YIELD OF ONION AND LEAF PURPLE BLOTCH INCIDENCE AS INFLUENCED BY DIFFERENT LEVELS OF IRRIGATION

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Abstract

This study investigated the level of leaf purple blotch incidence by different levels of irrigation and its effect on the bulb yield of onion (Allium cepa L.). Four irrigation levels comprised of: irrigation at 10- (I_1), 15- (I_2), 20- (I_3) and 30-day (I_4) intervals along with a non-irrigated control (Io) treatment were tested. A small difference in the score of leaf purple blotch disease in onion was found between the irrigated and non-irrigated plots. The highest level of disease infection (score: 1.96) was recorded in Io, and the lowest score (1.45) was found in I_1. There was a trend to decrease the disease incidence with increasing number of irrigations. However, irrigation had insignificant effects on the disease incidence of onion. Irrigation significantly increased the yield of onion; the highest yields were obtained from treatments I_1 and I_2 associated with higher percentage of bulbs having size greater than 30 g. The lowest yield was recorded in non-irrigated treatment, Io. The total water use was 248 mm in treatment I_1. The incremental benefit-cost ratio was the highest (28.36) in treatment I_2.

Key words: onion, bulb yield, yield components, irrigation, water use efficiency, disease infection, incremental benefit-cost ratio

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important and widely used vegetable and spice crops in Bangladesh as well as in many countries of the world. The current demand of onion in Bangladesh is 0.75 million metric tons while the production is only 0.153 million metric tons (BBS, 2004). The imbalance in the supply-demand in onion is increasing every year due to low production coupled with an increased population.

Onion suffers from many diseases, such as leaf blight, downy mildew, purple blotch, white rot, neck rot and *Fusarium* basal rot among which leaf purple blotch caused by *Alternaria porri* (Ellis) Cif. is a major one. This disease caused substantial loss of both bulb and seed yield of onion in most onion growing countries including Bangladesh (Ahmed and Hossain, 1985; Meah and Khan, 1987; Rahman et al., 1988; Ashrafuzzaman and Ahmad, 1976). It is, thus, a serious bottleneck in the cultivation of onion. The extent of yield loss incurred by the diseases was not well documented; there were evidences of complete damage of a number of onion fields every year.

Although water is regarded as the life blood for plants, it is generally believed that onion plants become susceptible to diseases when produced under irrigation. So, many farmers do not apply irrigation to onion. Some farmers irrigate this crop, but with a lower amount and number of irrigation than required. However, proper irrigation practices and disease control measures may be the key components of the strategy to offset the imbalance in the supply-demand in onion.

Although there is some information on control of the diseases of onion by spraying fungicides, little information is available on irrigation-disease interactions. Teviotdale et al. (1989) and Shabeer et al. (1998) investigated the effects of irrigation on disease incidence of onion, but they found no correlation between irrigation and disease severity. Abd-Elrazik et al. (1988), however, found that high irrigation frequency favored diseases in onion. In contrast, increase in disease incidence with increasing watering interval was reported by Ali et al. (1984) who tested onion under three watering regimes: 8, 12 and 16 days intervals. Bhonde et al. (2001) studied the resistance of onion to purple blotch under irrigation at 10-, 12- and 15-day intervals and observed the best performance of onion when irrigated at 10-day intervals. The results so far reported on irrigation-disease correlation are indicative rather than conclusive. This study, therefore, attempts to find out the effect of irrigation on disease (leaf purple blotch) infection as well as bulb yield of onion.

MATERIALS AND METHODS

Soil and climate of the experimental site

A field experiment was conducted at the Regional Agricultural Research Station, Jessore during the rabi season of 2004–2005 and 2005–2006. The site, at an elevation of 6.71 m above mean sea level, was located at 23.11ºN latitude and 89.14ºE longitude in the south-western part of Bangladesh. The experimental field belongs to a high land that lies in the high Ganges River flood plain, which is under agro-ecological zone (AEZ) 11 (BARC, 2005).

The soil of the experimental field was silty loam in texture having field capacity of 27.20 percent (weight basis), permanent wilting point of 13.98% and bulk density of 1.48 g/cc. The study site is under moderate to severe drought prone areas in rabi, pre- and post-kharif seasons (from October to March). The total annual rainfall varies from 1500 to 1700 mm and over 80% of the rainfall occurs during June to September. The mean monthly rainfall during rabi season (November to March) varies from 0 to 31 mm. Maximum temperature is in April–May (34–37°C, occasionally goes up to 40°C) and minimum (13–17°C, often goes below 10°C) in December and January. Days are longer in June (13.6 hours) and shorter in January (10.7 hours). The daily reference crop evapotranspiration (ETo) of the area varied from 2.2 to 6.0 mm with maximum in April–May and minimum in December–January.

