International Journal of Agricultural Sciences
Volume 17 | AAEBSSD | 2021 | 340-347
DOI:10.15740/HAS/IJAS/17-AAEBSSD/340-347
ISSN : 0973-130X
Visit us : *www.researchjournal.co.in*

A REVIEW

Enhancement of water productivity with surge irrigation

Sumandeep Kaur[1], Arun Kaushal[1] **and** Pramodkumar Shelke*
Krishi Vigyan Kendra, Hingoli (M.S.) India
(Email: ppshelke@gmail.com)

Abstract : Surge irrigation is the intermittent application of water to surface irrigated furrows or borders in a series of relatively short on and off time periods during the irrigation which may be between 20 minutes to two hours. In this technique, water is usually applied intermittently rather than with a continuous stream, as in conventional surface irrigation..Water productivity and water saving of six crops *viz.* wheat, cotton, maize, capsicum, onion and fennel under surge irrigation were compared with traditional method for the crops grown in different environmental conditions at different location of the world.It is concluded that surge flow irrigation performs better than continuous flow irrigation in terms of water saving and yield resulting in enhancement of water productivity. In case of wheat crop, surge irrigation saved and decreased irrigation water by 27, 33.4 and 37.4 % and increased yield by 15.1, 17.7 and 12.7 % under slope of 0.0, 0.1 and 0.2 % respectively compared with continuous flow irrigation for the same discharge. It had the maximum water use efficiency values of 1.39, 1.56 and 1.59 kg/m^3 for surge flow irrigation under slopes of 0.0, 0.1 and 0.2 %, respectively.Surge irrigation system for maize obtained the highest value of WUE (1.63 kg/m^3) with 40 m furrow length under 12.24 l/min inflow rate, while the lowest value of WUE obtained by continuous irrigation system, with 20 m furrow length under 44.4 l/min inflow rate (1.05 kg/m^3). It can be applied by farmers in areas where irrigation water is limiting factor in crop production and farmers canot afford costly micro-irrigation system.

Key Words : Irrigation, Surface irrigation, Surge Irrigation, Water Productivity

View Point Article : Kaur, Sumandeep, Kaushal, Arun and Shelke, Pramodkumar (2021). Enhancement of water productivity with surge irrigation. *Internat. J. agric. Sci.*, **17** (AAEBSSD) : 340-347, **DOI:10.15740/HAS/IJAS/17-AAEBSSD/340-347.** Copyright@2021: Hind Agri-Horticultural Society.

Article History : Received : 06.07.2021**; Accepted :** 16.07.2021

INTRODUCTION

Irrigation is the artificial process of applying controlled amounts of water to land to assist in production of crops. Irrigation helps to grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less than average rainfall. Irrigation also has other uses in crop production, including frost protection, suppressing weed growth in grain fields and preventing soil consolidation. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed. Out of various methods of irrigation sprinkler and drip irrigation are more efficient to supply the entire field uniformly with water, so that each plant receives the same amount of water it requires,without over or under-irrigating as compared with surface irrigation methods.,However, drip and sprinkler irrigation are quite expensive for poorfarmers.Surface irrigation, also known as gravity irrigation, is the oldest form of irrigation and has been in use for thousands of years. In surface (furrow, flood, or level basin) irrigation systems, water moves across the surface of an agricultural lands, in order

***Author for correspondence:**
[1]Department of Soil and Water Engineering, Punjab Agricultural University, Ludhiana (Punjab) India

