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RESPONSE OF LENTIL VARIRTIES ON YIELD AND YIELD CONTRIBUTING CHARACTER AS INFLUENCE BY DEFICIT IRRIGATION.

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A B S T R A C T

The field experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, during the period from 2nd December, 2018 to 21th March, 2019 to find out the effect of deficit irrigation schedule for lentil, which was measured on the basis of field capacity. The field experiment was set up using split plot experimental design including two lentil varieties (BARI masur-3 & BARI masur-6) and four irrigation regimes viz. T_1 (irrigation based on 125% of field capacity), T_2 (irrigation based on 100% of field capacity), T_3 (irrigation based on 75% of field capacity) and T_4 (irrigation based on 50% of field capacity). Considering different phyto-physiological responses as well as yield components, and yield of lentil, it was found that different irrigation regimes differed significantly and most of the cases highest performance was noted for maximum irrigation treatment (T_1) which reduced gradually with the reduction of irrigation amount. Highest grain yield (1.17 t ha^{-1}) was observed in the treatment T_1 which was statistically identical to the T_2 (1.03 t ha^{-1}). However, grain yield reduced significantly by 23.93% and 34.18% for T_3 and T_4 respectively, but water use efficiency (WUE) was higher in T_4 (2.82 kg ha^{-1} mm^{-1}) and the lower (2.18 kg ha^{-1} mm^{-1}) in T_3. The lentil varieties differ significantly; overall performance was good in V_2 (BARI masur-6). Highest grain yield (1.29 t ha^{-1}) was obtained from combination of V_2T_1, which was more or less similar to combination of V_2T_2. Based on my result, it was seemed that, irrigation amount equivalent to 100% of field capacity can produce nearly same amount of yield of lentil with 25 % less irrigational water compared with T_1. Therefore, it is suggested that irrigation amount equivalent to 100% of field capacity would be the best practices for lentil cultivation that achieves an acceptable grain yield and allows for reductions in irrigation water consumption.

1. INTRODUCTION

Among the pulse crops, lentil *(Lens culinaris)* is one of the important pulse crop grown in Bangladesh. In Bangladesh, lentil ranks second in acreage and production but ranks first in consumer preference, total consumption and market price (BBS, 2008). Cultivation of lentil is mainly concentrated within the Gangetic floodplains in the northern and southern districts of the country.

Lentils are used to prepare an inexpensive and nutritious split (Dal) all over Bangladesh. Lentil grain contains 59.8% carbohydrate, 25.8% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, M.A.A. 1981). The green plants can also be used as animal feed and its residues have manual value. Lentil grains contain high protein, good flavor and easily digestible component. It may play an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh. But the acreage and production of lentil are steadily declining (BBS, 2009).

At present the area under pulse crops is 0.73 million hectares with a production of 0.53 million tons, where lentil is cultivated in the area of 0.20 million hectares with a production of 0.17 million tons (BBS, 2008). The average yield of lentil in Bangladesh is very poor in comparison to other lentil growing countries of the world (BBS, 2008).

Table 1: Summary crop statistics of lentil (2015-16, 2016-17, 2017-18, BBS,2018)

Crop	2015-2016			2016-2017			2017-2018		
	Area Acres	**Per acre Yield (Kg)**	**Production M.Tons**	**Area Acres**	**Per acre Yield (Kg)**	**Production M.Tons**	**Area Acres**	**Per acre Yield (Kg)**	**Production M.Tons**
Lentil	381653	415	158228	382224	442	168837	385399	458	176633

There are many reasons of lower yield of lentil. The management of irrigation water is important one that greatly affects the growth, development and yield of this crop. We know that pulses, mostly lentil, need less amount of water. Water is required for its production and maintenance (Sadasivam *et al.*, 1988).

Bangladesh is a small developing country with rising population where water requirement has continued to increase in all sectors. North-Western part of Bangladesh is received lowest rainfall and now affected by water scarcity problems in agriculture and secured livelihood. For the last few decades Bangladesh is facing water related difficulties like river bed siltation, low water flow and a big dam made by neighboring country India.

Barind Tract has a different geographic character than other parts of Bangladesh. Its soil formation is also different. This northern part is 37 meter above the sea level. People in this area used to cultivate rice once a year, but now produce various crops round the year including lentil. Recently, farmers are switching to lentil cultivation in increasing numbers because of better prices of the pulses and high demand by feed. Therefore, improved irrigation techniques are needed to increase the water use efficiency of lentil.

Under conditions of scarce water supply and drought, deficit irrigation can lead to greater economic gain by maximizing water use efficiency. The term water use efficiency is used to describe the relation between crop yield and water use (Zhang and Owesis, 1998). The main objective of deficit irrigation is to increase the WUE of a crop by eliminating irrigations that have little impact on yield. The resulting yield reduction may be small compared with the benefits gained through diverting the saved water to irrigate other crops for which water would normally be insufficient under traditional irrigation practices.

