International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 15, 2019, pp.-8860-8864.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

ECONOMIC EVALUATION OF DRIP IRRIGATION SYSTEMS FOR WHEAT CROP UNDER DIFFERENT LATERAL AND EMITTER SPACINGS

LOKHANDE J.N.*[1], DESHMUKH M.M.[2], BAL KRISHNA[3], WADATKAR S.B.[4], POTDUKHE N.R.[5] AND WALKE R.D.[6]
[1,2,4]Department of Irrigation and Drainage Engineering, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104, MS, India
[3]Jain Irrigation Systems Ltd, Jain Hills, Jalgaon, 425001, MS, India
[5]Wheat Research Unit, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104, MS, India
[6]Department of Agricultural Economics and Statistics, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104, MS, India
*Corresponding Author: Email - jiyalokhande@gmail.com

Received: July 30, 2019; Revised: August 12, 2019; Accepted: August 13, 2019; Published: August 15, 2019

Abstract: This study was undertaken to assess the economic evaluation of drip irrigation system (surface and subsurface) in wheat cultivation. The experiment was laid out in Split plot design with three replications. Economic analysis revealed that the total cost of cultivation, gross and net monetary return increases with decrease in lateral and emitter spacings in both surface and subsurface drip irrigation system. The gross monetary return (114242 Rs ha^{-1}), net monetary return (72662 Rs ha^{-1}) was higher in the treatment combination surface drip irrigation with 60 cm lateral spacing and 20 cm emitter spacing. While minimum gross monetary return (53120 Rs ha^{-1}), Net monetary return (23813 Rs ha^{-1}) were recorded in check basin irrigation method. The highest benefit cost ratio of 2.75 was recorded in surface drip irrigation with 60 cm lateral spacing and 20 cm emitter spacing. The comparative economic analysis of drip irrigation method and check basin irrigation method presented in this study will assist the farmers in selection of lateral and emitter spacings for cultivation of wheat crop.

Keywords: *Economic analysis, Surface and subsurface drip irrigation, Lateral and emitter spacings, Benefit cost ratio*

Citation: Lokhande J.N., *et al*., (2019) Economic Evaluation of Drip Irrigation Systems for Wheat Crop under Different Lateral and Emitter Spacings. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 15, pp.- 8860-8864.

Academic Editor / Reviewer: Dwarika Mohan Das

Introduction

Wheat is one of the most important cereal crops of the world on account of its wider adaptability to different agro-climatic and soil conditions. Among major cereals, wheat ranks first in area and production at the global level and it is the staple food of nearly 35 percent of the world population. Wheat is sown in India at 30.78 million ha area with total production of 98.5 million tonnes (2017-18) [1]. Area and production of wheat in Maharashtra was 1.13 million ha and 1.88 million tonnes respectively during 2017-18 with the average yield of 1657 kg ha^{-1} [2]. About 90 percent of the total wheat crop is irrigated with average water needs of 45 cm - 65 cm, but with lot of variation among regions and states [3]. Most of the wheat crop in India irrigated with conventional method of irrigation; which has very poor water use efficiency due to substantial conveyance and distribution losses. As a result, farmers are not able to increase the productivity of the crops despite using the required yield increasing inputs [4]. Available fresh water supplies for future use have been declining at a faster rate, the requirement of food and other agricultural commodities has been on the rise because of continuous population growth and feed requirement for livestock. Since irrigation contributes substantially to the gross production of agricultural commodities, the fast increase in demand for irrigation water puts enormous pressure on policy makers to find ways to improve agricultural production while economizing irrigation water. The most efficient remedy for this scarce water is drip irrigation method. Drip irrigation method is one of the technical measures introduced to increase the water use efficiency in agriculture. Under this method water is delivered directly to the root zone of the crop using pipe network and emitters. This method is entirely different from the conventional method, where water is dispersed to the whole crop land instead of dispensing exclusively to the crop. Since water is supplied at the required time and quantity using pipe network under drip irrigation method, excess irrigation as well as water losses occurring through conveyance and distribution is completely eliminated. Surface and subsurface drip irrigation can be a viable alternative, when water is limited or when the irrigation capacity is insufficient with traditional methods. Although drip irrigation is an acceptable technology by the Indians farmers, its rate of adoption is limited in row crops such as wheat crop, due to involvement of initial high capital cost. Drip irrigation technology requires relatively higher amount of fixed capital and therefore, farmers are often reluctant to invest in it. Moreover, because of the absence of credible field level studies focusing on the advantages of this technology, farmers have doubt productivity, viability and benefit cost ratio of drip irrigation system. Though some studies have already answered some of these questions [5-7], not many studies seem to have answered these important questions using experimental data. Keeping this in view, in this study, an attempt is made to study the economic aspects of surface and subsurface drip irrigation method under different lateral and emitter spacings over check basin irrigation method of irrigation.

