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Water saving in cultivation of Potato in Bangladesh

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ABSTRACT

The present study was undertaken to evaluate how much water could be saved by using alternate wetting and drying furrow irrigation. The experiments were carried out under the deficit irrigation conditions in a sandy loam with pH 6.57 during Rabi season. Potato of Rojagold variety was used. Randomized complete block in a split design was used in this experiment. M_1: Alternate wetting and drying furrow irrigation (AWDFI) and M_2: Traditional furrow irrigation (TFI) were used. The plot size was 760 ft2 with 5ft×5ft per plot. Planting was done furrow to furrow center distance of 60cm. The depth of furrow was 10-15 cm, plant to plant spacing was 25cm. The effect of irrigation levels showed that the level I_1 (100% field capacity) produced significantly higher crop growth rate compared to the lower level of irrigation I_2 (80% FC) and I3 (60% FC). The yield results indicated that when less amount of irrigation water was applied, AWDFI (M_1) had insignificantly reduced yield. AWDFI could maintain approximately similar grain yield compared to TFI with almost 50% reduction in irrigation water. However considering the overall performance alternate wetting and drying furrow irrigation was found effective water saving technologies than traditional furrow irrigation.

Introduction

Potato is one of the most important vegetable crops in Bangladesh. It is a starchy, tuberous crop from the perennial nightshade *Solanum tuberosum*. It has attained great importance and popularity during the past two decades (Kashyap and Panada, 2003). Potato may be applied to both the plant and the edible tuber. Potatoes have become a staple food in many parts of the world and an integral part of much of the world's food. Raw potato is 79% water, 17% carbohydrates (88% of which is starch), 2% protein, contains negligible fat. In a 100 grams amount, raw potato provides 322-kilo joules (77 kilocalories) and is a rich source of vitamin B6 and vitamin C (23% and 24% of the Daily value, respectively), With no other nutrients in a significant amount).

Recently, potato cultivation area and production are increasing day by day during Rabi season due to high demand. Now, irrigation has become a vital issue to imply the concept of using less water to produce optimum yield. Yield can be reduced due to excess soil moisture, nutrient and oxygen availability and disfavor temperature in the root zone whereas available soil water is necessary to maintain the effective leaf water potential under evaporative demand in the atmosphere (Quanqi et al., 2008). Irrigation Water management is now challenging issues in targeting resource-constrained farmers with limited access to irrigation water apply in scarcity areas of Bangladesh. Efficient use of water has become extremely important in recent years because the scarcity of irrigation water has been retreating rapidly in Bangladesh. Researchers have proved that furrow irrigation improves water use efficiency. Alternate furrow irrigation (AFI) is a way of reducing irrigation water. The idea of the AFI has been taken from the concept of partial root drying concept. Partial drying of the root system saved water and increased the water use efficiency without significant yield reduction. Irrigation water allows the alternate furrows that keep dry on the previous occasion in the subsequent irrigation (Majumdar, 2004). So, sustainable irrigation water supply technique and effective water management methods are an urgent need today with changing the climate. Suitable irrigation water supply methods such as sprinkler, Drip Irrigation, sub-surface and sustainable available ground and surface water resources are limited in Bangladesh. Water saving technologies and productivity per unit of water are becoming of strategic importance for Bangladesh likewise many other countries, namely USA, China, India and Malaysia, etc. Efficient on-farm water management practices have an important role to play in enhancing the improvement of water as well as nutrient use efficiency. Most of the surface irrigation methods result in poor water application efficiency. However, more application efficiency may be achieved through efficient irrigation methods.

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The idea of the AWDFI (Alternate Wetting and Drying Furrow Irrigation) has been taken from the concept of partial root zone drying concept. This is essential to adopt under field conditions for sustainably increasing WUE (Water Use Efficiency). AWDFI is an irrigation technique by which water is applied in alternate furrows keeping the in-between furrow dry. In subsequent irrigation, water is applied to the alternate furrows that had been kept dry on the previous occasion. The soil sub-surface might be wetted after irrigation due to lateral movement. Partial drying of the root system saved water and increased the water use efficiency without much yield reduction (Kang and Zhang 2004; Li et al., 2007). It is reported that AFI technique can save irrigation water by 25 to 35% compared to TFI with the increase or decrease in crop yield to the extent of 2 to 16% (Reddi and Reddy 2009). The alternate furrow irrigation method is essential where the supply of irrigation water is limited. Therefore, water saving techniques, such as AWDFI for potato cultivation should be used. It may be introduced for improving WUE and other constraints associated with environmental and socioeconomic conditions. The present study was undertaken to evaluate how much water could be saved by using alternate wetting and drying furrow irrigation.