Before implementing a deficit irrigation program, it is necessary to know crop yield responses to water stress, either during defined growth stages or throughout the whole season (Kirda and Kanber, 1999). Deficit (or regulated deficit) irrigation is one of the most useful way for maximizing water use efficiency by producing higher yields per unit of irrigation water applied (Tekwa and Bwade, 2011). Technique of field capacity for irrigation scheduling is extensively used by many researchers.

Therefore, the objectives are- (i)To justify the varietal performance of lentil on the grain yield, (ii)To evaluate the effect of deficit irrigation on the yield of lentil, (iii)To see the interaction effect between varieties and deficit irrigation on the yield and yield components of lentil, (iv)To find out the optimum level and time of irrigation.

Materials and Methods

PLANT MATERIALS AND GROWTH CONDITION:

The experiment conducted at agronomy field laboratory, Department of Agronomy and Agricultural Extension, Rajshahi University, Rajshahi, during the period December 2018 to March 2019. The experimental field was situated at the western side of Agronomy and Agricultural Extension Department. Geographically the experimental field was located at $24^0$22'36" N latitude and $88^0$38' 36"E longitude at an elevation of 20m above the sea level belonging to the agro ecological zone (AEZ-11). The experimental field was a high land with sandy loam textured soil having p^H value of 8.1.

Two modern lentil varieties i.e. (BARI masur-3 & BARI masur-6) collected from Regional BADC Station, Rajshahi were used in this experiment. BARI masur-3 was rust & stemphylium disease tolerant and BARI Masur-6 was resistance to rust/STB and tolerant foot rot, moderately resistance to aphid and both varieties were high yielding. BARI masur-3 was released in 1996 & BARI Masur-6 was released in 2006.

Experimental treatments: Two factors are included in this experiment (Factor A & Factor B). Factor A= Varieties, V_1 (BARI masur -3) and V_2 (BARI masur -6) and Factor B= Irrigation frequency. The following irrigation frequencies were included in this experiment: T_1= irrigation based on 125% of Field capacity, T_2= irrigation based on 100% of Field capacity, T_3 = irrigation based on 75% of Field capacity and T_4= irrigation based on 50% of Field capacity. The experiment was laid out in a split plot design with three replications. The total number of unit plots in the entire experimental plot was 24 (2.5m×2m).

Estimation of irrigation water: The irrigation water was applied to bring the soil moisture at field capacity within effective root zone depth. Soil moisture was determined before irrigation by digital moisture meter and gravimetric method. The normal depth of water to be applied was determined using the following equation:

$$d = \frac{Fc - Mci}{100} \times A_s \times D \quad \text{...(i)}$$

where,

d = Depth of irrigation, mm, F_c = Field capacity of the soil %, M_{ci} = Moisture content of the soil at the time of irrigation %, As = Apparent specific gravity, D = Root zone depth, mm.

Crop cultivation and agronomic management: Power tiller was used for the preparation of the experimental field. All the weeds and stubbles were removed from the experimental field. The plots were spaded one day before planting and the basal dose of fertilizers were incorporated thoroughly before planting according to fertilizer recommendation guide (BARC, 1997). The soil was treated with insecticides at the time of final ploughing. Insecticides Furadan 5G was used @ 8 kg ha^{-1} to protect young plants from the attack of mole cricket, ants, and cutworms. One third of urea (45 kg ha^{-1}) along with whole TSP (80 kg ha^{-1}), MoP (80 kg ha^{-1}) and Gypsum (35 kg ha^{-1}) were applied during final land preparation and were thoroughly mixed to the soil. The remaining half of urea was top dressed at first irrigation (22 DAS) and least one third of urea was applied at 2^{nd} irrigation, 50 DAS.

Seeds of BARI masur varieties were hand sown in the experimental plot. Seeds were sown on 2^{nd} December 2018. The row to row and plant to plant distances were 25 and 4 cm, respectively. Seeds were placed at about 5 cm depth from the soil surface. Emergence of seedling was completed within 10 days after sowing. Overcrowded seedlings were thinned out two times.

The plot was irrigated three times during the growing period of crop. The irrigation was applied at 22 DAS, 50 DAS and 75 DAS. Drainage was done when necessary, by using drainage channels. Irrigation was done according to following rules (Table 2).

Table 2: Number of irrigation and Field capacity of water applied under different treatments 8cm (100%FC)

Treatment	Depth of Irrigation Water Applied(mm)				
	IR_1	IR_2	IR_3	Rainfall	Total
T_1 125%FC	100	80	160	192.5	532.5
$T_2$100%FC	80	50	120	192.5	442.5
$T_3$75%FC	60	30	80	192.5	362.5
$T_4$50%FC	40	0	40	192.5	272.5

mm = milimeter; FC=Field capacity

The field was observed time to time to detect visual difference among the treatments and any kind of infestation. The experimental crop was not infected with any disease and no fungicide was used.

Crop was harvested plot wise after 120 days of sowing for data collection when about 80% of the pods attained maturity. Data were recorded on $1m^2$ area of the middle portion of each plot. The harvested plants of each treatment were brought to the cleaned threshing floor and separated pods from pants by hand and allowed them for drying well under bright sunlight. After threshing, grain yields and stover yields of each plot were recorded separately.