Land preparation and experimental details

The experimental land was opened with a power tiller and kept exposed to the sun prior to next ploughing. It was prepared afterwards by ploughing and cross ploughing followed by laddering. The cropping pattern of the land was fallow-onion-fallow. The prepared land was divided into three blocks representing three replications maintaining a buffer strip of 1.5 m between the blocks. Each block was divided into 5 unit plots of 4 m × 3 m size keeping 1 m buffer between adjacent plots. The buffer area minimized water movement from one plot to another. Onion seedlings of 35 days old were transplanted on 30 December in both the study years. Just before transplanting, 30 kg N, 75 kg P_2O_5, 120 kg K_2O and 20 kg S.ha^{-1} in the form of urea, triple super phosphate (TSP), muriate of potash (MP) and zypsum, respectively, (BARC, 1989), were broadcasted and incorporated into the soil at the time of final land preparation. Urea was also applied in two equal splits at a rate of 30 kg N.ha^{-1} each at 25 and 50 days after transplanting (DAT).

Irrigation treatments and scheduling

Fixed interval method was chosen as the criteria for selecting the irrigation treatments. The treatments were:
Io: No irrigation (control)
I_1: Irrigation at 10 days intervals
I_2: Irrigation at 15 days intervals
I_3: Irrigation at 20 days intervals
I_4: Irrigation at 30 days intervals
The treatments, with three replications, followed a randomized complete block design. Soil moisture was determined by gravimetric method before transplanting and after harvest to estimate the amount of soil moisture depletion. Soil moisture was also monitored before irrigations to estimate the amount of irrigation water needed to bring the soil moisture to field capacity. The amount of irrigation water was estimated by formula suggested by Michael (1978) considering the effective root zone of onion as 50 cm for all growth stages. Measured quantity of irrigation water was applied to individual plot using hosepipe connected to a water tap of known discharge. Just after transplanting of seedlings, 30 mm irrigation was applied to each plot for plant establishment. Treatments were employed after 12 days of transplanting and were stopped before 25 days of harvesting following Doorenbos and Kassam (1979).

Assessment of disease severity

Disease severity was recorded at 40, 55 and 70 days of transplanting following a rating scale (Sharma, 1986) of 0–5 as:
0 = No symptom of disease
1 = A few spots towards the tip covering less than 10% of leaf area
2 = Several dark purplish brown patches covering less then 20% of leaf area
3 = Several patches with paler outer zone covering up to 40% of leaf area
4 = Long streak covering up to 75% of leaf area or breaking of the leaves from the centre, and
5 = Complete drying of the leaves or breaking of the leaves from the base

Data collection and analysis

Data on plant population were recorded on 1 m × 1 m area. Plant height and leaves per plant were recorded on randomly selected 10 plants at 60 DAT. Bulb diameters, unit bulb weight, and biomass weights were recorded at harvest. The matured crop was harvested on 28 March 2005 and 30 March 2006 for the first and second year experiments, respectively, from 2 m × 2 m area in each plot. Harvested bulbs were graded into < 15 g, 15–30 g and > 30 g sizes and the number of bulbs in each size grade was recorded. The ANOVA was done by using MSTAT-C programme. The least significance difference (LSD) test (≤ 0.05) was used to find out the significance of mean difference of various treatments.

Economic analysis

Cost-benefit analysis was done to evaluate the relative effectiveness of each irrigation treatments. The production cost of onion included expenses incurred in field preparation, cost of seedlings, fertilizers, irrigation and labour for transplanting, weeding and harvesting. The total income from the production was estimated using the existing local market price.