Material and Methods

Study area

The Field experiments were carried out in acid soils at one site. It was at the research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200 during the Rabi season of 2018-2019 to study the water saving in the cultivation of potato.

Geographically the experimental site is located between 25.13^0 N latitude and 88.23^0 E longitudes and at an elevation of 37.5 m above the sea level. The land belongs to the old Himalayan Piedmont plain (AEZ-1) (UNDP and FAO, 1988). The study was carried out under Dinajpur district.

Climatic condition

Dinajpur has subtropical humid monsoon climatic condition. It is characterized by comparatively high monsoon rainfall, high humidity and low to a high-temperature long day with less clear sunshine. Sometimes the sky remains cloudy for heavy rainfall during to April to September. The scanty rainfall, low humidity and low temperature, short day and more clear sunshine were from October to March 2017- 2018.The average temperature ranged from 15.60- 29.4^{o}C and average annual rainfall varied from 1391 -1708.4 mm around the year.

Soil

Generally, the soil of the experimental field was sandy loam and contains sand, silt, clay respectfully. The soil of the field experiment was sandy loam with pH 6.57.

The experiment

Potato of Rojagold variety was used. The class was TLS (Truthfully Labelled Seed) and grade B (41-55 mm). Randomized complete block in a split design was used in this experiment (Figure 1).

Figure 1: Potato planting

Two factors were considered in this experiment. Factors A (Main plot): Three irrigation levels (main plot treatment): I_1: Irrigation water applied to 100% FC (Flood Control); I_2: Irrigation water applied to 80% FC and I_3: Irrigation water applied to 60% FC.
Irrigation at colonization stage was 20-25 DAS, tuberization stage 40-45 DAS and at tuber enlargement stage was 60-65 DAS. Irrigation was performed at 15 days intervals.

Factors B (Sub plot): Three Irrigation Methods (subplot treatment): M_1: Alternate wetting and drying furrow irrigation (AWDFI) M_2: Traditional furrow irrigation (TFI). Each experiment was repeated three times.

The plot size was 760 ft^2 with 5ft×5ft per plot. Planting was done furrow to furrow center distance of 60cm. The depth of furrow was 10-15 cm, plant to plant spacing was 25cm. Irrigation water was used in the whole experiment.

Land preparation and fertilization

At first, the land was prepared thoroughly by plowed with a power tiller. Every plowed was followed by laddering. The experimental field was fertilized with cow dung, urea, TSP and gypsum (Table 1)

Table 1: Doses of fertilizers applied in the experimental plots

Nutrient	Quantity (kg/ha)	Source
N,P,& K	7082.15	Cow dung
N	141.64	Urea
P	141.64	Triple super phosphate
S	141.64	Gypsum

Calendar of operation

The different operations in the experiment were performed as per scheduled below.

Operations	Date of operation
Seed collection	5 November 2018
Sowing date	11 November 2018
First irrigation	2 December 2018
Second irrigation	20 December 2018
Third irrigation	9 January 2019
Harvesting	11 February 2019

Sowing of seeds

For sowing of seed, the furrows were made at a depth of 10-15 cm. Furrows to furrows distance were 60 cm. The plant to plant spacing was 25 cm.

Intercultural operation

After germination of seeds, various kinds of intercultural operations were accomplished for better growth and development of the plants.

Weeding

Various weeds grew in the experimental plots that were uprooted by weeding. First, weeding was done after 20 days of sowing. Subsequent weeding was done followed by application of irrigation.