The data of the different parameters of lentil were collected from randomly selected five plant samples which collected from the middle portion of the plot ($1m^2$). Finally, grain weights were taken on individual plot basis at moisture content of 12% and converted into kg ha^{-1}. The yield of dry stover was also taken. At final harvest, data on some morpho-physiological, yield components and yield were also collected.

Statistical procedure: The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) using the statistical computer package program, STATVIEW (Gomez and Gomez, 1984).

RESULTS

During our study growth, yield contributing characters and yield of lentil varieties influenced by deficit irrigation were evaluated. Plant height of lentil was measured on 84 days after sowing (DAS) and those are presented in (**Table 3)**. At 84 DAS, highest plant height (57.16 cm) was obtained in V_2 which reduced significantly (9.62%) in V_1. The effect of irrigation frequencies on plant height of lentil was statistically significant at 84 DAS. At 84 DAS highest plant height (60.33 cm) was observed in T_1 which reduced 6.26% in T_2 but significantly 13.16 and 19.79% for T_3 and T_4 respectively. Plant height was statistically significant due to interaction between varieties and irrigation frequencies at 84 DAS (**Table 3**). At 84 DAS, the tallest plant (61.89 cm) was obtained from V_2 with T_1 and the shortest plant (45.44) was observed in V_1 with T_4.

Ahmed *et.al.*, (2006) observed that the irrigation had a significant effect on plant height and the plant height increase gradually with increasing number of irrigations. Mugabe and Nyakatawa, (2000) stated that growth decreased when the three-quarters and half water requirements were supplied.

Plant dry matter was significantly varied within the lentil varieties. The total dry matter production was not differed significantly at 21 DAS, but it was significantly influenced at 42, 63 and 84 DAS (**Table 3**). At 21 DAS, the highest TDM (0.51 g $plant^{-1}$) was observed in V_2 and the lowest TDM (0.46 g $plant^{-1}$) was obtained at V_1. At 42 DAS, highest TDM (2.83 g $plant^{-1}$) was obtained in V_2 which reduced significantly (23.67%) in V_1. At 63 DAS, highest TDM (10.06 g plant^{-1}) was obtained in V_2 which reduced significantly (25.24%) in V_1. At 84 DAS, highest TDM (14.51 g plant^{-1}) was obtained in V_2 which reduced significantly (36.25%) in V_1.

The main effect of different irrigation levels on plant dry weight was significant except 21 DAS **(Table 3)**. At 21 DAS, the highest TDM (0.05 g plant^{-1}) was observed in T_1 and the lowest (0.48 g plant^{-1}) was in T_3. At 42 DAS, highest TDM (3.36 g plant^{-1}) was observed in T_1 which reduced 25.29% in T_2 but significantly 34.82% and 43.15% for T_3 and T_4 respectively. At 63 DAS, highest TDM (11.23 g plant^{-1}) was observed in T_1 which reduced 17.80% in T_2 but significantly 29.65% and 39.44% for T_3 and T_4 respectively. At 84 DAS, highest TDM (16.70 g plant^{-1}) was observed in T_1 which reduced 21.67% in T_2 but significantly 42.63% and 51.25% for T_3 and T_4 respectively.

Significant effects in TDM were observed in interaction between variety and irrigation frequency of lentil **(Table 3).** At 21 DAS, the highest TDM (0.56 g plant^{-1}) was observed in combination of V_2T_4 and the lowest value (0.43 g plant^{-1}) was observed in V_1T_4. At 42 DAS, the highest TDM (4 g plant^{-1}) was observed in V_2T_1 and the lowest value (1.66 g plant^{-1}) was observed in V_1T_4. At 63 DAS, the highest TDM (13.43 g plant^{-1}) was observed in V_2T_1 and the lowest value (5.70 g plant^{-1}) was observed in V_1T_4. At 84 DAS, the highest TDM (21.50 g plant^{-1}) was observed in V_2T_1 and the lowest value (6.86g plant^{-1}) was observed in V_1T_4. Khakwani, A. A., *et.al.*(2012) found in a field trial that two wheat varieties were subjected to water stress at booting and anthesis stage. Water stress at both stages reduced total dry matter.

Result showed that the two lentil varieties (BARI masur-3) and (BARI masur-6) differed significantly in crop growth rate **(Table 3).** At 21-42 DAS, the highest crop growth rate (0.80g m^{-2}day^{-1}) was found in V_2, and the lowest (0.69 g m^{-2}day^{-1}) was in V_1. At 43-63 DAS, the highest crop growth rate (2.49 g m^{-2} day^{-1}) was found in V_2 and the lowest (2.19 g m^{-2}day^{-1}) was in V_1. At 64-84 DAS, the highest crop growth rate (1.55g m^{-2}day^{-1}) was found in V_2 which reduced remarkably 49.67% in V_1.

