YIELD, IRRIGATION PRODUCTION EFFICIENCY AND ECONOMIC RETURN OF ONION UNDER VARIABLE IRRIGATION METHODS

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ABSTRACT

A Field study was carried out during the winter crop growing season of 2013-2014 (Nov to April) on clay loam soil to examine the effect of variable irrigation (50, 75, 100, 125, 150 & 175% of pan evaporation replenishment) on yield, irrigation production-efficiency and economic return of onion. The crop was irrigated by drip irrigation system. Irrigation at 125% of pan evaporation replenishment and 0.30m and 0.35m spacing (in every row every column) resulted in higher marketable yield. A further increase in irrigation level resulted from 150% pan evaporation replenishment reduced marketable yield significantly. The higher irrigation production efficiency was recorded at 50% of pan evaporation replenishment and it decreased significantly with an increase in irrigation methods. Irrigation at 125% of Pan Evaporation replenishment resulted in higher gross return, net return and benefit cost ratio. The seasonal water applied and marketable yield, gross return, net return and benefit cost ratio showed strong quadratic relationship for both drip and surface methods which in turn can be used for optimizing onion production under variable irrigation methods. The results revealed that drip irrigation system is profitable for onion production in spite of high initial investment.

Keywords: *Drip Irrigation, Surface Irrigation Marketable Yield, Irrigation Production Efficiency, Gross Return, Net Return, Benefit Cost Ratio, Yield and Onion*

INTRODUCTION

Water is the greatest resource to humanity. It not only helps in survival but also make life comfortable and luxurious. Although water is a renewable resource, its availability in appropriate quantity is under severe stress due to increasing demand from various sectors. Agriculture is the largest user of water, which consumes more than 80% of the exploitable water resource. Growing population, intensifying agriculture industrial development and increasing urbanization are leading to higher demands of water.

Irrigation scheduling is a critical management input to ensure adequate soil moisture for optimum plant growth, yield, quality, water use efficiency and economic return. Irrigation scheduling which determine the timing and amount of irrigation water is governed by many complex factors, but microclimate plays the most vital role. Therefore it is important to develop irrigation scheduling techniques under prevailing vital conditions in order to utilize scare and expensive water efficiently and effectively for crop production. Numerous studies were carried out in the past on the development and evacuation of irrigation scheduling techniques under a wide range of irrigation system and management, soil crop and climate conditions **(Mgadla *et al.* 1995; Tiwari and reddy 1998; Imtiyaz *et al.* 1996, 2000d Bucks, D.A *et al.*, 1981, Camp, C.R *et al.*, 1989)**.

Appropriate irrigation scheduling is to increase irrigation efficiencies by applying the exact amount of water needed to replenish the soil moisture to desire level, save water resources and energy. Therefore, it is important to develop scheduling techniques under prevailing climatic conditions in order to utilize scare water resources effectively for crop production.

Surface irrigation is the most common method for vegetable, fruit and flower crops in this region. The meteorological approach of scheduling irrigation is relating the evapotranspiration from crop to evaporation from an open pan, as it is well known that the rate of evapotranspiration is related to open pan evaporation. The meteorological approach such as pan evaporation replenishment, cumulative pan evaporation and ration between irrigation water and cumulative pan evaporation play a very important role in scheduling **(Singh *et al.*, 1997; Imtiyaz *et al.*, 2000a, c,e; Thakur and Spehia, 2005; Wanga *et al.*, 2007; Badr and Abuarab 2013)**. In spite of some limitations, evaporation from USWB class-A open pan sdata can be used to estimate reference evapotranspiration using Penman equation.

The Drip irrigation with its ability for small but frequent water application has been found superior in terms of water economy, yield and water use irrigation production efficiency. Efficient use of water by irrigation system is becoming increasingly important particularly in arid and semi-arid regions. The drip irrigation systems with its ability to apply small but frequent irrigation have numerous advantages over methods in terms of water economy, yield and quality. Water application efficiency in the drip irrigation is higher than other methods of irrigation **(Hanson *et al.*, 1997; Imtiyaz *et al.*, 2007, 2009; Boseveld *et al.*, 2011; Dingre *et al.*, 2012 Fekadu Y and Teshome T. 1997, Burman R.D *et al.*, 1980, Berhrouz Safi *et al.*, 2007)**.