RESULTS AND DISCUSSION

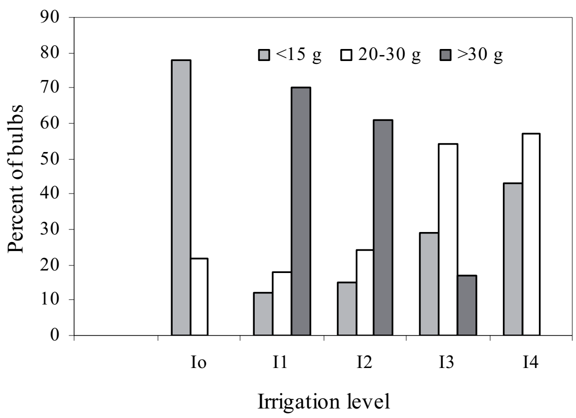
Yield components

Plant height, leaves plant^{-1}, unit weight of bulb, and diameter of bulb varied significantly at 5% level of significance between the different irrigation treatments (Table 1). Plant population showed identical values in all cases due to identical initial conditions. The largest bulb diameter was obtained in treatment I_1, and the lowest diameter was recorded in non-irrigated control treatment, Io. A similar trend was observed in case of unit weight of bulb. Weight of single bulb was found higher in irrigated treatments that in non-irrigated one. Martin de Santa Olalla et al. (1994) reported that bulb diameter and weight are directly related to amount of water applied. The number of leaves per plant also increased with the increasing irrigation frequency from 4.90 in Io to 7.37 in I_1. The other irrigation treatments showed significant difference with non-irrigated treatment in this regard. At harvest, the above ground biomass was 0.261, 0.724, 0.697, 0.549 and 0.539 t.ha^{-1} for Io, I_1, I_2, I_3, I_4 and I_5, respectively, with I_1 and I_2 provided significantly higher biomass than other treatments at 0.05 level. Irrigation water helped to taller plant growth and higher number of leaves with larger stem diameter. Consequently, onion plants of irrigated treatments had the higher biomass than non-irrigated plants.

Irrigation and bulb size distribution

The percentage of bulbs with various size grades under different levels of irrigation are shown in Figure 1. In non-irrigated control treatment, most of the bulbs (74%) were less than 15 g size and the rest 26% was of 15–30 g size. Hence, no bulb had more than 30 g. A remarkable reduction in the proportion of 15 g bulbs was recorded due to frequent irrigation. The highest percentage (70%) of > 30 g bulbs was obtained from the treatment I_1 close-

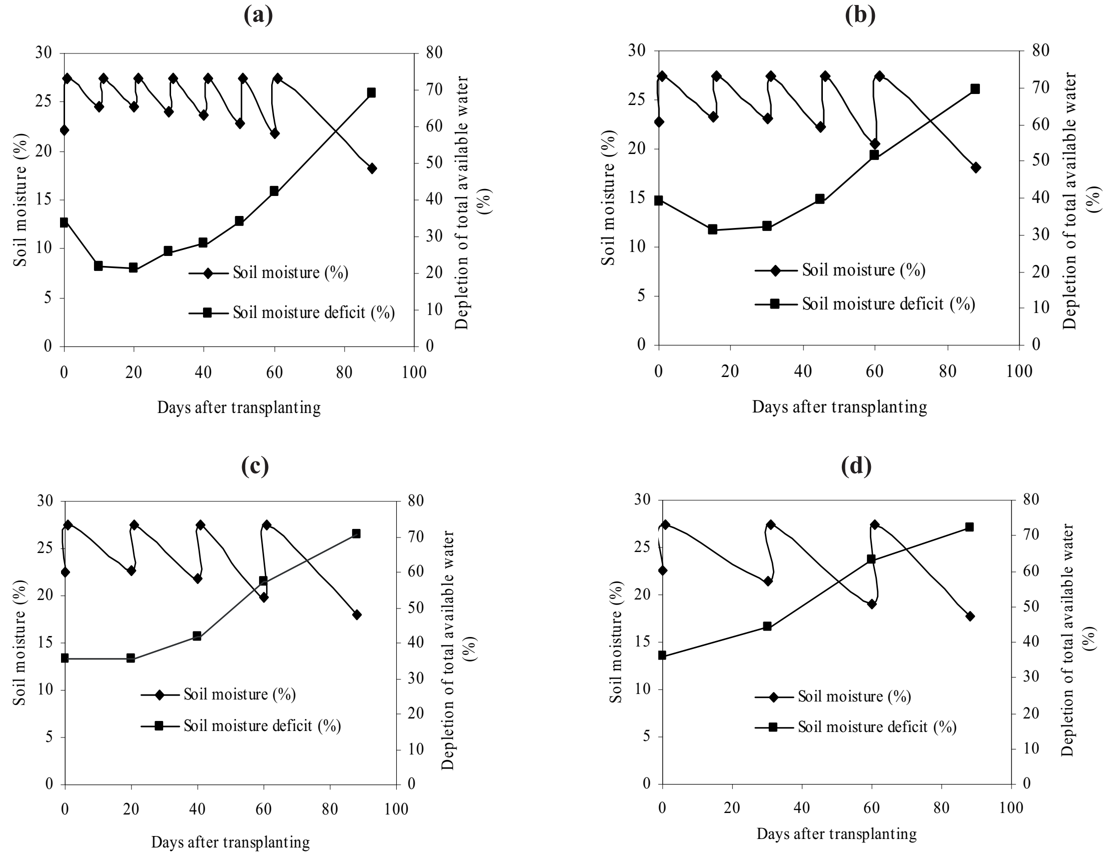
Figure 1: Percent of bulbs (number basis) under different grade size as influenced by irrigation