Deficit irrigation showed significant effect on crop growth at 21-42, 43-63 but remarkably at 64-84 DAS **(Table 3).** At 21-42 DAS, highest CGR (1.09 gm^{-2} day^{-1}) was observed in T_1 which reduced 31.19% in T_2 but significantly 42.20% and 52.29% for T_3 and T_4 respectively. At 43-63 DAS, highest CGR (3.00 gm^{-2}day^{-1}) was observed in T_1 which reduced 18.66% in T_2 but significantly 28.66% and 41% for T_3 and T_4 respectively. At 64-84 DAS, highest CGR (2.07 g m^{-2}day^{-1}) was observed in T_1which reduced 29.46% in T_2 but significantly 69.56% and 76.32% for T_3 and T_4 respectively.

Crop growth rate differed significantly due to interaction between varieties and irrigation frequencies **(Table 3)**. At 21-42 DAS, the highest CGR (1.27 g m^{-2}day^{-1}) was observed in combination of V_2T_1, and the lowest value (0.51 g m^{-2} day^{-1}) was obtained from V_1T_4. At 43-63 DAS, the highest CGR

(3.45 g $m^{-2}day^{-1}$) was observed in combination of V_2T_1, and the lowest value (1.66 g m^{-2} day^{-1}) was obtained from V_1T_4. At 64-84 DAS, the highest CGR (2.97 g $m^{-2}day^{-1}$) was observed in combination of V_2T_1, and the lowest value (0.49 g m^{-2} day^{-1}) was obtained from V_2T_4.

However, it is said that, CGR is decreased with irrigation regimes. Most of cases no significant result was found. This result is supported by Wang *et al.* (2016) where it was proved that water deficiency retarded plant growth.

Lentil varieties differed marginally in canopy cover (%) at 42 and 84 DAS but significantly at 63 DAS. At 42 DAS (**Table 3**), the highest canopy cover (77.76%) was obtained in V_2 and lowest at (75.58%) in V_1. At 63 DAS, the maximum canopy cover (89.68%) was obtained in V_2 which reduced significantly (4.57%) in V_1. At 84 DAS, the highest canopy cover (84.97%) was obtained in V_2 and lowest at (84.12%) in V_1.

Canopy cover of lentil showed statistically significant variation due to different irrigation frequencies **(Table 3)**. At 42 DAS, maximum canopy cover (79.66%) was recorded in T_1which reduced significantly (2.17, 4.89 and 7.94%) in T_2, T_3 and T_4 respectively. At 63 DAS, maximum canopy cover (90.90%) was recorded in T_1 which reduced significantly (2.09, 4.55 and 7.74 %) in T_2, T_3 and $T_{4,}$ respectively. At 84 DAS, highest canopy cover (89.16%) was observed in T_1 which reduced only 3.67% in T_2 but significantly (5.61 and 11.39%) for T_3 and T_4 respectively.

Significant interaction was found between varieties and irrigation frequencies in canopy cover **(Table 3)**. At 42 DAS maximum canopy cover (81.33%) was found in the combination of V_2 with $T_1$and the minimum (73.00%) canopy cover was observed in V_1 with T_4. At 63 DAS maximum canopy cover (92.80%) was found in the combination of V_1 with $T_1$and the minimum (81.00%) was observed in V_1 with T_4. At 84 DAS maximum canopy cover (90.76%) was found in the combination of V_2 with $T_1$and the minimum (78.93%) was observed in V_2 with T_4.

Both lentil varieties differed significantly in respect of number of branches $plant^{-1}$. The highest number of branches $plant^{-1}$ (14.66) was observed in V_2, which reduced significantly (38.06%) in V_1. Significant differences were observed in number of branches $plant^{-1}$for different irrigation frequencies of lentil **(Table 4)**. The highest number of branches $plant^{-1}$ (17.44) was recorded in T_1 which reduced (22.30%) in T_2 but significantly (45.52 and (59.86%) for T_3 and T_4 respectively. Significant interaction between varieties and irrigation frequencies were observed in number of branches $plant^{-1}$ of lentil **(Table 4)**. The highest number of branches (21.11) was obtained from V_2 with T_1 and the lowest number (5.77) was observed in V_1 with T_4.

Both lentil varieties differed significantly in respect of number of pods per branches. The highest number of pods per branch (11.02) was observed in V_2, which was significantly 8.43% thanV_1. Significant differences were observed in number of pods per branch of lentil for different irrigation frequencies **(Table 4)**. The highest number of pods per branch (11.66) was recorded in T_1 which reduced slightly 6.77% in T_2, but significantly by 13.12 and 18.09% in T_3 and T_4 respectively. Significant interaction between varieties and irrigation frequencies were observed in number of pods per branch of lentil **(Table 4)**. Maximum number of pods per branch (12.05) was recorded in the combination of V_2 with T_1 and the lowest (9.17) was found in V_1T_4.

Both lentil varieties differed significantly in respect of number of effective pods per plant. The highest number of effective pods per plant (52.86) was observed in V_2, which reduced significantly (9.28%) in V_1. Significant differences were observed in number of effective pods per plant for different irrigation frequencies of lentil **(Table 4)**. The highest number of effective pods per plant (55.50) was recorded in T_1 which reduced slightly (5.89%) in T_2, but significantly by 12.66 and 18.12% in T_3 and T_4 respectively. Significant interaction between varieties and irrigation frequencies were observed in number of effective pods per plant of lentil **(Table 4)**. Maximum number of effective pods per plant (58.07) was recorded in the combination of V_2 with T_1 and the minimum number (44.07) was found in V_1T_4.