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Onion (*Allium cepa* L.) is one of the important vegetable extensively grown in India. Onion is regarded as a cash crop. Onion is rich source of vitamins A, C, potassium, minerals and fibers. Drip irrigation is popular in several agro-climatic zones in India except in the state of Uttar Pradesh mainly due to the lack of information on irrigation scheduling techniques and economic viability of the system. The objective of the present study was to investigate the effect of variable irrigation methods of irrigation and irrigation method on yield, yield components and irrigation production efficiency of onion, variable irrigation and irrigation method on total, cost of production, gross return, net return and benefit cost ratio.

MATERIALS AND METHODS.

Field experiments was conducted at the irrigation research farm of Sam Higginbottom University of Agriculture, Technology And Sciences, Allahabad (25^{0}27'N, 81^{0}44'E, 98m above mean sea level) during Rabi season of 2013-2014 in order to examine the effect of variable irrigation methods on yield, irrigation production efficiency and economic return of onion. The climate in this part of the country has been classified as semi-arid. The soil of the experimental field was fertile clay loam (35.5% sand, 25.8% silt and 36.6% clay) with average bulk density of 1.31 g cm^{-3}. The soil moisture content at field capacity (-1/3 bar) and wilting point (-15 bar) were 19.5% and 9.1% on dry weight basis. The plant avail-able soil moisture was 136.2 mm m^{-1}.

The experiment consisted of six irrigation levels i.e. the amount of water in different treatment was 50, 75, 100, 125, 150 and 175% USWB class A pan evaporation replenishment Crop was irrigated when the sum of the daily mean (5 years) of pan evaporation reached approximately a pre-determined value of 16.3mm (rooting depth in m x plant available soil moisture in mm/m x readily available soil moisture in fraction). The crops were irrigated by the surface drip irrigation method. The drip irrigation system was designed and installed to meet the objectives of the experiment. The irrigation water was pumped directly from tube-well to the concrete tank and thereafter it was pumped from the tank to the drip irrigation system. Screen filter was installed on the main line to minimize dripper blockage. The 50mm diameter PVC pipes and 12mm diameter Low Density Polyethylene pipes were used for the sub-main and laterals respectively. The onion was watered by 4 l/h non-pressure compensated on-line drippers. The spacing between drippers was 0.30m. The experimental plot was connected by a control valve in order to deliver the desired amount of water. The sub-main was connected to a water meter and control valve. The crop was harvested from 30th April 2014. Further irrigation production efficiency was obtained by the formula

Irrigation Production Efficiency, Kg m^{-3}

$$= \frac{\text{marketable yield (kg-ha}^{-1}\text{)}}{\text{seasonal water applied (m}^2\text{ha}^{-1}\text{)}} \qquad (1)$$

In order to assess the economic viability of drip irrigation system under variable irrigation methods, both fixed and operating cost are included. Total cost of production, gross return and net return under different irrigation levels will be estimated on the following assumptions.

Salvage value of the components	= 0
Useful life of tube well, pump, motor and pump house	= 25 years
Useful life of drip irrigation systems	= 10 years
Useful life of weeding and spraying equipments	= 7 years
Interest rate	= 13%
Repair and maintenance	= 7.5%
No. of crops/year	= 2

The fixed cost including water development (tube well, pump, motor, pump-house and other accessories) and irrigation system poly vinyl chloride (PVC) and low density polyethylene pipes (LDPE) for main, sub-main and laterals, filters, fertilizer unit, pressure gauges, control valves, water meter, drippers and other accessories was calculated for different irrigation methods **(James and Lee, 1971)**

$$\text{CRF} = \frac{i\,(1+i)^n}{(1+i)^n\text{-}1} \qquad \ldots\ldots\ldots (2)$$

where,

CRF= capital recovery factor

I= interest rate (fraction)

n= useful life of the component (years)