to wet it and infiltrate into the soil. Water moves by following gravity or the slope of the land. Surface irrigation can be subdivided into furrow, border strip or basin irrigation. It is often called flood irrigation when the irrigation results in flooding or near flooding of the cultivated Basin flood irrigation of land. Historically, surface irrigation has been the most common method of irrigating agricultural land and is still used in most parts of the world. Where water levels from the irrigation source permit, the levels are controlled by dikes, usually plugged by soil. This is often seen in terraced rice fields (rice paddies), where the method is used to flood or control the level of water in each distinct field. In some cases, the water is pumped, or lifted by human or animal power to the level of the land. The water application efficiency of surface irrigation is typically lower than other forms of irrigation.Over exploitation of surface water resources and unscrupulous pumping of groundwater have led the farming community to a precarious situation where counting every drop of water towards sustaining maximum possible crop production has become a necessity. Even as micro irrigation systems embedded with fertigation components are gaining popularity and momentum, surface irrigation systems such as border strips or furrows or check basins are still in vogue and are quite inevitable from the point of view of farm management.Excessive runoff and deep percolation in surface-irrigated fields result in wastage of water and can result in increased levels of dissolved salts and fertilizer residues to enter groundwater and surface water. Growers are increasingly concerned with how to stretch limited supplies of water, while maintaining yield. At the same time, growers face more stringent standards regarding water quality. Irrigation management practices that reduce deep percolation and runoff will address both of these concerns. It is in this fore-ground, a much efficient proposition is use of surge irrigation to harmonize both.Surge irrigation may be defined as the intermittent application of water to surface irrigated furrows or borders in a series of relatively short on and off time periods during the irrigation which may be between 20 minutes to two hours. In this technique, water is usually applied intermittently rather than with a continuous stream, as in conventional surface irrigation. The concept of "surge flow" was introduced at Utah State University by Stringham and Keller in 1979. Intermittent water applications during the irrigation advance phase generally reduced infiltration by providing a short drainage period following wetting. Thus more rapid advance of the wetting front occurs than with continuous flows. The difference in intake opportunity time between the upper and lower ends of furrows reduces and more uniform distribution of water intake over the length of the furrows occurs. In surge irrigation, a butterfly valve is placed in the centre of the top of the field from where water enters through pipeline. Gated pipe leads out of the valve and goes in both directions along the top of the field. The valve oscillates water from one side to the other at predetermined intervals. As against conventional surface irrigation systems where the water flows continuously during the irrigation set, the alternating flow of water in surge irrigation on each side of the valve causes an intermittent wetting and soaking cycle in the irrigated furrows which is often corroborated as the ON and OFF system.The alternating wetting and soaking cycle causes soil particles to settle to the bottom of the furrow and they partially seal the soil surface. The water intake rate is curtailed. As a result, less water is lost due to deep percolation at the beginning of the furrow and the water can advance down faster. Precise timing shuts off the water flow and by reducing deep percolation at the beginning of the row and tail-water runoff at the end, the result is more uniform water application, less total water applied and water runoff. Fine textured soils are less responsive to surge irrigation than coarse textured soils having higher initial intake rate. If the land is steeper the water may move down rapidly rendering this method ineffective.The surge effect depends upon a number of factors such as soil texture and consolidation, antecedent moisture content and number and duration of the ON- OFF cycles. Invariably in all the continuous flow long furrows, the water front advance could not reach the furrow tail end within the designed duration of irrigation and nearly 25 to 40% additional times are required. The continuous flow long furrow layout could have high water distribution uniformity around 55% only, but the surge irrigation will have 80 to 85%.The present study is an in-depth review of work done on surge irrigation and its effect on Productivity of Water on different crops across the Globe.

RESULTS AND DISCUSSION

Testezlaf *et al.* (1986) studied anopen ditch surge flow furrow irrigation system. An automated rotating gate enabled an existing open channel furrow irrigation system to be adapted to surge flow. Equipment performance was found to be reliable. System hydraulics were analyzed with respect to unequal outlet elevations, spatially varied flow within an irrigation bay, and unsteady flow due to the opening or closing of the automated gate.

Ismail (2004) conducted a study on effectiveness of surge flow irrigation for water use efficiency in field crop production in Egypt. This study was carried out to demonstrate the applicability of surge flow irrigation for water saving under the short field conditions that prevail in Egypt.The results indicate that surge flow irrigation is an effective irrigation.

Abdelmonem (2005) conducted a study in the use of surges to improve surface irrigation. surge surface Irrigation is studied to show how it could be used to improve the performance indicators of continuous surface irrigation. First, the Surge Surface Irrigation technique was introduced and defined. Second, Data of the applied irrigation depth and the infiltrated depth was collected from field test area. The data was analyzed and discussed using fit curves and regression techniques. The analysis showed that surge surface irrigation increases the efficiency of continuous surface irrigation, decreases the deep percolation, decreases the waste of fertilizers, and improves the economy of the irrigation process especially on the long run.