Both lentil varieties were not significant in respect of number of non-effective pods per plant. Both highest and lowest number of non-effective pods per plant (4.27) was observed in V_2 and V_1, respectively. Non-significant differences were observed in number of non-effective pods per plant for different irrigation frequencies of lentil **(Table 4)**. The highest number of non-effective pods per plant (4.43) was recorded in T_4 and lowest (4.17) was in T_3. No significant interaction between varieties and irrigation frequencies were observed in number of non-effective pods per plant of lentil **(Table 4)**. Maximum number of non-effective pods per plant (4.47) was recorded in the combination of $V_1$with T_4 and the lowest (4.00) was found in V_1T_3.

Significant difference was found in number of seeds pod^{-1} between two lentil varieties. The highest number of seeds pod^{-1} (1.94) was observed from V_2, which reduced significantly (0.51%) in V_1. **(Table 4)**. Significant differences were observed in number of seeds pod^{-1} for different irrigation frequencies of lentil **(Table 4)**. The highest number of seeds pod^{-1} (1.95) was recorded in T_1 which reduced significantly 0.51, 1.02 and 1.53% in T_2, T_3 and T_4, respectively. No significant interaction was observed between lentil varieties and irrigation frequencies in number of seeds pod^{-1} of lentil **(Table 4)**. Maximum number of seeds pod^{-1} (1.95) was found in the combination of V_2 with T_1 and the minimum (1.92) was found in the V_1 with T_4.

Varieties differ significantly in 1000 grains weight of lentil. The highest 1000 grains weight (19.08 g) was observed from V_1, which reduced significantly (6.07%) in V_2 **(Table 4)**. Significant differences in

1000 grains weight were observed for different irrigation frequencies **(Table 4)**. The maximum1000 grains weight (19.50g) was recorded in T_1 which reduced slightly 3.07% in T_2but significantly by 7.17 and10.25% in T_3 and T_4 respectively. Significant interaction between varieties and irrigation frequencies were observed in 1000 grains weight of lentil **(Table 4)**. Maximum 1000 grains weight (20.17 g) was found in the combination of V_1 with $T_1$and the minimum (16.90 g) was observed in V_2 with T_4. Oladir *et al.* (1999) observed that water stress during grain growth was found to decrease grain size.

Both lentil varieties differed significantly in grain yield. The highest grain yield (1.07 t ha-1) was observed in V_2(BARI masur-6) which reduced significantly (19.62%) in V_1 (BARI masur-3) **(Table 4).** Grain yield showed significant differences due to different irrigation frequencies **(Table 4)**. The maximum grain yield (1.17 t ha^{-1}) was recorded in T_1 which reduced slightly (11.96%) in T_2 but significantly 23.93 and 34.18% in T_3 and T_4 respectively.

Significant interaction was found between varieties and irrigation frequencies in grain yield of lentil **(Table 4)**. Maximum grain yield (1.29 t ha^{-1}) was observed in the combination of V_2 with T_1 and minimum (0.71 t ha^{-1}) was observed in V_1 with T_4.

Although no remarkable differences in grain yield were observed between both lentil varieties, it was slightly higher in V2 (BARI masur-6). This results further supported by Bangladesh Agricultural Research Institute (Islam et al, 2015). In case of irrigation frequencies, it was seemed that the grain yield was reduced with the reduction of irrigation frequencies, but T2 showed more amount of grain yield Jia *et al*. (2014) found that AFI can maintain the same GY as conventional irrigation, while reducing the amount of irrigation water.

Significant differences were noted between two lentil varieties in stover yield. Maximum strover yield (4.08 t ha^{-1}) was observed in V_2 which reduced significantly (14.70%) in V_1 **(Table 4)**. Stover yield showed significant differences due to different irrigation frequencies **(Table 4)**. The maximum stover yield (4.37 t ha^{-1}) was recorded in T_1 which reduced slightly (8.86%) in T_2 but significantly 20.82 and 26.31% in T_3 and T_4 respectively. Significant interaction was found between varieties and irrigation frequencies on stover yield of lentil **(Table 4)**. The highest stover yield (4.65 t ha^{-1}) was observed in the combination of V_2 with T_1 and lowest (3.07 t ha^{-1}) was in V_1 with T_4 .

Significant differences were found between two varieties of lentil in biological yield. Maximum biological yield (5.15 t ha^{-1}) was observed in V_2 which reduced significantly (15.53%) in V_1 **(Table 4)**. Remarkable differences were observed in biological yield for different irrigation frequencies **(Table 4)**. The highest biological yield (5.54 tha^{-1}) was recorded in T_1, which reduced slightly (7.94%) in T_2

but significantly (21.48 and 27.97%) in T_3 and T_4 respectively. Significant interaction between varieties and irrigation frequencies were observed in biological yield of lentil **(Table 4)**. The highest biological yield (5.94 t ha^{-1}) was observed in the combination of V_2 with T_1 and lowest (3.78 t ha^{-1}) in V_1 with T_4. Jia *et al*, (2014) reported significant differences in biological yield among the different irrigation treatments.