Annual fixed cost/ha = CRF × fixed cost ha^{-1} ...... (3)

Annual fixed cost/ha = (Annual fixed cost ha^{-1})/2 ...... (4)

The operating cost which includes labour (system installation, fertilizer, chemical application and harvesting etc.); land preparation, seeds, fertilizer, chemicals (insecticides and pesticides) and water pumping (electricity) and repair and maintenance (tube well pump, motor, pump house, irrigation systems and pipe conveyance system etc.) was estimated. The gross return for different irrigation methods and schedules was calculated taking into consideration of marketable yield and wholesome price of cabbage. Subsequently, the net return for the tomato was calculated considering total cost of production (fixed and operating costs) and gross return.

Net return (Rs ha^{-1}) = Gross return (Rs ha^{-1}) - Total cost of production (Rs ha^{-1}) ....(5)

The benefit cost ratio B/C was calculated as follows :

B/C = ...(6)

RESULTS AND DISCUSSION

4.1 Yield and irrigation production efficiency

The effect of irrigation levels and lateral spacing on yield during crop growing and irrigation production efficiency of onion is presented in *Table 4.1.* irrigation schedules had marked effect on number of the onion/m^2, mean onion weight, marketable yield of onion and irrigation production efficiency of onion. The mean marketable of onion for different irrigation schedules ranged 11.65 to 20.65 t/ha of onion. The highest mean marketable yield of onion (28.44t/ha) was obtained when irrigation during crop growing was applied at 125% of pan evaporation replenishment. A further increase in irrigation levels resulted from175% of pan evaporation replenishment reduced the marketable yield of onion (20.65 t/ha) due to poor aeration caused by excessive soil moisture marketable yield of onion *(Table 1)*. The Irrigation levels had marked effect on irrigation production efficiency of onion *(Table 4.1)*. The irrigation production efficiency for different irrigation levels ranged from 6.39 to 3.2 kg/m^3. The irrigation production efficiency decreased significantly with the increase in irrigation levels because increase in the mean crop yield was lower than the seasonal water applied. Irrigation at 100% of pan evaporation replenishment resulted in higher mean irrigation production (7.13

kg/m^3) because reduction in seasonal water was higher than the reduction in crop yield. A further increase in irrigation levels from 50 to 175% of pan evaporation replenishment reduced the irrigation production efficiency significantly because increase in crop yield was less than increase in seasonal water applied. The irrigation production efficiency decreased significantly with an increase in yield was much less as compared with seasonal water applied. The significantly minimum irrigation production efficiency (3.23kg/m^2) was recorded when irrigation during crop growing season was applied 175% of pan evaporation replenishment because it increased seasonal water applied considerably but decreased the marketable yield *(Table 4.1)*. The irrigation methods had significant effect on yield, yield component and irrigation production efficiency *(Table 1)*. The mean marketable yield of onion under different irrigation methods ranged from 25.10 to 17.98t/ha. The mean marketable yield of onion was significantly higher for drip irrigation methods, followed by drip and surface irrigation methods.

The marketable yield of onion was slightly higher in drip irrigation as compared with surface whereas surface irrigation methods resulted in considerably lower yield (24%) due to poor water distribution. Drip and surface resulted in significantly higher irrigation production efficiency. The surface irrigation methods resulted in minimum production efficiency due to considerably low marketable yield of onion *(Table 4.1)*.

The overall result presented in *table 4.1*, clearly revealed that both irrigation methods and irrigation schedules considerably influenced yield; yield component and irrigation production efficiency of onion. The higher marketable yield of onion was recorded when irrigation during the crop growing season was applied at 125% of pan evaporation replenishment whereas irrigation production efficiency was higher with irrigation at 100% of pan evaporation replenishment.