Ismail and Depeweg (2005) made an attempt to study water productivity and crop production simulation under surge flow irrigation in short furrows in Egypt. It described the simulation results of water productivity and yield production *in relation to water supply by either continuous or surge flow irrigation in short fields for clay and sandy soils in Egypt. The input data required by the Cropwat model are meteorological data, plant and soil characteristics and water supply. Cotton was used as the most important crop for the simulation and its growing characteristics come from the Cropwat model. Soil characteristics and water supply are measured data obtained from field experiments in Assiut. During the simulation all the parameters considered have been kept constant except for the water supply and application efficiency, which are variable. The yield has been determined with Cropwat at the beginning, middle and the end of a furrow as well as for the average stored water depth along the whole furrow. The simulation has been carried out for two different approaches; one based on optimal continuous flow and the other based on optimal surge flow irrigation. The simulation indicates that using an optimal surge flow gives higher crop yields than using an optimal continuous flow. For optimal surge flow irrigation the simulation revealed distinct differences in yield reduction between continuous and surge flow irrigation compared to the results based on optimal continuous flow. Surge flow irrigation is an efficient tool either to produce the same yield with less water than in continuous flow or to produce higher yields than continuous flow by using the same gross irrigation supply. Surge flow irrigation is an effective tool for water saving in short fields as prevails in Egypt.

Mathew and Senthilvel (2005) studied performance evaluation of two automated surge irrigation systems. One based on a soil moisture sensor and the other sequentially operated, were fabricated and field tested, and their efficacies were compared with that of a manual surge irrigation and conventional furrow irrigation. The experiment was carried out at Tamil Nadu Agricultural University, Coimbatore by providing irrigation to maize in two field trials, *i.e.*, one trial each during two consecutive years. Both the automatic irrigation systems performed consistently and accurately. Grain and stover yield and water use efficiency of the automatic irrigation system were on a par with the manual surge irrigation. It saved 7% of water in the first trial and 13% of water in the second trial compared to conventional furrow irrigation. Corresponding increase in water use efficiencies were 19% and 27%, respectively. The sequentially operated automatic irrigation system over-irrigated the crop since irrigation was given without considering the prevailing soil moisture tension in the crop root zone. Compared to the conventional furrow irrigation, it provided 15% and 34% more irrigation during first and second field trials respectively. Water use efficiency for the first trial crop was on a par with that of conventional furrow irrigation, whereas it showed a reduction of 11% for the second trial crop. Economic analysis of the irrigation systems showed that there was a saving of 20 and 39% respectively for crops irrigated with automatic surge irrigation based on a soil moisture sensor for both the field trials compared to that of manual furrow irrigation, However, savings were considerably less, 15% and 31% respectively for crops irrigated with sequentially operated surge irrigation for both the trials. Manual surge irrigation recorded maximum savings, 52% and 59% respectively. method to save water and to increase crop production.

Abou El-Hassan *et al.* (2006) studied assessment of surge irrigation technique under furrow irrigation system in the Nile delta. Field experiments were conducted to investigate the performance and limitations of surge irrigation technique in the Nile Delta of Egypt The experiments consisted of different surge irrigation treatments compared with continuous discharge; and evaluated using two irrigation discharges-2.4 (Ql) and 3.2 (Q2) s' per furrow. The irrigation treatments were: continuous discharge (II), surge flow with cycle ratio (CR) of 0.33 (12), surge flow with CR of 0.50 (13), surge flow with CR of 0.67 (14) and surge flow with CR of 0.75 05). The suitability of surge irrigation was assessed based on consumptive use of water, water advance rate, grain yield and several efficiencies. Results obtained on the average basis of two discharge treatments indicated that 15 could save 11% (75 mm) and12.1% (84.4 mm) of the water applied in 2002 and 2003, respectively. For consumptive use of water, 14 treatment could save 2.7% (14.6 mm) and 2.9% (15.8 mm) under Ql and Q2 irrigation discharge respectively, for the two studied seasons. Applying die surge irrigation technique increased maize grain yield by 9.8% (746.7 kg ha^{-1}) and 4.4% (344.4 kg ha^{-1}) under respective discharge treatments for the two studied seasons. Increased irrigation discharge led to increased water application efficiency and improved water distribution uniformity. The highest mean values (kg m^{-1}) of water utilization efficiency were 1.284.

