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KVR Rao
ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Suchi Gangwar
ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Pushplata Aherwar
ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Deepika Yadav
ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Correspondence
KVR Rao
ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Growth, yield, economics and water use efficiency of onion (*Allium cepa* L.) under different micro irrigation systems

KVR Rao, Suchi Gangwar, Pushplata Aherwar and Deepika Yadav

Abstract
Selection of the proper irrigation method will be advantageous to manage limited water supplies and increase crop profitability. The overall objective of this study was to evaluate the growth, field economics and water use efficiency on onion under different micro irrigation system. This study was conducted in PFDC field, ICAR-CIAE Bhopal. In this study four irrigation methods (Drip, Sprinkler, Perforated pipe and Flood irrigation method) were used. The higher onion yield obtained with the drip irrigation followed by perforated pipe system and the lowest yield was obtained in flood irrigation system. The large onion sized was higher for the drip irrigation method than the other three methods. It was concluded that drip irrigation system gives more yield and increased onion size while using almost half of the water. This was due to drip irrigation system allowing for more frequent and smaller irrigation depths with higher irrigation efficiency.

Keywords: Micro irrigation methods, water use efficiency, economics, yield, onion

Introduction
Onion (*Allium cepa* L.) is one of the important vegetable crops commercially grown in India. It is a member of Alliaceae family, rich in sulphur containing compounds that are responsible for their pungent smell and for many of their health promoting effects. Onion bulb is a rich source of minerals like phosphorus and calcium. It also contains protein and vitamin C. Onions are now being used in several ways as in fresh, frozen, canned, caramelized, pickled, powdered, chopped and dehydrated forms. Onion powder is a spice used for seasoning in cooking. The World Health Organization (WHO) supports the use of onions for treating poor appetite and to prevent atherosclerosis.

India is the second largest producer of onion in the world, next only to China. In India, onion is being grown in an area of 0.83 million hectares with production of 13.57 million tonnes and the productivity is 16.30 t ha-1 which is low (Bagali et al., 2012) [2]. Maharashtra is the leading onion producing state followed by Karnataka, Gujarat etc. (Bijay Kumar, 2010) [7]. On farm water management plays a crucial role in inhancing onion productivity (Kumar et al. 2007 and Enciso et al. 2009) [8, 5].

The scarcity of irrigation water is an effective factor in reducing the cultivated areas in the world. Therefore, researchers and farmers resorted to the development and use of new systems to reduce wastage of water. One of the most efficient method to apply water is drip irrigation system. Irrigation through drip is a new technique to increase agricultural production and to enhance the Water use efficiency (Kusçu et al. 2009; Shock 2013; Enciso et al. 2015) [9, 12, 6].

With a direct and incremental irrigation of crops, drip irrigation is able to target the roots and base of a plant in a potent way through a system of pumps, controls, pipes, and emitters. Another type of micro irrigation can be seen in different-sized sprinklers that replicate the small droplets of rainfall. The low rate of water delivery to the plant over time allows it to maintain the prime amount of irrigation required for maximum yield. The International Journal of Environmental Sciences stated in 2012 that sprinkler systems, themselves, can be 63% more efficient than flood irrigation (Mehtra). Moreover, the use of water is often reduced by anywhere between 20 % and 50 %. **C**limate change has brought changes to our rainfall patterns. The Irrigation method of Onion is directly related to profitable and sustainable Onion production and onion needs frequent and light irrigation to maintain high soil moisture. To overcome this, a new irrigation technology, the perforated pipe irrigation system has been introduced. It is an affordable spray Irrigation technology and a replacement for sprinkler irrigation systems. It is widely suitable for closely spaced crops like onion, vegetable crops, groundnut, etc. Currently, this technology mainly being adopted by onion cultivators.

In case of flood irrigation due to under and over irrigation leads to loss in yield, market grade, soil erosion, bulb disease susceptibility, etc. Keeping this in mind, an experiment was planned on onion to study the feasibility of onion cultivation under different micro irrigation systems.