Material and Methods

The field experiment was carried out at Jain Irrigation Systems Ltd., Jalgaon, Maharashtra, during both *rabi* seasons of 2016-17 and 2017-18 to study the economic evaluation of drip irrigation system (surface and subsurface) in wheat cultivation. The experiment was laid out in split-split plot design with three replications. The layout of experimental plot was presented in [Fig-1]. The experiment consisted of two irrigation methods in main treatment *viz*., S1 - surface drip irrigation, S2 - subsurface drip irrigation, three sub treatment *viz*., L1 - 60 cm lateral spacing, L2 - 80 cm lateral spacing, L3 -100 cm lateral spacing and three sub-sub treatment *viz*., E1-20 cm emitter spacing, E2-30 cm emitter spacing and E3-40 cm emitter spacing.

One control treatment with check basin irrigation method was also included for comparison. In subsurface drip irrigation lateral was buried at 20 cm depth. Treatment details are presented in [Table-1]

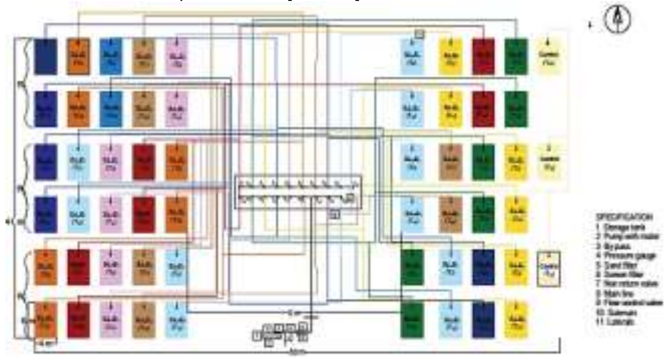

Fig-1 Layout of experimental plot

Table-1 *Treatment Details*

S_1		Combinations of treatment for surface drip irrigation
T_1	$S_1 L_1 E_1$	60 cm lateral spacing with 20 cm emitter spacing
T_2	$S_1 L_1 E_2$	60 cm lateral spacing with 30 cm emitter spacing
T_3	$S_1 L_1 E_3$	60 cm lateral spacing with 40 cm emitter spacing
T_4	$S_1 L_2 E_1$	80 cm lateral spacing with 20 cm emitter spacing
T_5	$S_1 L_2 E_2$	80 cm lateral spacing with 30 cm emitter spacing
T_6	$S_1 L_2 E_3$	80 cm lateral spacing with 40 cm emitter spacing
T_7	$S_1 L_3 E_1$	100 cm lateral spacing with 20 cm emitter spacing
T_8	$S_1 L_3 E_2$	100 cm lateral spacing with 30 cm emitter spacing
T_9	$S_1 L_3 E_3$	100 cm lateral spacing with 40 cm emitter spacing
S_2	Combinations of treatment for sub-surface drip irrigation at 20cm lateral depth	
T_{10}	$S_2L_1 E_1$	60 cm lateral spacing with 20 cm emitter spacing
T_{11}	$S_2L_1 E_2$	60 cm lateral spacing with 30 cm emitter spacing
T_{12}	$S_2L_1 E_3$	60 cm lateral spacing with 40 cm emitter spacing
T_{13}	$S_2L_2 E_1$	80 cm lateral spacing with 20 cm emitter spacing
T_{14}	$S_2 L_2E_2$	80 cm lateral spacing with 30 cm emitter spacing
T_{15}	$S_2L_2 E_3$	80 cm lateral spacing with 40 cm emitter spacing
T_{16}	$S_2 L_3E_1$	100cm lateral spacing with 20 cm emitter spacing
T_{17}	$S_2 L_3E_2$	100cm lateral spacing with 30 cm emitter spacing
T_{18}	$S_2L_3E_3$	100cm lateral spacing with 40 cm emitter spacing
Control Treatment (T_{19})		Check basin method of irrigation Six irrigations were applied at six critical growth stages of wheat crop, *viz*. crown root initiation (CRI), maximum tillering, late jointing, flowering, milking stage and dough stage.