Gao *et al* (2006) studied multi-objective fuzzy optimization model for the determination of furrow surge irrigation parameters. In view of the small quota of irrigation by collected water, multi-objective fuzzy optimization model was established based on field experiment data and fuzzy modeling techniques. A combination of parameters for optimization of irrigation was gained by the solution of this model, *i.e.* in cycle of 15 minutes water supplying, 15 minutes stopping and 1 L/s water flow rate of entering into furrow. It was shown that the irrigation quality indexes predicted by this model were close to those measured in the field experiment and that the comprehensive irrigation quality effect produced by these parameters was satisfactory. The results of this paper provide an effective irrigation plan for the surge irrigation area with small quota of irrigation water. Also, this paper provides an effective method for determination of technical parameters of surge irrigation.

Mattar *et al.* (2006) studied development of perforated pipes to improve surface irrigation performance. A major cost of surface irrigation may be due to labor requirements high percent of the applied water and improper management. It is caused deficiency of surface irrigation. The main goals of this study were improve surface irrigation performance and to minimize some undesirable consequences by using telescopic perforated pipes. Field experiments were conducted on soybean "Giza 111 variety" during the summer growing season of 2004 to achieve the qualification of the preceding developed technique. The developed (telescopic) perforated pipe (T.P.P.) was tested, however mean inflow rate was 0.83 l/s for each end closed furrow. The results indicate that, the discontinuity in infiltration rate accounted for the accelerated advance rates that occurred in surge irrigation after one complete cycle. Surge flow treatments with telescopic perforated pipes (T.P.P.) had faster advance time, especially with longer off-time. Surge flow "15 min on - 45 min off" by using T.P.P. saved the amount of water by 46.63 % of the water applied for continuous irrigation with conventional perforated pipes (C.P.P.). Also, high water application efficiency (Ea) and water application efficiency of low quarter (Ealq), water distribution efficiency (Ed) and water distribution uniformity (Du), and lower deep percolation percentage (Dpp) are observed for surge flow "15 min on - 45 min off" by using T.P.P. Generally, it can be concluded that surge flow with T.P.P. technique can not only save the water amount, but also enhance the soybean yield and therefore, the net income of the farmers.

Mostafazaeh-Fard *et al.*(2006) studied development and evaluation of surge flow irrigation system.Surge flow irrigation can reduce the irrigation water losses and improve irrigation performance. In this study evaluation and design of an automatic surge flow irrigation system was done. The system includes an automatic surge valve, which can be programmed by user based on field conditions such as soil infiltration characteristics changes during the irrigation season. The surge valve is inexpensive, portable and wireless and its energy is supplied by a chargeable battery, which the battery can also be recharged by a solar panel for a long duration uses. To evaluate the performance of the system, the surge valve including constant head water delivery system to the furrows were installed in an furrow irrigation experimental farm and based on input data given to the system the furrows were irrigated automatically by surge method with cycled inflow of 10 min on and 10 min off. The results showed that the system is able to accurately and automatically irrigate the furrows by surge method based on information given to the system. For the same discharge and volume of water applied to the furrows the water advance along the furrows were faster for surge flow as compared to the continuous flow.