Both lentil varieties differed non-significantly in harvest index (HI). Maximum HI (20.67%) was observed in V_2, and the minimum (19.70%) was found in V_1, **(Table 4)**. Harvest index was not statistically significant due to different irrigation frequencies **(Table 4)**. The maximum HI (20.95%) was recorded in T_1 and the minimum HI (19.26%) was recorded in T_4. Significant interaction was observed between varieties and irrigation frequencies in harvest index (HI), **(Table 4)**. The Maximum HI (21.68%) was observed in the combination of V_2 with T_1 and the minimum (18.77 %) in V_1 with T_4.

Both varieties differed marginally in WUE of lentil. The highest WUE (2.713 kg ha^{-1} mm^{-1}) was observed in V_2 (BARI masur-6) which reduced significantly (18.94%) in V_1 (BARI masur-3), **(Figure 1(a).** Significant effects were found in water use efficiency due to different irrigation frequencies **Figure 1(b)**). The maximum WUE (2.828 kg ha^{-1} mm^{-1}) was recorded in T_4 (irrigation equivalent to 50% FC) which reduced slightly (22.86%) in T_1 (irrigation equivalent to 125%FC) & (17.51% and 13.86%) in T_2 &T_3 (irrigation equivalent to 100% and 75%FC). No significant interaction was observed between varieties and irrigation frequencies in water use efficiency **Figure 1(c)**). Maximum WUE (3.07 kg ha^{-1} mm^{-1}) was found in the combination of V_2 with T_4 (irrigation equivalent to 50% FC), and the minimum (1.95 kg ha^{-1} mm^{-1}) in V_1 with T_1 (irrigation equivalent to 125% FC). Costa *et al*, (2007) stated that with a 25% water deficit under deficit irrigation, WUE was 1.2 times that achieved under normal irrigation practice.