Tab. 1: Comparison of the yield components and disease severity of onion for different irrigation treatments (average over 2 years)

Treatment	Plant population (no. m^{-2})	Plant height (cm)	Leaves plant^{-1} (no.)	Bulb dia. (cm)	Unit bulb wt. (g)	Biomass yield (t.ha^{-1})	Disease score (scale: 0–5)
I_0	48.33	35.02	4.90	2.63	12.13	0.261	1.96
I_1	48.91	54.98	7.37	4.41	34.33	0.724	1.45
I_2	49.33	54.64	7.27	4.28	32.01	0.697	1.50
I_3	49.41	52.21	7.00	3.51	25.65	0.549	1.67
I_4	48.83	47.95	5.70	3.14	19.28	0.539	1.75
LSD(0.05)	NS	3.75	0.611	0.3183	3.73	0.396	NS
CV%	3.08	5.40	6.91	6.45	11.11	0.1621	12.23

Figure 2: Soil moisture depletion pattern of (a) treatment I_1, (b) treatment I_2, (c) treatment I_3, and (d) treatment I_4 of onion



ly followed by I_2 in which the percentage of > 30 g bulbs was 61%. The lowest number of bulbs, less than 15 g, was also recorded in treatment I_1. Figure 2 reveals that soil moisture deficit under non-irrigated condition hampered the normal growth of the plants as well as bulbs and caused the highest percentage of bulbs smaller than 15 g. Increased level of irrigation, on the other hand, was associated with higher percentage of larger sized bulbs resulting in the higher yield. Irrigation water might increased formation of reproductive structure of sink strength and increased production of assimilates leading to increased percentage of larger bulb.

Leaf purple blotch incidence

Though irrigation had no significant effect on leaf purple blotch incidence of onion (Table 2), it showed a negative correlation ($R^2 = 0.93$) with disease severity. With the increasing number of irrigations there was a tendency of decrease that was expressed by $Y = -0.0875x + 1.9305$. Thus, the disease incidence could be reduced at a rate of 0.0875 per unit increase of irrigation. However, disease infection was found maximum (score: 1.96) in non-irrigated control treatment while it was minimum (score: 1.45) in treatment I_1 with 6 irrigations at 10 days intervals. This result is in agreement with Bondhe et al. (2001) who obtained the best performance of onion in terms of resistance to purple blotch under irrigation at 10-day intervals compared to 12- and 15-day intervals. Increased disease incidence with increased watering interval was also reported by Ali et al. (1984), while other investigators (Abd-Alrazik, 1988; Srivastava et al., 2005) reported an increase in disease incidence with increasing irrigation frequency. Onions irrigated at very low soil water tension maintained excessive soil moisture for prolong time and thereby promoted disease incidence (http://extension.oregonstate.edu). In our experiment, soil moisture in the wettest treatment I_1 was optimal that might be the cause of less disease incidence in it. Besides, optimal irrigation with well-balanced nutrients resulted in good growth of onion plants that might be another cause of less susceptibility to disease.