Kifle *et al.* (2008) evaluated surge flow furrow irrigation for onion production in a semiarid region of Ethiopia, The study was conducted to evaluate surge irrigation against continuous irrigation in terms of irrigation and water use efficiencies to produce onion. It was carried out at Mekelle Agricultural Research Center, Ethiopia on 70m long and 0.6m center–center spacing furrows of 0.26% average slope on a clay soil. The treatments consisted of factorial combination of two discharges (Q 1=1l/s and Q 2=2l/s) and three-cycle ratios (CR1=1/3, CR2=1/2, and C=1 for continuous irrigation). Surge flow treatments advanced faster than the respective continuous flow treatments with surge flow treatment SF21 being the fastest. The best value of application efficiency (60%) was achieved for SF11 and the least (46%) for CF2. The maximum (87%) and minimum (68%) values of distribution uniformity were obtained for cycle ratios CR1 and C, respectively. Storage efficiency was highest (89%) for CF2 and lowest (78%) for SF12. Onion yield was significantly affected ($p<0.05$) by the interaction effect, the highest (14,400kg/ha) and the lowest (13,363kg/ha) yields were obtained for SF11 and SF21, respectively. The maximum irrigation water use efficiency (2.27kg/m3) was observed for SF11 and the minimum (1.68kg/m3) for CF2. Surge irrigation was found to be a promising irrigation practice for onion production in the study area as it saves water, reduces irrigation period, and increases the crop yield.

Gospodinov *et al.*(2010) studied in amendment speed of water infiltration in surge irrigation for cinnamon forest soil. There are many explorations on the surge irrigation by furrows showing that it has considerable advantages to the continuous one. The advantages are as follows: shorter time for reaching the furrow end by the water, significantly improved uniformity of irrigation water application, reduction of irrigation water losses caused by the deep filtration and the flow, and so on. The experiments have been carried out in experimental field "Chelopechene" for 3 years. The furrow slope is 1 percent and the distance - 150 m. The number of furrows observed is 8. It has been established that the time for reaching a certain part of the furrow during the second phase of the water flow has been reduced, and the time for draining away the back head of the water has been increased, and constant values are demonstrated. The speed of infiltration approaches the constant value of water filtration in the soil

Kapur *et al.* (2013) studied a comparative field study of the alternate every other furrow surge irrigation and the every furrow surge irrigation techniques.This study was conducted in order to compare the alternate every other furrow surge irrigation (AFO) to the every furrow surge irrigation (EFO), under Mediterranean conditions in Turkey at the Çukurova University experimental farm. The experiment was undertaken in order to determine the appropriate throughput at furrow lengths of 110 m. In general, depending on the water flow (0.87-1.16 L/s) and the duration of the irrigation application (228-272 min), there may be differences on the amount of water under the same flow rates with the use of similar forms of operating furrow application of the AFO, which was determined to be more advantageous than the application of the EFO. The application efficiencies were quite similar by 78% in the EFO and 84% in the AFO, respectively. The reason for these high efficiencies was found to be due to the lacking irrigation application concerning the time of irrigation and the rate of water flow. Significant water savings were achieved by AFO compared to the EFO technique in the field by using the furrows in turns at each irrigation operation. The average soybean yields for both two years were 252 kg/da for the EFO and 259 kg/da for the AFO application. The results of the experiment revealed that the AFO furrow irrigation technique was the appropriate surface irrigation technique for the studied area.

Gudissa and Edossa (2014) studied evaluation of surge and cutback flow furrow irrigation systems for pepper (*Capsicum annuum*) production.The aim of this field experiment was to evaluate surge, cutback and conventional flow furrow irrigation systems in terms of hydraulic, technical and agronomic performance measures for pepper production in Gambella Regional State, Ethiopia. The treatments consisted of two surges (SR1=1/3 cycle ratio and SR2=1/2 cycle ratio), one cutback (CB) and one conventional (C) flow furrow irrigation systems. The advance time ratios (ATR) recorded under the two surge treatments ranged from 0.57 to 0.70. Maximum application efficiency of 61.8%, storage efficiency of 95.1% and uniformity coefficient of 77.3% were recorded under SR1, whereas the lowest corresponding values of 52.8, 81.2 and 56.1% were recorded under C. Maximum deep percolation (23.6%) and tailwater (27.7%) losses were recorded from CB and C treatments, respectively, whereas SR1 and SR2, respectively, gave minimum deep percolation (14.3%) and tailwater (20.5%) losses. In terms of all agronomic performance measures, it was found that SR2 performed well, followed by SR1. However, the C treatment gave minimum yield (6450kgha-1), crop water productivity (17.5kgha^{-1}mm^{-1}) and irrigation water productivity (11.3kgha^{-1}mm^{-1}). From the findings of this study, it was concluded that surge and cutback flow furrow irrigation systems are promising technologies for pepper production in areas with minimal water use.