The seeds were sown on 30th November 2016 in the first year and on 23rd November 2017 in the second year of study and harvested 4th March 2017, 1st March 2018 during first and second year of the study respectively. In this study, AKAW 4210-6 (PDKV Sardar) variety of wheat was used. Wheat crop was sown in 20 cm crop spacing during both years of the study. Inorganic fertilizers were applied in all the plots with the recommended doses of 120 N, 60 P_2O_5 and 60 K_2O kg ha^{-1}. Half of the recommended dose of nitrogen and all of the phosphorus and potash were applied at the time of sowing through broadcasting. Remaining N was applied in two equal splits at 21 and 42 days after sowing using water-soluble fertilizers through drip irrigation system. In surface and subsurface drip irrigation methods, irrigation was applied on alternate day considering cumulative pan evaporation for previous two days. While, in check basin method of irrigation, six irrigations were scheduled at six critical growth stages of wheat crop, *viz*. crown root initiation (CRI), maximum tillering, late jointing, flowering, milking stage, and dough stage. First common irrigation was given to all the treatments just after sowing to bring the experimental plots to field capacity. The expenditure incurred from field preparation to harvest was worked out and used for calculating the economics of drip irrigation system. The crop yield was computed per hectare and the total income was worked out based on market rate which was prevalent during the time of this study. Net returns were obtained by subtracting the cost of cultivation from gross return for each treatment. The benefit cost ratio (B:C) was worked out by using following formula [8].

$$Benefit\ cost\ ratio = \frac{Gross\ \ Return\ (Rs\ ha^{-1})}{Cost\ of\ cultivation\ (Rs\ ha^{-1})}$$

The cost of drip system for one hectare was worked out based on current market rates.

Results and Discussion

Yield of wheat crop under different treatments

Treatment combination T1-S1L1E1 *i.e*. surface drip irrigation with 60 cm lateral spacing and 20 cm emitter spacing recorded higher grain yield (64.31 q ha^{-1}) followed by T2-S1L1E2 (64.31 q ha^{-1}). Similarly, in case of subsurface drip irrigation method maximum yield of wheat crop (50.70 q ha^{-1}) was recorded in 60 cm lateral spacing and 20 cm emitter spacing *i.e*. T10-S2L1E1. Comparing grain yield in surface and subsurface drip irrigation method with check basin irrigation method, the lowest grain yield (31.46 q ha^{-1}) was recorded in check basin irrigation method as presented in [Table-2]. Similar results have been also reported by Arafa, *et al*., (2009) [6]. [Fig-2] shows the view of experimental plot. The results of the present investigation clearly indicated that as lateral and emitter spacings were increased, the yield of wheat crop decreased. These results are in conformation with those results obtained by Rao, *et al*., (2015) [9].

Fig-2 View of experimental plot

Economic evaluation as affected by different treatments

The economics of the drip irrigation system was computed considering the longer life span of the drip irrigation system. The life of the pipe materials was taken as ten years. Interest of twelve percent on fixed cost was taken into consideration for working out the total cost. The economics of the system of irrigation under study were worked out in Rs ha^{-1}.

Total cost of cultivation of wheat crop under different treatments was determined from the fixed cost and operating cost. Total cost of cultivation including fixed cost and operating cost is presented in [Table-3]. Fixed cost and operating cost were found different for different treatments. Fixed cost varied due to different lateral & emitter spacings, cost of excavation of trenches; whereas operating cost varied due to different labour requirement and electric charges. For determining total cost of different treatments, fixed cost was added in the operating cost of cultivation of respective treatment. Drip installation cost per year was calculated by dividing system operational life to total investment on installation.