Soil water depletion pattern

Figure 2 illustrates that different irrigation treatments affected the dynamics of soil moisture. The onion plants of the various treatments tolerated soil-water stress for different duration depending on irrigation interval. The

Tab. 2.: Effect of irrigation levels on yield, total water use and water use efficiency of onion (average over 2 years)

Treatment	Irrig.(no.)	Irrigation for plant establish-ment (mm)	Irrigation after plant establish-ment (mm)	Total water applied (mm)	Soil moisture deficit (mm)	Rain-fall (mm)	Total water used (mm)	Bulb yield ($t.ha^{-1}$)	Water use efficiency ($kg.ha^{-1}.mm^{-1}$)	Yield increase over control (%)
I_0	0	30	–	30	54	12	96	3.55	36.97	–
I_1	6	30	175	205	31	12	248	12.53	50.52	252.95
I_2	4	30	154	184	33	12	229	12.13	52.96	241.69
I_3	3	30	135	165	34	12	211	10.27	48.67	189.23
I_4	2	30	107	137	36	12	185	7.62	41.18	114.65
LSD(0.05)								1.50		
CV(%)								11.53		

treatments with long interval were affected more from water stress, especially before the irrigation events at late stage. The longer the irrigation interval the higher was the soil moisture depletion before next irrigation. Before the end of irrigation, only the onions of treatment I_1 were under optimum soil water conditions (21–34% of available soil moisture) with little exception before the last irrigation when depletion was a bit higher (42%) than optimum level. In case of treatment I_2, soil moisture depletion ranged from 31 to 48% during the irrigation period.

Yield, water use and water use efficiency

Irrigation had significant effects on bulb yield of onion. There was a quantum jump in bulb yield due to application of irrigation indicating the necessity of irrigation for onion production. Bulb yield increased with the increasing amount of applied irrigation water. However, the increase in onion yield was significant up to 4 irrigations, though the highest yield (12.53 $t.ha^{-1}$) of bulb was obtained from I_1 that received 6 irrigations at 10 days intervals. This was due to the higher percentage of large size bulbs (> 30 g) produced in this treatment. This yield was significantly higher than that from other treatments except I_2 with 4 irrigations at 15 days intervals. The yield of onion bulbs was found to be non-significant in treatments I_1 and I_2 which was probably due to the fact that irrigation in I_2 was adequate to provide sufficient soil moisture for optimum onion bulb production. This result is in agreement with Orta and Ener (2001). The increase in bulb yield of the irrigated treatments over the non-irrigated control treatment varied from 114.65 in I_4 to 252.95% in I_1. However, there was a decreasing trend in the rate of yield increase with the increasing number of irrigation. It could be inferred that bulb yield of onion increased with increasing levels of irrigation up to a certain limit. Islam et al. (1999) and Biswas et al. (2003) reported similar result for onion yield.

The total amount of irrigation water varied from 205 mm in I_1 to 137 mm in I_5 and the number of irrigation events was from 6 to 2 in various treatments. The average rainfall during the two crop seasons was 12 mm (no rainfall occurred in the first year; 23.7 mm was recorded in the second year) and total was effective since it was much less than the soil moisture deficit. The development of crop therefore largely depended on the irrigation water. Total water use varied with the variation of the amount of irrigation water applied to the plots. Total water use was found maximum (248 mm) in treatment I_1 and minimum (96 mm) was recorded in I_o. The highest amount of irrigation water (205 mm) was required in the treatment that received irrigation at 10 days interval (I_1). The quantities of water applied during each irrigation event were low under this treatment. Quantity of water applied during each irrigation increased for treatments I_2, I_3 and I_4 as they received irrigation at long interval. The higher was the frequency of irrigation the lower was the amount of water needed for each irrigation dose. This was due to the existence of higher soil moisture in the treatments in which the intervals were short.

Although total water use was the highest in treatment I_1, the WUE in terms of yield per unit water use was found the highest (52.96 $kg.ha^{-1}.mm^{-1}$) in treatment I_2 with a total water use of 229 mm (Table 3), which was 4.82, 8.81 and 28.60% higher than in I_1, I_3 and I_4, respectively. The highest WUE in I_2 reveals that water was used most effectively in this treatment. WUE decreased in I_1 because of less improvement in yield (3.29%) than the percentage increase in irrigation water (11.41%) in this treatment compared to I_2. The increase in yield was linear with crop

Tab. 3: Components of benefit-cost and incremental benefit-cost analysis of onion as influenced by irrigation