Khalifa *et al.* (2015) studied manufacturing control valve and flowmeter to measure flow rate and development of surface irrigation using surge irrigation in clayey soil. The experiment was conducted to develop and evaluate surge irrigation under different slopes and discharges against continuous irrigation under traditional levelling in terms of irrigation and water use efficiencies to produce wheat crop in clay soil under short field conditions. It was carried out at the experimental farm, Faculty of Agriculture, Kafrelsheikh University, during the winter season 2013/2014.The furrows with blocked ends were 50 m long and 1.1 m center – center spacing furrows and the wheat was planted on beds with 0.8 m width(7 rows of wheat per bed with 0.10 m spacing between rows).The treatments for surge irrigation consisted of factorial combination of three slopes S1= 0.0%, S2= 0.1% and S3= 0.2%, three discharges Q1= 0.4 l/s, Q2 = 0.55 l/s and Q3 = 0.75 l/s and two – cycle ratios (T_1 = 1/2 and T_2 = 2/3), in addition, treatments of continuous flow for the same discharges under traditional levelling. To monitor the advance time, five points were established along the furrows at 0, 12.5, 25, 37.5 and 50 m from the inlet. Soil moisture content was measured with gravimetric methods at 0 - 0.15, 0.15 – 0.30, 0.30 – 0.45 and 0.45 – 0.60 m depths at the beginning, middle and end of the furrows. The discharge was measured using control valve and flowmeter which manufactured to measure and control the applied irrigation water to each treatment. Results indicated that surge irrigation under three different slopes 0.0, 0.1 and 0.2% reduces amount of irrigation water applied, increases advance time, irrigation uniformity, water application efficiency, grain yields and water use efficiency compared with continuous flow irrigation under traditional levelling. The best treatment is the discharge of 0.55 l/s with 1/2 cycle ratio under three different slopes.

Kiflea *et al.* (2017) studied effect of surge flow and alternate irrigation on the irrigation efficiency and water productivity of onion in the semi-arid areas of north. The study was conducted in the semi-arid areas of northern Ethiopia with the objective of evaluating the effect of surge flow and alternate irrigation on irrigation performance indicators, water use efficiency and crop yield. The result of this experiment indicated that the interaction effect of the irrigation system and irrigation flow methods did not show statistically significant difference on the performance indicators, crop yield and water use efficiency. The result of this study explicitly showed that demonstration of these irrigation methods can enhance the poor water management practices in the semi-arid areas of Ethiopia and elsewhere in the world with limited water resources and similar soil characteristics.

Mattar *et al.* (2017) conducted a study in field assessment of surge and continuous furrow irrigation methods in relation to tillage systems. The aim of this study was to investigate the effect of surge furrow irrigation on water management compared with continuous irrigation for different tillage systems. The results showed that water savings obtained using the surge technique were 18.58, 11.84 and 18.93% lower water use than with continuous flow, for the mouldboard, chisel and rotary ploughs, respectively. The 3-surges treatment with the rotary plough reduced the advance time by 25.36% from that for continuous irrigation. The 4-surges treatment with the mouldboard plough had the highest water application efficiency (88.13%). The 3-surges treatment with the rotary plough had the highest distribution uniformity (85.01%).