Measurement of soil moisture

Soil moisture was measured gravimetrically before each irrigation to find out the depth of water required to replenish the deficit. For this, soil samples were collected with a soil auger up to the depth of 75 cm. They are collected in air tight aluminum containers. The samples are then weighed and dried in an oven at 105^o C for about 20 hours until all the moisture is driven off (Michael, 1978). After removing from the oven they are cooled slowly to room temperature and weighed again. Then the soil moisture on weight basis was calculated by the following formula:

Soil moisture content (percent by weight)

Irrigation practices

Irrigation was scheduled on the basis of crop stages like colonization stage, tuberization stage and at tuber enlargement stage. The amount of applied irrigation water was the depth of water needed to refill the soil profile (0-45, 60 and 75 cm depending on growth stages) to different levels of field capacity. The amount was controlled to 100%, 80% and 60% FC for irrigation to each plot (Figure 2 & 3).

Figure 2: Irrigated field

Figure 3: Photographic view of experimental field

Harvesting

Maturity of crops was determined when 100% of the spikes became straw color. The crop was harvested on 11 February 2019. The harvested crop of each plot was kept separately and weighted properly. Finally, grain and straw yields and yield contributing parameters were recorded separately.

Data collection

Data were recorded during and after harvest of crop. Plant height, root length, stem per plant, potato per plant, the maximum and minimum diameter of potato, biomass and yield were considered for data.

Results and Discussion

Crop growth rate

Crop growth rate (CGR) was influenced by the treatments. The effect of irrigation levels and methods significantly ($P \leq 0.01$) affected the CGR among the treatments at the different growth stages of potato dry biomass. CGR was significantly lower when the irrigation level was drastically reduced. The effect of irrigation levels showed that the level I_1 (100% field capacity) produced significantly higher crop growth rate compared to the lower level of irrigation I_2 (80% FC) and I3 (60% FC). The results indicate that CGR was not significantly different when were irrigated alternately (M_1) and traditional (M_2) irrigated with the irrigation level-up to 100% FC. The interactive effect of irrigation level and method showed that less amount of irrigation water also significantly reduced the crop growth rate in the crop biomass among the treatments while the same level of irrigation produced dry matter insignificantly different between the irrigation method M_1 and M_2. The result thus indicates that AWDFI irrigation may reduce excess transpiration loss without reducing the photosynthesis rate by slightly limiting stomata opening on potato growing.

Yield and yield contributing parameters

Yield and yield components of potato under different irrigation levels and methods are given in Table 2. There was a significant interaction between irrigation level and method (Table 2 and Table 3). The interactive effect of irrigation levels and methods showed that total grain yield in alternate furrow irrigation treatment (M_1) was higher compared to the traditional method when irrigated with 100% FC. The yield contributing parameters viz. as potato per plant, steam per plant were found non-significant between the methods of AWDFI (M_1) and TFI (M_2). Results showed that yields were significantly different among the methods when irrigated to 100% field capacity (I1). There was a consistent trend for similar yield on AWDFI (M_1) and TFI (M_2). The yield results indicated that when less amount of irrigation water was Applied, AFI (M_1) had insignificantly reduced yield. AFI could maintain approximately similar grain yield compared to TFI with almost 50% reduction in irrigation water.

Table 2: Effect of irrigation levels and methods on yield contributing characters and yield of potato

Treatment		Stem per plant	Potato per plant	Plant height (cm)	Root length (cm)	Grain yield (kg/ha)	Biomass (kg/ha)
Irrigation level	Irrigation method						
I_1	M_1	5	11	42	12.33	19638.76	8841.74
	M_2	5	9	44	11.67	19065.36	7827.4
I_2	M_1	4	8	35.3	16.33	16198.39	7155.14
	M_2	4	9	35	15	14908.25	6782.47
I_3	M_1	4	9	32.6	13	15481.65	3609.10
	M_2	3	8	38.33	12.83	14621.55	4913.42

Treatments: I_1, I_2, & I_3 indicate irrigation up to 100%, 80% and 60% field capacity, respectively; M_1: Alternate wetting and drying furrow irrigation, M_2: Traditional furrow irrigation (TFI).