In surface drip irrigated wheat, total cost of cultivation was found maximum in 60 cm lateral spacing and 20 cm emitter spacing (41579 Rs ha^{-1}) and minimum in 100 cm lateral spacing with 40 cm emitter spacing (33580 Rs ha^{-1}). Similarly, in subsurface drip irrigation method, total cost of cultivation was found maximum in 60 cm lateral spacing and 20 cm emitter spacing (44491 Rs ha^{-1}) and minimum in 100 cm lateral spacing with 40 cm emitter spacing (35784 Rs ha^{-1}). Lowest cost of cultivation was found in check basin method of irrigation (29307 Rs ha^{-1}) as per data presented in [Table-3]. It was also clear from [Table-3] that the investment in raising wheat crop under drip irrigation was decreased with an increase in both lateral and emitter spacings, which might be due to the decrease in the cost of lateral and emitter under wider lateral and emitter geometry. Similar results are recorded Rao, *et al*., (2015) [9]. Total cost of cultivation recorded in subsurface drip irrigation method was found maximum than that of surface drip irrigation method, which might be due to cost of excavation of trenches of 20 cm depth and laying lateral beneath the surface. Total cost of cultivation under drip irrigation treatment was higher as compared to check basin irrigation, which may be due to extra investment in the installation of drip irrigation system.

Table-2 *Grain yield of wheat in surface, subsurface drip irrigation method and check basin irrigation method*.

Surface drip irrigation method				Subsurface drip irrigation method			
Treatment	Yield of wheat (q ha^{-1})			Treatment	Yield of wheat (q ha^{-1})		
	2016-17	2017-18	Pooled mean		2016-17	2017-18	Pooled mean
T_1-$S_1L_1E_1$	60.26	68.35	64.31	T_{10}-$S_2L_1E_1$	47.33	54.07	50.7
T_2-$S_1L_1E_2$	49.02	52.72	50.87	T_{11}-$S_2L_1E_2$	41.56	47.13	44.34
T_3-$S_1L_1E_3$	42.43	32.72	40.57	T_{12}-$S_2L_1E_3$	37.81	41.54	39.68
T_4-$S_1L_2E_1$	34.33	41.31	37.82	T_{13}-$S_2L_2E_1$	43.31	46.91	45.11
T_5-$S_1L_2E_2$	35.39	37.94	36.67	T_{14}-$S_2L_2E_2$	45.8	45.2	45.5
T_6-$S_1L_2E_3$	34.33	34.33	34.33	T_{15}-$S_2L_2E_3$	36.02	37.39	36.7
T_7-$S_1L_3E_1$	34.8	37.85	36.32	T_{16}-$S_2L_3E_1$	43.74	44.78	44.26
T_8-$S_1L_3E_2$	32.83	34.31	33.57	T_{17}-$S_2L_3E_2$	36.3	36.78	36.54
T_9-$S_1L_3E_3$	31.3	33.19	32.24	T_{18}-$S_2L_3E_3$	37.94	33.94	35.94
T_{19} - Check basin irrigation					35.31	27.61	31.46

Table-3 *Total cost of cultivation under different lateral and emitter spacings*

Treatment	Fixed cost, (Rs ha^{-1})	Operating cost,	Total cost of cultivation (Rs ha^{-1})	Fixed cost, (Rs ha^{-1})	Operating cost, (Rs ha^{-1})	Total cost of cultivation (Rs ha^{-1})	Pooled mean
	2016-17	2016-17	2016-17	2017-18	2017-18	2017-18	
T_1-$S_1L_1E_1$	18161	23606	41767	18161	23232	41392	41579
T_2-$S_1L_1E_2$	15160	23512	38671	15160	23137	38297	38484
T_3-$S_1L_1E_3$	14047	23606	37653	14047	23232	37279	37466
T_4-$S_1L_2E_1$	13737	23669	37406	13737	23295	37032	37219
T_5-$S_1L_2E_2$	11533	23606	35139	11533	23232	34765	34952
T_6-$S_1L_2E_3$	11198	23606	34804	11198	23232	34430	34617
T_7-$S_1L_3E_1$	11475	24550	36026	11475	24176	35651	35838
T_8-$S_1L_3E_2$	9560	24550	34110	9560	24176	33736	33923
T_9-$S_1L_3E_3$	9217	24550	33767	9217	24176	33392	33580
T_{10}-$S_2L_1E_1$	18161	26518	44679	18161	26144	44304	44491
T_{11}-$S_2L_1E_2$	15160	26424	41583	15160	26049	41209	41396
T_{12}-$S_2L_1E_3$	14047	26518	40565	14047	26144	40191	40378
T_{13}-$S_2L_2E_1$	13737	26227	39965	13737	25853	39590	39778
T_{14}-$S_2L_2E_2$	11533	26164	37698	11533	25790	37323	37510
T_{15}-$S_2L_2E_3$	11198	26164	37363	11198	25790	36988	37176
T_{16}-$S_2L_3E_1$	11475	26755	38230	11475	26381	37856	38043
T_{17}-$S_2L_3E_2$	9560	26755	36315	9560	26381	35940	36128
T_{18}-$S_2L_3E_3$	9217	26755	35972	9217	26381	35597	35784
T_{19} - Check basin irrigation		29734	29734		28881	28881	29307