Khalifa *et al.* (2019) studied development of surface irrigation using surge irrigation technique**.** A field experiment was conducted at Research Farm,Faculty of Agriculture, Kafrelsheikh University, Egypt, during successful growing season 2016/2017. The experiment was included two different irrigation methods (surge with cycle ratio 1/2 and continuous irrigation), three furrow lengths were used 20, 30 and 40 m and three different inlet discharges were used, (12.24, 24 and 44.4 l/min) to irrigate the maize crop .This results can be summarizing as follows: surge irrigation caused to decrease in mean advance time about 11%, also obtained the highest mean value of water use efficiency was 1.70kg/m^3 at flow rate of 12.24 l/min and furrow length of 40m. The highest mean value of grain yield (3920 kg/fed) at flow rate of 12.24 l/minlength of 40m under continuous irrigation, also the highest mean value of applied water was 2430.89 m^3/feddan achieved at flow rate of 12.24 l/min and furrow length 30 m with continuous irrigation. The inflow rate treatment of 44.4 l/min acheived the highest value of mean water saving by 14.47 % under surge irrigation technique.

Sengupta *et al.* (2019) conducted a study in surge irrigation: conceptualizing 'more crop per drop' into a reality. Water, the elixir of life, on one hand is becoming scarce day by day while India's population is outgrowing its water supply on the other. Among the different methods of irrigation followed throughout the country, surface irrigation deserves special mention. However, due to poor efficiency, a huge wastage of water is incurred through excessive runoff and deep percolation. Surge irrigation is a better technology which results in less labor and costs besides saving water and indirectly increases the net income of the farmers.

Rao *et al.* (2020) studied surge-flow alternate furrow irrigation for enhancing water productivity in semiarid regions. An experiment was conducted during 2014–16 in farmer's fields of Panchmahal, Gujarat under Department of Science and Technology to study the effect of various furrow irrigation techniques on water saving, water productivity and yield of fennel (*Foeniculum vulgare* Mill.) crop. The treatments contained different furrow irrigation techniques such as furrow irrigation, plough furrow irrigation, alternate furrow irrigation with and without surge flow. The experimental data proved that the alternate furrow with surge flow irrigation is the best method that saves up to 78% of irrigation water without affecting the crop growth and yields. The surge flow, alternate furrow irrigation increased the water productivity and amount earned from unit of water over the check basin method of irrigation by 4 times. The saved irrigation water can bring the additional area under cultivation of high-value crops like fennel and vegetable during rabi season.

Conclusion:

– For wheat crop, surge irrigation saved and decreased amount of irrigation water applied by 27, 33.4 and 37.4 % and increased the yield by 15.1, 17.7 and 12.7 % under slope of 0.0, 0.1 and 0.2 %, respectively compared with continuous flow irrigation under traditional levelling for the same discharge. It had the maximum water use efficiency values of 1.39, 1.56 and 1.59 kg/m^3 for surge flow irrigation under slopes of 0.0, 0.1 and 0.2 %, respectively.

– Surge irrigation system for maize obtained the highest value of WUE (1.63 kg/m^3) with 40 m furrow length under 12.24 l/min inflow rate, while the lowest value of WUE obtained by continuous irrigation system, with 20 m furrow length under 44.4 l/min inflow rate (1.05 kg/m^3).

– For cotton crop there is saving of 15% water in case of surge flow irrigation(1475 mm)as compared with traditional method (1733 mm). The water use efficiency was 17% more as compared with traditional method.

– For fennel crop water productivity under surge irrigation was observed as 0.49 kg/m^3 ascompared to 0.27 kg/m^3 by check basin. There was saving of 44% water by using surge irrigation as compared with check basin method.

– For capsicum crop,the maximum water productivity (16.5 kg $ha^{-1}mm^{-1}$) was achieved under surge of 1/2 cycle ratio, followed by surge of 1/3 cycle ratio (14.2 kg/ ha/mm). However, the minimum water productivity of 11.3 kg /ha/mm was obtained under the conventional irrigation treatment.

– For onion crop,highest irrigation water use efficiencies were obtained for the surge flow with lower discharge and lower cycle ratio which indicated 35% increase in water productivity of surge flow irrigation over the continuous flow.

From the study it can be concluded that surge flow irrigation was found to perform better than continuous flow irrigation in terms of water productivity.

REFERENCES

Abdelmonem, Y. (2005). The use of surges to improve surface irrigation. *Irri. & Drain.,* **40**:1-12.

Abou El-Hassan, W. H., Kitamura, Y., Gamal, F. S. and Eneji Egrinya, A. (2006). Assessment of surge irrigation technique under furrow irrigation system in the Nile Delta. *Japan J. Agric. Sci.,* **38**:462-70.