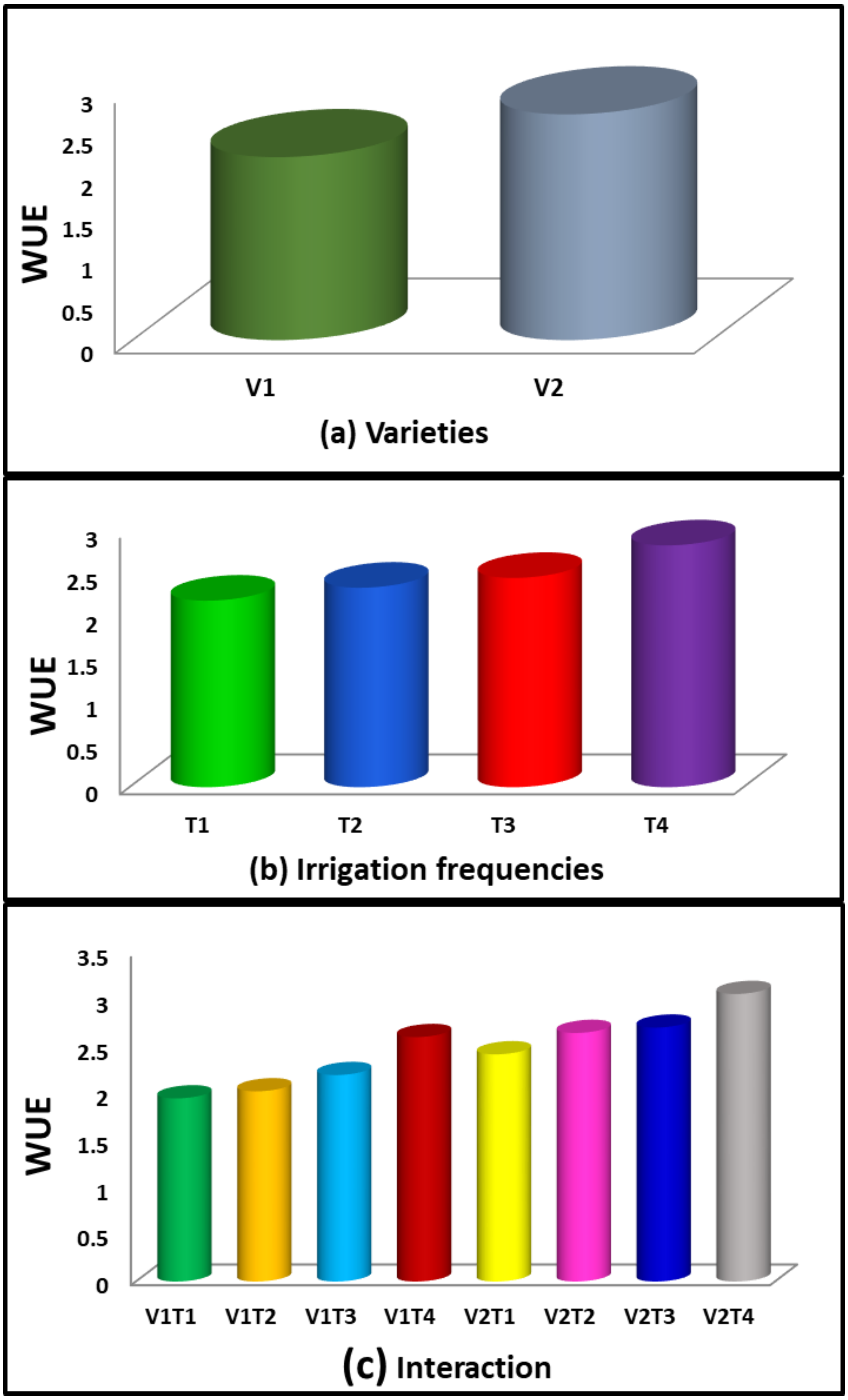

Figure 1: (a) Varietal differences in water use efficiency (WUE) of lentil. **(b)** Effects of irrigation frequencies in water use efficiency (WUE) of lentil. **(c)** Effects of interaction between variety and irrigation frequency in water use efficiency (WUE) of lentil. V_1 = (BARI masur-3),V_2 = (BARI masur-6), T_1 = irrigation equivalent to125% FC, T_2 = irrigation equivalent to 100% FC, T_3 = irrigation equivalent to 75% FC, T_4 = irrigation equivalent to 50% FC.

Table 3: Effect of irrigation frequencies, varietal effect and interaction effect on plant height, total dry matter, crop growth rate and canopy efficiency of lentil at different days after sowing

Varieties	Plant height	Total Dry Matter (TDM) g plant^{-1}				Crop Growth Rate (CGR) g m^{-2} day^{-1}			Canopy efficiency(CE)%		
	84 (DAS)	21(DAS)	42 (DAS)	63 (DAS)	84 (DAS)	21-42 DAS	43-63 DAS	64-84 DAS	42 (DAS)	63 (DAS)	84 (DAS)
V_1	51.66 b	0.46	2.16 b	7.52 b	9.25 b	0.69	2.19	0.78 b	75.58	85.58 b	84.12
V2	57.16 a	0.51	2.83 a	10.06 a	14.51 a	0.08	2.49	1.55 a	77.76	89.68 a	84.97
LS	0.05	NS	0.05	0.05	0.05	NS	NS	0.05	NS	0.05	NS
Treatment											
T_1	60.33 a	0.5	3.36 a	11.23 a	16.70 a	1.09 a	3.00 a	2.07 a	79.66 a	90.90 a	89.16 a
T_2	56.55 ab	0.48	2.51 b	9.23 ab	13.08 ab	0.75 b	2.44 ab	1.46 ab	77.93 ab	89.00 ab	85.88 a
T_3	52.39 bc	0.48	2.19 b	7.90 bc	9.58 bc	0.63 b	2.14 bc	0.63 bc	75.76 bc	86.76 bc	84.15 a
T_4	48.39 c	0.5	1.91 b	6.80 c	8.14 c	0.52 b	1.77 c	0.49 c	73.33 c	83.86 c	79.00 b
LS	0.05	NS	0.05	0.05	0.01	0.05	0.05	0.01	0.05	0.05	0.05
Interaction											
$V_1 T_1$	58.77 ab	0.46	2.73 b	9.03 bc	11.91 c	0.91 ab	2.55 ab	1.16 c	78 abc	89 abc	87.56 ab
$V_1 T_2$	53.22 abc	0.46	2.4 bc	8.1 bc	9.62 cd	0.79 b	2.34 b	0.88 c	76.17 bc	87.03 bc	85.27 ab
$V_1 T_3$	49.22 bc	0.5	1.86 bc	7.23 bc	8.58 cd	0.56 b	2.21 b	0.57 c	75.16 bc	85.3 c	84.6 ab
$V_1 T_4$	45.44 c	0.43	1.66 c	5.7 c	6.86 d	0.51 b	1.66 b	0.5 c	73 c	81 d	79.0t c
$V_2 T_1$	61.89 a	0.53	4.00 a	13.43 a	21.5 a	1.27 a	3.48 a	2.97 a	81.33 a	92.8 a	90.76 a
$V_2 T_2$	59.88 ab	0.5	2.63 bc	10.36 bc	16.54 b	0.71 b	2.54 ab	2.04 b	79.7 ab	90.96 ab	86.5 ab
$V_2 T_3$	55.55 abc	0.46	2.51 bc	8.56 bc	10.58 cd	0.69 b	2.07 b	0.69 c	76.36 bc	88.23 bc	83.7 ab
$V_2 T_4$	51.33 abc	0.56	2.16 bc	7.9 bc	9.41 cd	0.52 b	1.87 b	0.49 c	73.66 c	86.73 bc	78.93 c
LS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	10.35	29.87	21.2	19.57	21.95	32.22	23.05	33.02	3.45	2.71	5.69

Mean values in a column having the same letters or without letter do not differ significantly as per Duncan's multiple range test (DMRT) NS= Non significant, CV= Co-efficient of variation, LS= Level of significant DAS=Day's after sowing. V_1 = Variety 1 (BARI masur-3), V_2 = Variety 2 (BARI masur-6), T_1 = irrigation equivalent to 1.25 FC, T_2= irrigation equivalent to 1.00 FC, T_3 = irrigation equivalent to 0.75 FC, T_4 = irrigation equivalent to 0.50 FC.