Economic Return

The total cost of production, gross return and benefit cost ratio of onion in relation to irrigation methods and schedules are presented in *Table 4.2*. The total cost of production increased slightly with an increase in irrigation levels due to increase in pumping cost induced by variation in seasonal water application. The total cost of production for drip and surface irrigation methods varied from 80131.21 Rs/ha to 86956.21 Rs/ha and 24536.97 Rs/ha to 31358.97 Rs/ha respectively. The total cost of production in drip irrigation was considerably higher as compared with surface irrigation mainly due to variation in irrigation system cost.

The gross return under different irrigation schedules for drip and surface irrigation methods ranged from 347500 Rs/ha to 610000 Rs/ha and 235000 Rs/ha to 422666 Rs/ha respectively. The increase in gross return when irrigation during crop growing season was applied 175% of pan evaporation replenishment decrease the gross return considerably due to reduction in marketable yield. The drip and surface irrigation method resulted almost some gross return, but surface irrigation method gave considerably low gross return due to lower marketable yield induced by poor water distribution. The net return increased considerably with an increase in irrigation levels. The maximum net return for drip 267368.79 Rs/ha and surface 523043.79 Rs/ha irrigation methods were obtained when irrigation during crop growing season was applied at 150% of pan evaporation replenishment.

A further increase in irrigation levels resulted from 125% of pan evaporation replenishment reduced the net return considerably due to reduction in gross return. In spite of lower system cost, the surface irrigation methods gave considerably low net return as compared with drip and surface irrigation methods ranged from 4.33 to 7.01, 9.57 to 13.47 respectively. The benefit cost ratio increased with irrigation levels up to increase in irrigation levels resulting from 150% of pan evaporation replenishment reduced the total cost of production. The surface and drip irrigation system resulted in higher benefit cost ratio *(Table 4.2)*

The overall result revealed that both irrigation methods and irrigation schedules considerably influenced yield; yield component and irrigation production efficiency of onion. The higher marketable yield of onion was recorded when irrigation during the crop growing season was applied at 125% of pan evaporation replenishment whereas irrigation production efficiency was higher with irrigation at 100% of pan evaporation replenishment.

Water supply and yield

The relationship between seasonal water applied and marketable yield of onion under drip and surface irrigation methods are presented in *fig. 4.1*. In spite of some variation, the seasonal water applied and marketable yield of onion under drip (R^2 = 0.963) and surface (R^2= 0.955) irrigation methods exhibited strong quadric relationship. The marketable yield of onion increased with an increase in seasonal water applied 182 to 637 mm for drip and surface irrigation methods respectively and thereafter, and irrigation production efficiency of onion tended to decline.

The quadric yield- water applied irrigation schedules relationship probably resulted from nutrients leaching through deep percolation and poor aeration. **Imtiyaz *et al.*, (2000a,b,e, 2002)** reported strong quadric relationship between seasonal water applied and marketable yield of cabbage, broccoli, carrot, cauliflower, onion, spinach, and turnip in drip and irrigation methods in the semi- arid climates of Botswana many researchers reported the quadratics relationship between yield and seasonal water applied for vegetable and field crops under wide variety of

Table 1- Effect of different irrigation schedules and irrigation methods on marketable yield, yield components and irrigation production efficiency of tomato.

Treatment	Marketable yield	Irrigation production efficiency (kg/m^3)
50	11.65	6.39
75	18.10	6.62
100	25.98	7.13
125	28.44	6.24
150	24.43	4.46
175	20.65	3.23
CD (0.05)	2.363	0.513
Irrigation methods Drip	25.10	6.64
Surface Interaction	17.98	4.71
CD (0.05)	5.789	1.257

Table 2- Economic return of onion under different irrigation schedules and irrigation methods.