Plant height

Table 2 reveals that irrigation water quality had a significant effect on plant height. In 100%, 80% and 60% FC irrigation water on traditional furrow irrigation, the plant height were found to be 44cm, 35cm and 38.33cm respectively. Then 100%, 80% and 60% FC irrigation water on alternate wetting and drying furrow irrigation, the plant height were found to be 42cm, 35.3cm, 32.6 cm respectively. So the plant height in traditional furrow irrigation was comparatively larger than alternate wetting and drying furrow irrigation.

Root length

Table 2 reveals that irrigation water quality had a significant effect on root length height. In 100%, 80% and 60% FC irrigation water on traditional furrow irrigation, the plant height were found to be 11.67 cm, 15 cm and 12.83 cm respectively. Than 100%, 80% and 60% FC irrigation water on alternate wetting and drying furrow irrigation, the root length were found to be 12.33 cm, 16.33 cm and 13 cm respectively. So the root length in alternate wetting and drying furrow irrigation was comparatively larger than traditional furrow irrigation.

Number of potato per plant

Table 2 reveals that irrigation water quality had a significant effect on potato per plant. In 100%, 80% and 60% FC irrigation water on traditional furrow irrigation, the number of potato per plant were found to be 9, 9 and 8 respectively. Then 100%, 80% and 60% FC irrigation water on alternate wetting and drying furrow irrigation, the potato per plant were found to be 11, 8 and 9 respectively. So the potato per plant in alternate wetting and drying furrow irrigation was comparatively larger than traditional furrow irrigation.

Stem per plant

Table 2 reveals that irrigation water quality had a significant effect on stem per plant height. In 100%, 80% and 60% FC irrigation water on traditional furrow irrigation, the stem per plant were found to be 5, 4 and 3 respectively. Then 100%, 80% and 60% FC irrigation water on alternate wetting and drying furrow irrigation, the stem per plant were found to be 5, 4 and 4 respectively. So the stem per plant in alternate wetting and drying furrow irrigation was similar to traditional furrow irrigation.

Weight of the crop yield

Table 2 reveals that the weights of crop yield applying irrigation at 100% FC using M_1 and M_2 methods were found to be 13.7 kg and 13.3 kg respectively and applying irrigations at 80% FC and 60% FC using same methods, the weights of crop yield were found to be 11.3 kg, 10.4 kg and 10.8 kg, 10.2 kg respectively. The result reveals that the highest weight of crop yield was found applying irrigation at 100% FC using M1 method and the lowest weight of grain yield was found applying irrigation at 60% FC using M_2 method. So the alternate wetting and drying furrow irrigation gave more crop yield than traditional furrow irrigation.

Weight of biomass

Table 2 reveals that irrigation water quality had a significant effect on the weight of biomass. In 100%, 80% and 60% FC irrigation water on traditional furrow irrigation, the biomass were found to be 1.82 kg, 1.57 kg and 1.14 kg respectively. Then 100%, 80% and 60% FC irrigation water on alternate wetting and drying furrow irrigation, the weight of biomass was found to be 2.056 kg, 1.33 kg and 0.84 kg respectively. So the weight of biomass in alternate wetting and drying furrow irrigation was larger than traditional furrow irrigation.

Table 3: Calculation of crop yield and water saving

Irrigation timing (DAS)	Treatment		Irrigation water amount (liter)	Effective rainfall	Grain yield (kg/ha)	% water saving of M_1 over M_2
	Irrigation level	Irrigation method				
20	I_1	M_1	240	0	19638.76	41.67%
		M_2	480	0	19065.36	
40	I_2	M_1	192	0	16198.39	33.33%
		M_2	384	0	14908.25	
61	I_3	M_1	144	0	15481.65	25%
		M_2	288	0	14621.55	

The results in table 3 shows that alternate wetting and drying furrow irrigation had higher water use efficiency and comparatively higher crop yield than traditional furrow irrigation. As a result, WUE was substantially improved by AWDFI (M_1). Alternate wetting and drying furrow irrigation (M_1) is an effective water-saving irrigation method which efficient soil moisture utilization improves soil enzymatic activities and crop water use. However, AWDFI had the potential to save water and may be a useful irrigation water application method where water and water supply methods are limited to irrigation for crop production.

Conclusion

Alternate wetting and drying furrow irrigation was found effective water saving technologies than traditional furrow irrigation.

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