Treatment	Gross return ($Tk.ha^{-1}$)	Cost of cultivation ($Tk.ha^{-1}$)	Net return ($Tk.ha^{-1}$)	Incremenal return ($Tk.ha^{-1}$)	Incremetal cost ($Tk.ha^{-1}$)	Incremental net return ($Tk.ha^{-1}$)	BCR ($Tk.ha^{-1}$)	Incremental BCR ($Tk.ha^{-1}$)
I_0	42	55	(–)13	–	–	–	0.82	–
I_1	150	60	90	107,760	4,220	103,540	2.59	25.53
I_2	145	59	86	102,960	3,630	99,330	2.54	28.36
I_3	123	59	64	80,640	3,160	77,480	2.17	25.51
I_4	91,440	58,365	33,145	48,840	2,170	46,670	1.64	22.50

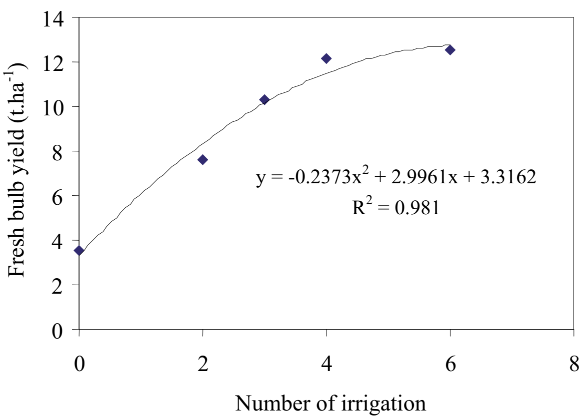
Tk. = Taka (the currency of Bangladesh) Tk. 68 = US$ 1.0
Cost of items considered for calculation:
Cost of ploughing: Tk. 700/ha/pass, Onion seedling: Tk. 30/thousand, Labor: Tk. 120/manday, Irrigation Cost: Tk. 70/hour, Urea: Tk. 7/kg, TSP: Tk. 30/kg, MP: Tk. 28/kg, Zypsum: Tk. 6/kg, Product price: Tk. 12/kg

evapotranspiration (ETc) up to 4 irrigations at 15-day interval. The results thus indicated that neither deficit nor excess of irrigation have significant effect on yield and water use efficiencies. Similar findings were also reported by Chopade et al. (1998) and Imtiyaz et al. (2000). However, the lowest water use efficiency (36.97 $kg.ha^{-1}.mm^{-1}$) was recorded in non-irrigated control as formation of reproductive structure of sink was not capable to give a better yield due to shortage of water.

Production function

The production function selected was the number of irrigation against fresh bulb yield in ton per hectare. Figure 3 shows the relationships between bulb yield and number of irrigation which was determined through non-linear regression analysis. Second degree polynomial showed a highly significant coefficient of determination (R^2 = 0.981). The curve shows a markedly upward trend indicating clear response of production to irrigation. The increase in onion yield was not proportional with the increase in number of irrigations. The production function showed that bulb yield of 10-day intervals irrigated treatment I_1 (12.53 $t.ha^{-1}$) was close to the theoretical maximum yield (12.75 $t.ha^{-1}$) calculated using regression equation. So, a total of 6 irrigations at 10-day intervals were needed for maximum bulb yield of onion. Total 205 mm water was required for 6 irrigations.

Figure 3: Relationship between fresh bulb yield and number of irrigations



Economics

The highest gross return, net return, incremental return and incremental net return were recorded in treatment I_1 followed by I_2, I_3 and I_4 (Table 3). The benefit-cost ratio (BCR) was also found the highest (2.59) in I_1 but the highest incremental benefit-cost ratio (28.36) was recorded in I_2. This was due to higher cost of irrigation in I_1 than that in I_2. The lowest BCR (0.89) was observed in non-irrigated control Io indicating the dire necessity of irrigation in onion production. The difference between incremental net return registered by I_1 and I_2 was marginal (Taka 4, 210) indicating scope for decreasing the number of irrigation in case of I_1. However, the difference was Tk.26, 060 in between I_1 and I_3.

CONCLUSIONS

Irrigation had insignificant effect on leaf purple blotch incidence of onion, but there was a decreasing tendency in its severity with increasing number of irrigation. Production function of yield versus number of irrigation was found to be polynomial. The highest bulb yield was obtained from the treatment, which received a total of six irrigations at 10 days interval and it was at par with the treatment, which was irrigated four times at 15 days interval. Although the highest incremental net return and the highest BCR were recorded in the former treatment, the latter treatment gave the highest WUE and the highest incremental benefit-cost ratio. Irrigation both at 10 and 15-day intervals was found suitable, but 15-day interval was found most suitable for cultivation of onion (cv.BARIonion-1) from the view point of WUE and economics.

