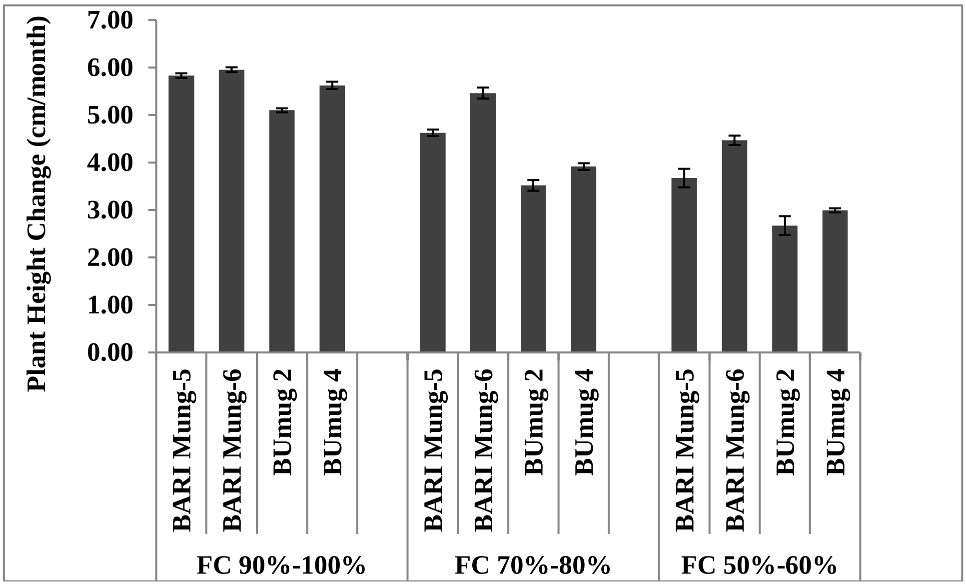

Fig 3. Increase of plant height from 20 DAS to 50 DAS at different level of water regime in four mungbean varieties. Bars represent mean ±SE.

Number of pods per plant

Drought stress adversely affected the pod number per plant, as treated with different level of field capacity (Table 3). Pod number was found higher in all the four mungbean varieties at 90%-100% field capacity (17.00 to 23.00 pod/plant) which decreased in 12.00 to 16.00 pod/plant with field capacity (70%-80%) and the lowest pod number (7.00 to 11.00 pod/plant) was recorded at 50%-60% field capacity. The reduction in number of pod/plant was might be due to water shortage at flowering phase that increased pollen abortion which is consistent with the report of Prakash *et.al*, (2017). It seems that shortage of water in the reproductive phages led to the reduction in photosynthesis and increased in ABA catalyst (Bangar *et.al,* 2019) that ultimately caused the abscission of flowers and young pods. Under water deficit condition (60%-50% field capacity) BARI Mung-6 had the highest pod number (11.00 pod/plant), while BUmug 2 had the lowest pod number (7.00 pod/plant). It indicated that water status of BARI Mung-6 at flowering stage was comparatively higher in drought stress condition among all the for mungbean varieties, which resulted in less abscission of flower or young pod.

Table 3. Number of pod per plant of four mungbean varieties under three variable water regime

Variety	Number of Pod/Plant		
	FC of 90%-100%	FC of 70%-80%	FC of 50%-60%
BARI Mung-5	20.00 b	14.00 d	10.00 g
BARI Mung-6	23.00 a	16.00 c	11.00 fg
BUmug 2	17.00 c	12.00 ef	7.00 h
BUmug 4	19.00 b	13.00 de	8.00 h
CV%		8.90	

Means along both rows and columns followed by the same letter (s) did not differ significantly at 5% level of probability.

Conclusion

Drought stress effect on different morpho-physiological parameters was found minimum in BARI Mung-6, followed by BARI Mung-5 and BUmug 4. The effect of drought stress was maximum in BUmug 2. Based on the findings it was concluded that BARI Mung-6 is relatively tolerant to water shortage effect and can be recommended for cultivation in the drought prone area of Bangladesh.

Acknowledgement

We acknowledge greatly the financial support of Research Management committee (RMC), Bangabandhu Sheikh Mujibur Rahman Agricultural University and Ministry of Science and Technology for the successful completion of this research work.

References

Ahmed, S., A. Quddus, M. Mohiuddin, M. Islam, and M. Hossain. (2019). Performance of lentil-mungbean-T.aus rice-T.aman rice against existing cropping pattern lentil-jute-T.aman rice in Faridpur region. *Bangladesh Journal of Agricultural Research*. **44**(3): 537-552. Available at: https://doi.org/10.3329/bjar.v44i3.43484

Asana, R. D. and R. F. Williams. 1965. The effect of temperature stress on grain development in wheat. *Australian. J. Agric. Res*. **16**: 1-3.