Pan evaporation replenishment (%)	Total cost of production (Rs/ha)		Gross return (Rs/ha)		Net return (Rs./ha)		Benefit cost ratio (Rs./ha)	
	Drip	**Surface**	**Drip**	**Surface**	**Drip**	**Surface**	**drip**	**Surface**
50	80131.21	24536.97	347500	235000	267368.79	210463.03	4.33	9.57
75	81496.21	25901.97	540083	365083	465253.77	339181.36	6.62	14.08
100	82861.21	27266.97	741916	557666	659055.45	53039.69	8.64	20.44
125	84226.21	28631.97	824500	597666	741183.79	569044.69	9.76	20.87
150	83953.21	28358.97	701500	520166	617546.79	491807.69	8.35	18.34
175	86956.21	31358.97	610000	422666	523043.79	391307.69	7.01	13.47

Note: - the price of onion is taken Rs. 25 Kg

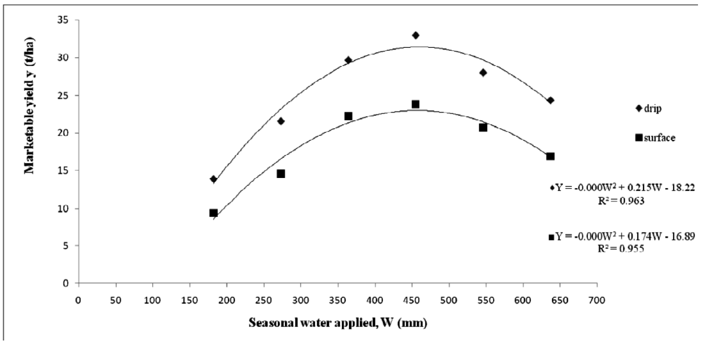

Fig 4.1 Relationship between Marketable Yield and seasonal water applied of onion

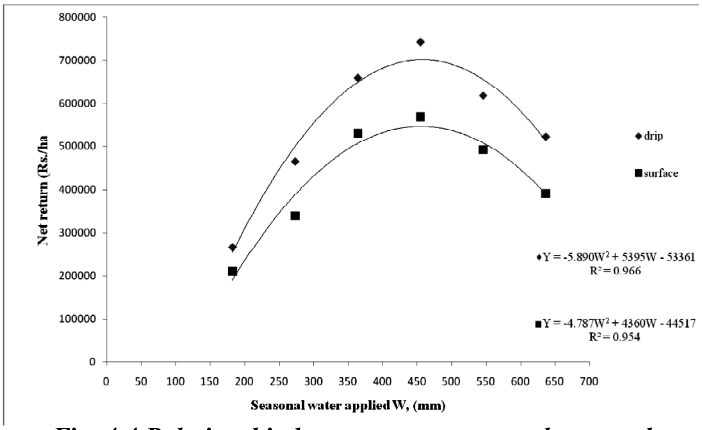

Fig. 4.4 Relationship between net return and seasonal water applied

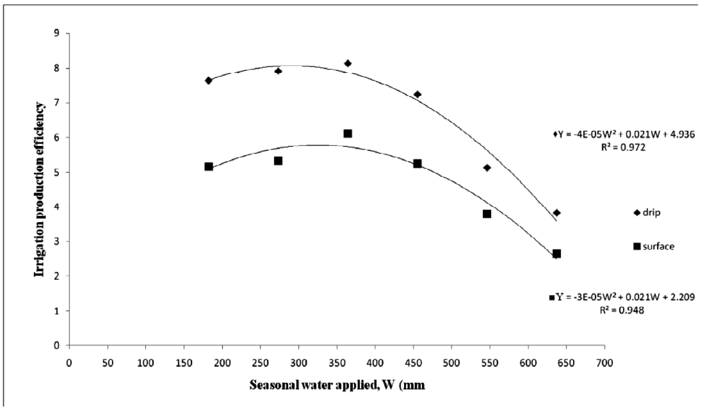

Fig 4.2 Relationship between Marketable Yield and seasonal water applied of onion