Method and Materials

Study Area

The present work was carried out at ICAR-Central Institute of Agricultural Engineering at PFDC Bhopal. Soils of the experimental site are classified as heavy clay soils with clay content varying between 49.7 to 53.7 % and with the field capacity ranging from 28.5 to 31 %. Four treatments T1-Flood irrigation (Control), T2- drip irrigation, T3-Perforated pipe irrigation, T4- Sprinkler irrigation, were tested in onion. Each treatment plot consisted of 5 raised beds. The bed width was 1 m and the bed length was 18 m in 5 replications and laid down in RBD design. Before transplanting of seedlings Nitrogen, Phosphorus and Potassium per hectare were applied @ 100 kg N and 50 kg P2O5 and 50 K2O. The sources of N,P and K were Urea, Diammonium Phosphate (DAP) and Muriate of Potash (MOP) respectively. The entire quantity of P and K with one half of N was applied as basal dose at the time of final land preparation and the remaining half N was applied as top dress.

Crop Detail

Transplanting of 40 Days old onion crop seedlings raised on raised beds was done in last week of August, 2018 at a spacing of 30 cm x 10 cm. Before transplanting, water was applied to the plots to maintain the soil moisture at field capacity as the soil was very dry. All other agronomic practices were kept uniform for all treatments. Crop management after transplanting includes: timely weed control, top dressing, pests and diseases control and timely water application according to irrigation schedule. The most common pests were thrips and onion fly.

Five plants from each plot were selected randomly and tagged for recording growth parameters *viz.*, plant height, number of leaves, and neck girth. Yield parameters *viz.*, polar diameter, equatorial diameter, bulb weight were recorded from the plants used for recording observations. The crop was harvested in the last week of December. When the leaves matures and start collapsed the bulb yield per hectare was worked out based on the plot yield. The crop was harvested on 120th day after transplanting when bulb onions were mature and the leaves had collapsed or bent over and left to dry for 10-12 days. Mature bulb onions were manually uprooted from the soil and cured in the sun for 10-14 days before taking measurements of yield and quality parameters. Dried leaves were cut off at 3.5 cm from the bulb.

Irrigation Details

For irrigating onion, crop water requirements (CWR) was determined from the crop consumptive use of water or evapotranspiration includes evaporation of water from land and water surfaces and transpiration by vegetation. The excess estimation of crop consumptive use may ultimately create the problems of water logging whereas the under estimation leads to crop failure or low yield of crops. Thus the under estimation of CWR become major constraint to achieve the full economic benefits from agriculture produce. To establish net water requirements of a crop in any environment, potential evapotranspiration (ETo) and crop coefficient (Kc) are required to calculate crop evapotranspiration (ETc). The Modified Penman method was for estimation of ETo. A set of climatic data of a specific location is used in the computation of ETo. For interpretation purpose, data was used on daily bases. For The calculation of crop water requirement of onion at different crop growth stages the value of crop coefficient was taken from FAO-56 (Allen et al, 1998) [1]. Planting date, stage of growth of the crop and length of growing season are the major factors, which have been also considered for calculation of water requirement. Similarly, to determine the net water requirements the effective rainfall was subtracted from the calculated crop water requirement.

The irrigation systems *viz*; drip, sprinkler, perforated pipe and conventional irrigation method was taken for irrigating onion crop. In drip irrigation system consisted of the control unit and distribution lines. The control unit contained a sand media filter, fertilizer tank, disk filter and control valves. The distribution system consisted of HDPE pipes which were used as the mainline (75 mm in diameter) and sub mains (63 mm in diameter), drip laterals that were 16 mm in diameter and 18 m in length had inline emitters spaced 20 cm apart with a 2 l/h flow rate at the pressure of 1 atmosphere. The lateral lines placed between 2 plant rows. Water is applied in alternate day through drip irrigation based on rainfall.