Gao, C., Zuo, Y. and Ren, K. (2006). Muti-objective fuzzy optimation model for the determination of furrow surge irrigation parameters. *Irri. & Drain.,* **36**: 132-40.

Gospodinov, I. Chehlarova, S. S., Stoianova, A. and Petkova, R. (2010). Amendment speed of water infiltration in surge irrigation for cinnamon forest soil. *Bulgaria Agric Sci.,* **4**: 227-229.

Gudissa, H. D. and Edossa, D. C. (2014). Evaluation of surge and cutback flow furrow irrigation systems for peeper (*Capsicum annum*) production. *Irri. & Drain.,* **63**: 463-473.

Ismail, S. M. (2004). Effectiveness of surge flow irrigation in Egypt:water use efficiency in field production. *Irr. & Drain.,* **24** : 35-60.

Ismail, S. M. and Deepeweg, H. (2005). Water productivity and crop production simulation under surge flow irrigation in short furrows in Egypt. *Irrig. & Drai.,* **54**: 103-113.

Kapur, B., Unlu, M., Kanber, R., Tekin, S., Koc Levent, D. and Kekec, U. (2013). A comparative field study of the alternate every other furrow surge irrigation and the every furrow surge irrigation techniques. *J. Food Agric. & Envi.,* **11**: 389-397.

Khalifa, S. M., EL-Nemr, M. K. and Sharaby, N. N. (2015). Manufacturing control valve and flowmeter to measure flow rate and development of surface irrigation using surge irrigation in clayey soil. *Annu Conference Mis. Soc. of Agric. Engg.,* **25**: 335-54.

Khalifa, S., Okasha, A. and Shawat, S. (2019). Development of surface irrigation using surge irrigation technique. *Dept. Agric. Engg.,***28**: 3121-3130.

Kifle, M.E., Gebremicael, T.G., Girmaya, A. and Gebremedihina, T. (2017). Effect of surge flow and alternate irrigation on the irrigation efficiency and water productivity of onion in the semi-arid areas of North. *Agric. Water Manage.,* **187**: 69-76.

Kifle, M. Zeleke, K. T. and Yazew, E. (2008). Evaluation of surge and cutback flow furrow irrigation systems for pepper (*Capsicum annuum*) production. *J. Civil & Agric. Sci. Univ.,* **63**: 463-473.

Mathew, A.C. and Senthilvel, S. (2005). Performance evaluation of two automated surge irrigation systems. *Int. Agric. Engg. J.,* **14**: 19-27.

Mattar, M.A., Motaleb, I.A., Saadawy, M.A., Hindy F. I. (2006). Development of perforated pipes to improve surface irrigation performance. *J. Agric. Sci.,* **32**:120-135.

Mattar , M.A., El-Saadawy, M.A., Helmy, M .A. and Sorour, H. M. (2017). Field assessment of surge and continuous furrow irrigation methods in relation to tillage systems. *Int. Agro.,* **31**: 219-230.

Mostafazadeh-fard, B., Osroosh, Y. and Eslamian, S. (2006). Development and evaluation of an automatic surge flow irrigation system. *J. Agric.& Socio Sci.,* **3**: 129-132.

Rao, B.K., Bhatnagar, P. R., Kambles, T., Kurothe, R.S., Mishra P. K., Sharma, R., Kumar, A. and Pande, V. C. (2020). Surge-flow alternate furrow irrigation for enhancing water productivity in semiarid regions. *Indian J. Agric. Sci.,* **89**: 1999-2002.

Sengupta, S. Mukherjee, S. and Pilli, K. (2019). Surge irrigation: conceptualizing more crop per drop into a reality. *West Bengal Agric. Soil Sci.,* **1**: 415-418.

Testezlaf, R., Garton, J. E, Anthony, J. C. and Elliott, R.L. (1986). An open ditch surge flow furrow irrigation system. *App. Engg. Agric.,* **2**: 133-136.

17th Year
★★★★★ of Excellence ★★★★★