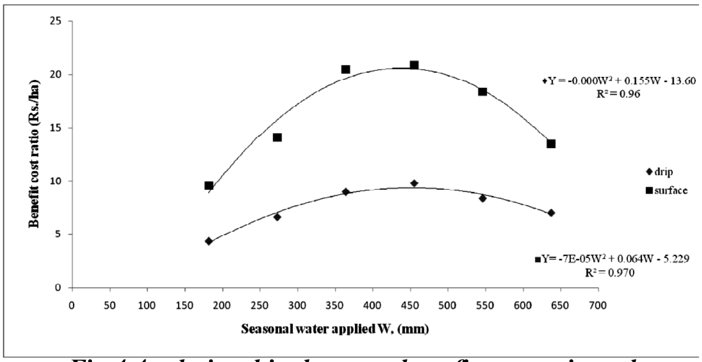

Fig.4.4 relationship between benefit cost ratio and seasonal water applied

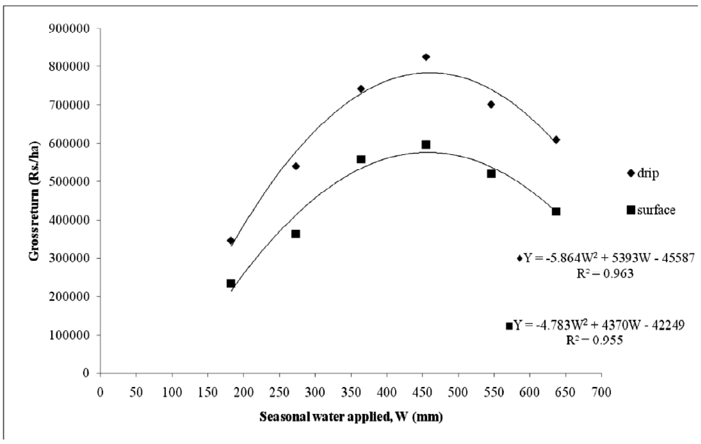

Fig 4.3.Relationship between Gross return and seasonal water applied of Onion

irrigation system and regimes, soil and climatic conditions **(Musick *et al.*, 1997; Singh, 1897, Farah *et al.*, 1997; Howell *et al.*, 1997; Tiwari and Reddy 1997; Zhang and Owesis 1999; Imtiyaz *et al.*, 2002)**.

CONCLUSION

The experimental results showed that irrigation with 125% evaporation replenishment resulted in the highest marketable yield of winter onion. Irrigation at 50% pan evaporation replenishment produced higher irrigation production efficiency. Irrigation with 150% pan evaporation replenishment reduced the irrigation production efficiency because it increased the seasonal water application considerably without a significant improvement in marketable yield. Seasonal water applied and marketable yield of onion for 0.30m and 0.35m spacing exhibited strong quadratic relationship. Finally the overall results clearly suggest that in order to obtain an optimum yield, irrigation production efficiency and net return of onion in the northern plain of India, crops during the winter season should be irrigated at 125% of pan evaporation replenishment and the irrigation method. Further it is also observed that among the two methods of irrigation drip gives highest gross return, net return. Thus it can be concluded that in order to procure the higher crop yield, irrigation production efficiency and net return of onion during the winter growing season, the crop should be irrigated at 125% of pan evaporation replenishment with drip irrigation method.

REFRENCES

Imtiyaz M., Srivastava S. K. and Alam M. A. (2009) Yield and economic return of tomato as influenced by irrigation schedules and lateral spacing. Proceeding of the 10th International Agricultural Engineering Conference, Bangkok, Thailand.

Imtiyaz M, Mgadla N P and Manase S K. (2000e) Response of green mealies to water levels under sprinkler and drip irrigation. Proc. Of International Agricultural Engineering Conference, Asian institute of technology, Bangkok, 343-350.

Imtiyaz M, Saroha N, Alam M A. (2007). Marketable yield, irrigation production efficiency and economic return of onion under variable irrigation and lateral spacing. Proceeding of the International Agricultural Engineering Conference, Bangkok, Thailand.

Bringgs, L.J. and H.L. Shantz,(1913). The requirement of plants. Investigation in the Great Plain in 1910 and 1911. Bull. No. 284. U.S.Bur. PLANT Ind., Washington D.C.