Bangar, P., A. Chaudhury, B. Tiwari, S. Kumar, R. Kumari and K. V. Bhat. (2019). Morphophysiological and biochemical response of mungbean [*Vigna radiata* (L.) Wilczek] varieties at different developmental stages under drought stress. *Turkish Journal of Biology*. **43**(1): 58-69.

Baroowa, B., N. Gogoi and M. Farooq. (2016). Changes in physiological, biochemical and antioxidant enzyme activities of green gram (*Vigna radiata* L.) genotypes under drought. *Acta Physiol. Plant*. **38:** 219.

BBS. (2019). Yearbook of agricultural statistics, Bangladesh bureau of statistics. Statistics and Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh. Retrieved from: http://www.bbs.gov.bd/site/page/3e838eb6-30a2-4709-be85-40484b0c16c6.

Giriappa, S. 1988. Water use efficiency in agriculture. Oxford and IBH Publishing Co. New Delhi. 6.

Imtiaz, A. A., S. A. Shahriar, M. A. Baque, M. N. K. Eaty and M. R. Falguni. (2020). Screening of mungbean genotypes under polyethylene glycol (PEG) induced drought stress condition. *Annual Research & Review in Biology*. 1-12.

Islam, M. R., M. M. Kamal, M. A. Alam, J. Hossain, W. Soufan, M. Skalicky and M. S. Islam. (2021). Physiochemical changes of Mung bean [*Vigna radiata* (L.) R. wilczek] in responses to varying irrigation regimes. *Horticulturae*. **7(12):** 565.

Islam, M. R., M. M. Kamal, M. F. Hossain, J. Hossain, M. G. Azam, M. M. Akhter and M. S. Islam. (2022). Drought Tolerance in Mung Bean is Associated with the Genotypic Divergence, Regulation of Proline, Photosynthetic Pigment and Water Relation. Phyton-International Journal of Experimental Botany.

Karim, Z., S. M. Rahman, M. Tdris and A. J. M. S. Karim. 1988. Soil bulk density. In: A manual for determination of soil physical parameters. Soil and irrigation division. BARC.

Khan, M., N. Sultana, N. Akter, M. Zaman and A. Choudhury. (2018). Increasing cropping intensity and productivity through mungbean inclusion in wheat-fallow-T. Aman rice cropping pattern. *Bangladesh Journal of Agricultural Research*. **43**(2): 333-343. Available at: https://doi.org/10.3329/bjar.v43i2.37336.

Nair, R., and P. Schreinemachers. (2020). Global status and economic importance of mungbean. *The mungbean genome*. 1-8.

Porra, R. J., W. A. Thompson and P. E. Kriedemann, (1989). Determination of accurate extinction coefficients and simultaneous equations for assaying chlorophylls a and b extracted with four different solvents: verification of the concentration of chlorophyll standards by atomic absorption spectroscopy. *Biochimica et Biophysica Acta (BBA)-Bioenergetics*. **975**(3): 384-394.

Prakash, M., B. Sunilkumar, G. Sathiyanarayanan and J. Gokulakrishnan. (2017). Screening for drought tolerance in mungbean. *Legume Research-An International Journal*. **40**(3): 423-428.

Sangakkara, U. R., U. A. Hartwig and J. Nösberger. (1996). Response of root branching and shoot water potentials of french beans (*Phaseolus vulgaris* L.) to soil moisture and fertilizer potassium. *Journal of Agronomy and Crop Science*. **177**(3): 165-173.

Schonfeld, M. A., R. C. Johnson, B. F. Carver and D. W. Mornhinweg. 1988. Water relations in winter wheat as drought resistance indicator. *Crop Sci*. **28**: 526-531.

Singh, L., D. Kohli, K. Gaikwad, R. Kansal, A. Dahuja, V. Paul, C. Bharadwaj and P.K. Jain. (2021). Effect of drought stress on morphological, biochemical, physiological traits and expression analysis of microRNAs in drought-tolerant and sensitive genotypes of chickpea. *Indian Journal of Genetics and Plant Breeding*. **81**(02): 266-276.

Zare, M., B. Dehghani, O. Alizadeh and A. Azarpanah, (2013). The evaluation of various agronomic traits of mungbean (*Vigna radiate* L.) genotypes under drought stress and non-stress conditions. *Int. J. Farming Allied Sci.* **2**: 764–770.