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REFERENCES

ABD-EL RAZIK A.A., EL-SHABRAWY A.M., RUSHDI M.H., EL-GANIENY R.M. (1988): Effect of certain environmental factors and fungicides on blasting disease of onion seed-head. Egyptian J. Phytopath., 20 (1): 13–24.

AHMED H.U., HOSSAIN M.M. (1985): Final report of the project crop disease survey and establishment of a herbarium at BARI, Plant Path. Div. BARI, Joydebpur, Gazipur, p. 170.

ALI M., GAAFER H., FREGOON SAMI O., EL HASSAN HASSAN S. (1984): Effect of frequency of irrigation and cultivar on the incidence of pink root rot disease of onions. Acta Hort. (ISHS), 143: 427–432.

ASHRAFUZZAMAN M.H. AHMAD M.U. (1976): Control of foliage disease of onion by spray fungicides, Bangladesh Hort., 4 (2): 28–30.

BARC (Bangladesh Agricultural Research Council) (2005): Soil fertility status of different Agro-ecological zones. BARC Soils Publication No. 45, pp. 15─32.

BARC (Bangladesh Agricultural Research Council) (1989): Fertilizer Recommendation Guide. Bangladesh Agril. Res. Coun., Dhaka, p. 96.

BBS (Bangladesh Bureau of Statistics) (2004): Monthly (February) Statistical Bulletin of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, p. 54.

BHONDE S.R., CHOUGULE A.B., SINGH N.B. (2001): Effect of irrigation and nitrogen level on seed crop performance of onion variety Agrifound Dark Red. News Letter National Hort. Res. and Dev. Foundation, 21 (1): 24–26.

BISWAS S.K., SARKER P.K., MAZHARUL ISLAM A.K.M., BHUIYAN M.A., KUNDU B.C. (2003): Effect of irrigation on onion production. Pakistan J. Bio. Sci., 6 (20): 1725–1728.

CHOPADE S.O., BANSODE P.N., HIWASE S.S. (1998): Studies on fertilizer and water management to onion. PKV Res. J., 22: 44–47.

DOORENBOS J., KASSAM A.H. (1986): Yield response to water. FAO irrigation and Drainage paper No.33. Food and Agricultural Organization of the United Nations. Rome, Italy, p. 111.

IMTIYAZ M., MGADLA N.P., CHEPETE B., MANASE S.K. (2000): Response of six vegetable crops to irrigation schedules. Agric. Water Manage., 45: 331–342.

ISLAM M.S., KHAN B.R., RASHID M.H. (1999): Irrigation scheduling for onion. Bangladesh J. Agril. Res., 24 (2): 233–240.

MARTIN DE SANTA OLALLA F., VALERO J.A.J., CORTES C.F. (1994): Growth and production of onion crop (Allium cepa L.) under different irrigation scheduling. Eur. J. Agron., 3 (1): 85–92.

MEAH M.B., KHAN A.A. (1987): Check list of fruit and vegetable diseases in Bangladesh. Dept. of Plant Pathology, BAU, Mymensingh, p. 23.

MICHAEL A.M. (1978): Irrigation Theory and Practice. Vikas Publishing House Pvt. Ltd., New Delhi.

ORTA A.H., ENER M. (2001): Irrigation scheduling of onion in Turkey. J. Biol. Sci., 1 (8): 735–736.

RAHMAN M.L., AHMED H.U., MIAN I.H. (1988): Efficacy of fungicides in controlling purple leaf blotch of onion, Bangladesh J. Plant Path., 4 (1&2): 71–76.

SHABEER-AHMAD KARIMULLAH, AHMAD S. (1998): Relevance of management practices to downy mildew in onion. Sarhad J. Agric., 14 (2): 161–162.

SHARMA S.R. (1986): Effect of fungicidal sprays on purple blotch and bulb yield of onion. Indian Phytopath., 39 (1): 78–82.

SRIVASTAVA K.J., GUPTA R.P., SHARMA H.K., PANDEY N.K. (2005): Effect of nitrogen doses and irrigation intervals on the stemphylum blight disease and thrips in onion bulb crop. News Letter National Hort. Res. and Dev. Foundation, 25 (1): 6–9.

TEVIOTDALE B.L., DAVIS R.M., GUERARD J.P., HARPER D.H. (1989): Effect of irrigation management on sour skin of onion. Plant Disease, 73 (10): 819–822.

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