Table 4: Effect of irrigation frequencies, varietal effect and interaction effect on yield contributing characters and yield of lentil at different days after sowing

Varieties	Number of branches plant^{-1}	Number of pods branch^{-1}	Number of effective pods plant^{-1}	Number of non-effective pods plant^{-1}	Number of seeds pod^{-1}	1000 grain weight (g)	Grain yield(t ha^{-1})	Stover yield (t ha^{-1})	Biological yield(t ha^{-1})	Harvest index (%)
V_1	9.08 b	10.09 b	47.95 b	4.27	1.93 b	19.08 a	0.86 b	3.48 b	4.35 b	19.7
V_2	14.66 a	11.02 a	52.86 a	4.27	1.94 a	17.92 b	1.07 a	4.08 a	5.15 a	20.67
LS	0.05	0.05	0.05	NS	0.05	0.05	0.05	0.05	0.05	NS
Treatment										
T_1	17.44 a	11.66 a	55.50 a	4.27	1.95 a	19.50 a	1.17 a	4.37 a	5.54 a	20.95
T_2	13.55 ab	10.87 ab	52.23 ab	4.2	1.94 ab	18.90 ab	1.03 ab	4.07 ab	5.10 ab	20.21
T_3	9.50 bc	10.13 bc	48.47 bc	4.17	1.93 bc	18.10 bc	0.89 bc	3.46 bc	4.35 bc	20.31
T_4	7.00 c	9.55 c	45.44 c	4.43	1.92 c	17.50 c	0.77 c	3.22 c	3.99 c	19.26
LS	0.05	0.05	0.05	NS	0.05	0.05	0.05	0.05	0.05	NS
Interaction										
V_1T_1	13.78 abc	11.27 ab	52.93 abc	4.27	52.93 abc	20.17 a	1.04 abc	4.09 abc	5.13 abc	20.21
V_1T_2	10 bc	10.29 bcd	49.07 abc	4.33	49.07 abc	19.5 ab	0.9 bc	3.54 cd	4.44 bc	20.15
V_1T_3	6.78 c	9.61 cd	45.73 c	4	45.73 c	18.57 bc	0.8 cd	3.24 cd	4.04 c	19.67
V_1T_4	5.77 c	9.17 d	44.07 c	4.47	44.07 c	18.1 bcd	0.71 d	3.07 d	3.78c	18.77
V_2T_1	21.11 a	12.05 a	58.07 a	4.27	58.07 a	18.83 abc	1.29 a	4.65 a	5.94 a	21.68
V_2T_2	17.11 ab	11.44 ab	55.4 ab	4.07	55.40 ab	18.3 bcd	1.17 ab	4.6 ab	5.77 ab	20.28
V_2T_3	12.22 bc	10.65 bc	51.2 abc	4.33	51.20 abc	17.63 cd	0.98 bc	3.68 bcd	4.66 abc	20.97
V_2T_4	8.22 c	9.92 cd	46.8 bc	4.4	46.80 bc	16.9 d	0.84 cd	3.38 cd	4.21 c	19.75
LS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	38.08	6.61	9.47	7.94	127.5	4.58	14.28	13.59	16.61	10.49

Mean values in a column having the same letters or without letter do not differ significantly as per Duncan's multiple range test (DMRT) NS= Non significant, CV= Co-efficient of variation, LS= Level of significant DAS=Day's after sowing. V_1 = Variety 1 (BARI masur-3), V_2 = Variety 2 (BARI masur-6), T_1 = irrigation equivalent to 1.25 FC, T_2= irrigation equivalent to 1.00 FC, T_3 = irrigation equivalent to 0.75 FC,T_4 = irrigation equivalent to 0.50 FC.

SUMMARY AND CONCLUSION

The overall result could be summarized as, V_2 (BARI masur-6) showed good performances than V_1 (BARI masur-1). The highest grain yield (1.07 t ha^{-1}) was obtained from V_2 and the lowest (0.86 t ha^{-1}) in V_1. Here V_2 showed more effectiveness than V_1 in the competition of deficit irrigation practices. The highest grain yield (1.17 t ha^{-1}) was observed in T_1 (irrigation equivalent to125% FC) which was closely similar to (1.03 t ha^{-1}) in T_2 (irrigation equivalent to 100% FC) by 20.42% less water, so that irrigation amount given as treatment T_2 (irrigation equivalent to 100% FC) would be the best practices for lentil cultivation mainly for drought affected north western areas of Bangladesh. The most effective interaction was observed in the combination of V_2 with T_1 where, the grain yield was obtained 1.04 tha^{-1}. Diminishing water resource and increasing food requirement need greater efficiency in water use both in rainfed and irrigated agriculture. If we get more or less same amount of yield by applying less water, we should follow the deficit irrigation practices to save our future agriculture, next generation as well as our country.

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