In sprinkler irrigation, HDPE pipes were used. The main and lateral lines consisted of HDPE pipes with 63 mm and 16 mm diameters, respectively. The micro sprinklers which has 1.92 mm nozzle size and 180 l/h flow rate while operating at 2 atmosphere pressure and 5m wetting diameter were used in the experiment. Two lateral lines were planned for the sprinkler irrigation method and each of the laterals was 18 m long and has 9 sprinklers which were spaced at 2 meters. Two lateral lines were located parallel and the distance between two laterals was 2m.

In perforated pipe irrigation method, the main and lateral lines consisted of 63 mm and 40 mm diameter respectively. The perforated pipe pipe which has 40 mm in hose diameter, thickness 350 micron and 1 l/min/m flow rate while operating pressure 1 kg/cm^2. Two perforated pipe line were installed for irrigating experimental area under this treatment with distance between two perforated pipe lines at 3m. The radius of throw in this irrigation method varies between 5-6 m. In sprinkler and perforated system water is applied at depletion of 50 % soil moisture.

In flood irrigation method, plot consisted of 40 plant rows and the width and length of each plot were 8 m and 18 m, respectively. Water is delivered at the head and through gravity spread till tail end. Irrigation was provided at 65 % water depletion of field capacity depletion of field capacity.

Result and Discussion

Growth attributes characters

The results revealed that all growth and yield parameters of onion are significantly influenced by irrigation methods. The highest plant height *i.e*. 42 cm was recorded in drip irrigation system followed by perforated pipe irrigation 40.6 cm, where as in 32.6 cm in flood irrigation.

Number of leaves and neck or stem thickness were also higher in drip irrigation method (6.89 & 1.36 cm) followed by perforated pipe irrigation (6.00 & 1.30cm) and lowest were recorded in flood irrigation (5.41 & 1.05 cm) respectively, (Table 1). Under drip irrigation system the soil moisture content could have favourers for enlargement of root system thereby plant growth and vigour is high. The results are in line with the Bhonde et al. (2003) [4] and Bangali et al. (2012) [2] for plant growth in onion crop.

Yield contributing parameters

The bulb diameter and bulb weight are important parameters that are influenced by soil and water management approaches. In the present study under drip irrigation method highest bulb diameter and weight (61.85 mm and 105.64 g) followed by perforated pipe irrigation (55.48mm and 90.45 g) the lowest bulb diameter and weights were recorded in flood irrigation (34.53mm and 42.23 g). These results are in agreement with the earlier findings of Rao *et al.* (2016) [11]. In this study, significantly higher yield recorded in drip irrigation (45.25 t/ha) followed by perforated pipe irrigation method (36.65 t/ha) and lowest yield were recorded in flood irrigation method (24.52 t/ha).

In general, the drip irrigation method had higher application efficiency over conventional irrigation systems and supplies water to the root zone with a lower discharge rate not more than the infiltration rate of soil (Ramaha et al. 2011) [10]. Maintenance of ideal moisture in drip irrigation method therefore resulted in higher yield and yield contributing parameter.

The water productivity, calculated as ratio of onion bulb yield to water consumption that includes applied water and rainfall varied significantly with different irrigation methods across the irrigation level. Comparatively higher water productivity values (12.36 kg/m^3) were noticed in drip irrigation method and lower value (4.10 kg/m^3) in flood irrigation method. A decline in water productivity of onion to almost half (12 to 6.4 kg/m^3) has earlier been reported by Zheng et al. (2013) [13]. Others (Bekele and Tilahun, 2007) [3] reported that up to 23 % reduction in water use efficiency for onion grown under different growth stages.

Economics

The total cost of production, gross return and net return of onion under different irrigation methods are presented in Table-3. The cost involved in installation, cost of labour, cost of fertilizer & FYM, fungicide and insecticides, cost on water and electricity, cost of harvesting etc. are considered while calculating the economics. All these costs and benefits obtained were calculated on annual bases for one hectare of land. The total cost of production for drip, sprinkler, perforated pipe and flood irrigation methods varied from 98550Rs/ha, 82910Rs/ha, 65290 Rs/ha and 44550Rs/ha respectively bases on the present day market rate of material and labour. The total cost of production in drip irrigation was considerably higher as compared with other treatments mainly due to larger material requirements.