Bucks, D.A., L.J. Fire O.F. French, F.S. Nakaranma and W.D. Pew (1981). Subsurface Trickle irrigation management with multiple cropping. Transaction of the ASCE, 24(6): 1482-1489.

Burman, R.D., J.R. Nixon, J.L. Wright and W.O. Pruitt (1980). Water requirements. In design and operation of farm irrigation system, ed. ME Jensen St. Joseph, Mich. ASCE.

Camp,C.R.,E.R. Sadler and W.J. Busscher (1997b). A compression of uniformity measure for irrigation systems. Transactions of the ASCE 40 (40:1013-1020)

Camp, C.R., Sadler and W.J. Busscher (1989). Subsurface and alternate-idle micro Irrigation for the southeast coastal plane. Transaction of the ASCE.32 (2):451- 456.

Camp, Garrett, C.R., Sadler, J.T. Busscher, E.J. (1993a). Micro-irrigation Management for double-cropped vegetable in humid area. Trans. ASCE 36(6) 1693-1644.

Fekadu Y and Teshome T. (1997). Effect of drip and furrow irrigation and plant spacing on yield of tomato at Dire Dawa, Ethiopia. *Agric Water Manage*. 35: 201-207.

Fekadu Y and Teshome T. (1997). Effect of drip and furrow irrigation and plant spacing on yield of tomato at Dire Dawa, Ethiopia. *Agric Water Manage*. 35: 201-207.

Berstein, J. W.H. and L.E. Franneous (1993). Comparison of Drip, Furrow and Sprinkler Irrigation, Soil Science, 115 : 73-76

Braey, R.P., R.J. Edling and E.B. Moses (1995). Drip irrigation management and fertilization of bell peper in a humid area. In proc. 5th Micro irrigation congress. Ed. F.R. Lamm, 181-186. St. Joseph, Mich, ; ASCE

Berstein, J. W.H. and L.E. Franneous (1973). Comparison of Drip, Furrow and Sprinkler Irrigation, Soil Science, 115 : 73-76

Berhrouz Safi *et al.*, (2007). Water application uniformity of a surface drip irrigation system at various operating pressure and tape length. College of Agriculture, Tabriz University, Tabriz- IRAN. College of Agriculture, Tarbiat Modares University, Tehran- IRAN.

Bogoucos, C.J. (1950). A practical soil moisture meter as a scientific guide to irrigation Practices. *Agro. J.* 42: 104-107

Bougoin, T.L., (1984). Developing of Potato irrigation scheduling program. The main situation. A.M. Patato J61(4):195-203.

Branthome, X., peley, Y., Machado, J.R., and Biche, B.J. (1994). Influence of drip irrigation on the technological characteristics of processing tomatoes. Acta-Horticulture. 376:285-290.

De-Witt, C.T. (1958). Transpiration and crop yields. Vrsl Handbook. Orders. No. 6 Wageninegen. The Netherland.

Hutchmacher R.B., S.S Vail, J.G. Muthamia, V. Mwaja and Liu (1985). Effect of trickle Irrigation frequency and installation depth of tomato growth and water status In proc. 3th Int., drip / trickle irrigation Congress, 2:798-804. St. Joseph, Mich: ASCE.

Imtiyaz, M. and S.J. Singh. (1990). The effect of soil moisture stress on onion; Evapotranspiration- Yield relationship. Proceeding of the International Agricultural Engineering Conference and Exhibition. Asian Institute of Technology, Bangkok, 3:889-898.

Imtiyaz, M., N.P. Mgadla and B.Chepete (1995). Yield and water expense efficiency ofs onion, tomato and green pepper as influenced by irrigation schedules, Irrigation research paper No. 3 Department of Agriculture Research, Botswana, 25p.

Imtiyaz, M., N.P. Mgadla, S.K. Manse, D. Kaisara and Cheno and E.O. Moth obi. (2000a) Yield and economic return of Vegetable Crop under variable irrigation. Irrg. Sci. 19:pp.87-93.