Higher gross returns was recorded in drip irrigation (226250Rs/ha) followed by perforated pipe irrigation (183250 Rs/ha) and lowest gross return obtained in flood irrigation (122600 Rs/ha). The highest net returns were obtained under drip irrigation (127700 Rs/ha) followed by perforated pipe irrigation (117960Rs/ha) and lowest net return was obtained in flood irrigation (78050Rs/ha).

(Table 4 about here)

Table 1: Effect of different irrigation systems in growth and yield of onion

Treatments	Plant height (cm)	No of leaf per plant	Neck thickness (cm)	Bulb diameter (mm)	SPAD value	Average bulb weight (g)	Yield (t/ha)
Flood Irrigation	32.56	5.41	1.05	34.53	42.50	42.23	24.52
Sprinkler Irrigation	36.40	5.89	1.24	48.26	43.87	65.89	34.20
Perforated pipe Irrigation	40.60	6.00	1.30	55.48	43.58	90.45	36.65
Drip Irrigation	42.00	6.89	1.36	61.85	43.26	105.64	45.25
CD (0.05%)	5.60	1.50	0.27	16.89	NS	40.89	23.07

Table 2: Break up cost of cultivation of onion (Rs/ha)

Particulars	Flood Irrigation	Sprinkler Irrigation	Perforated pipe Irrigation	Drip Irrigation
Field preparation with machine	2200	2200	2200	2200
Transplanting	5000	5000	5000	5000
Seed cost	9000	9000	9000	9000
FYM	4500	4500	4500	4500
Fertilizer	1550	1550	1550	1550
Plant protection	2200	2200	2200	2200
Weeding	10000	6000	6000	6000
Irrigation	3600	1600		1600
Perforated pipe irrigation system cost	0	0	28340	0
Sprinkler irrigation system cost	0	0	0	44360
Drip irrigation system cost	0	65000	0	0
Electricity	1500	1500	1500	1500
Harvesting	5000	5000	5000	5000

Table 3: Economics of different treatments

Treatments	Cost of Cultivation (Rs/ha)	Gross Monetary Return (Rs/ha)	Net Monetary Return (Rs/ha)
Flood Irrigation	44550	122600	78050
Sprinkler Irrigation	82910	171000	88910
Perforated pipe Irrigation	65290	183250	117960
Drip Irrigation	98550	226250	127700

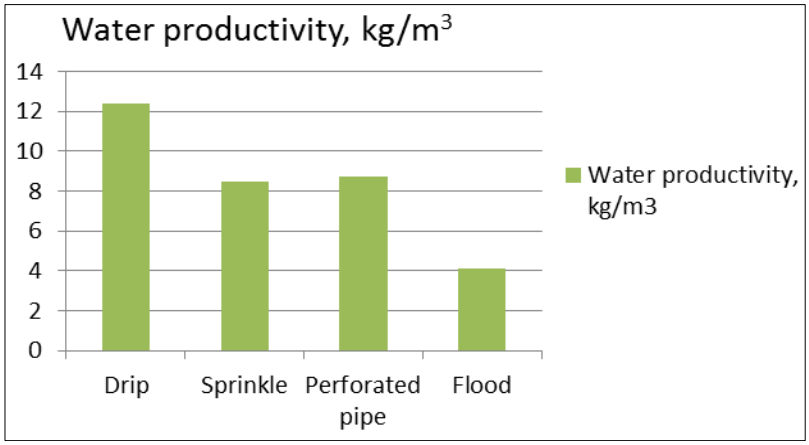

Fig 1: Water productivity with different irrigation method

Conclusions

The micro irrigation system allowed more frequent application at smaller irrigation depth than the flood irrigation. The irrigation efficiencies were higher for the drip irrigation system followed by perforated pipe irrigation system. It was concluded that more yields increased onion size while using drip irrigation method. This was due to drip irrigation system allowing for more frequent application and smaller irrigation depths with higher irrigation efficiency than flood irrigation systems.

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