Table-4 *Cost economic analysis of different lateral and emitter spacings of surface and subsurface drip irrigation method and check basin irrigation method*

Treatment	Gross monetary returns (Rs.)			Net monetary returns (Rs.)			Benefit cost ratio		
	2016-17	2017-18	Pooled mean	2016-17	2017-18	Pooled mean	2016-17	2017-18	Pooled mean
T_1-$S_1L_1E_1$	105454	123030	114242	63687	81638	72662	2.52	2.97	2.75
T_2-$S_1L_1E_2$	85782	94896	90339	47111	56599	51855	2.22	2.48	2.35
T_3-$S_1L_1E_3$	74245	69696	71971	36592	32417	34504	1.97	1.87	1.92
T_4-$S_1L_2E_1$	60083	74358	67221	22677	37326	30001	1.61	2.01	1.81
T_5-$S_1L_2E_2$	61931	68292	65111	26791	33527	30159	1.76	1.96	1.86
T_6-$S_1L_2E_3$	60083	61794	60939	25279	27364	26321	1.73	1.79	1.76
T_7-$S_1L_3E_1$	60894	68130	64512	24868	32479	28673	1.69	1.91	1.8
T_8-$S_1L_3E_2$	57458	61758	59608	23348	28022	25685	1.68	1.83	1.76
T_9-$S_1L_3E_3$	54769	59742	57255	21002	26350	23676	1.62	1.79	1.71
T_{10}-$S_2L_1E_1$	82833	97326	90080	38155	53022	45588	1.85	2.2	2.03
T_{11}-$S_2L_1E_2$	72722	84834	78778	31139	43625	37382	1.75	2.06	1.9
T_{12}-$S_2L_1E_3$	66176	74772	70474	25611	34581	30096	1.63	1.86	1.75
T_{13}-$S_2L_2E_1$	75801	84438	80119	35836	44848	40342	1.9	2.13	2.01
T_{14}-$S_2L_2E_2$	80144	81360	80752	42446	44037	43241	2.13	2.18	2.15
T_{15}-$S_2L_2E_3$	63032	67302	65167	25670	30314	27992	1.69	1.82	1.75
T_{16}-$S_2L_3E_1$	76546	80604	78575	38316	42748	40532	2	2.13	2.07
T_{17}-$S_2L_3E_2$	63519	66204	64861	27204	30264	28734	1.75	1.84	1.8
T_{18}-$S_2L_3E_3$	66403	61092	63747	30431	25495	27963	1.85	1.72	1.78
T_{19} - Check basin irrigation	56543	49698	53120	26809	20817	23813	1.9	1.72	1.81

Gross and Net Return

The gross monetary returns were taken as total income received from the grain yield of wheat as per prevailing market rates *i.e.* minimum support price of wheat of Rs.1750 and Rs 1800 per quintal during year 2016-17 and 2017-18 respectively, (Source; DDR Seeds, PDKV Akola). Net monetary income was calculated by reducing the total cost from gross monetary return. In surface drip irrigation, maximum gross and net monetary returns (114242 Rs ha^{-1} and 72662 Rs ha^{-1} respectively) were recorded in T1-S1L1E1 *i.e.* surface drip irrigation with 60 cm lateral spacing with 20 cm emitter spacing; whereas minimum gross and net monetary return (57255 Rs ha^{-1} and 23676 Rs ha^{-1} respectively) were obtained in T9-S1L3E3 *i.e.* surface drip irrigation with 100 cm lateral spacing with 40 cm emitter spacing presented in [Table-4]. In case of subsurface drip irrigation, maximum gross and net monetary returns (90080 Rs ha^{-1} and 45588 Rs ha^{-1} respectively) were obtained in T10-S2L1E1 *i.e.* subsurface drip irrigation with 60 cm lateral spacing and 20 cm emitter spacing whereas minimum gross and net monetary returns 63747 Rs ha^{-1} and 27963 Rs ha^{-1} respectively) were recorded in

Economic Evaluation of Drip Irrigation Systems for Wheat Crop under Different Lateral and Emitter Spacings

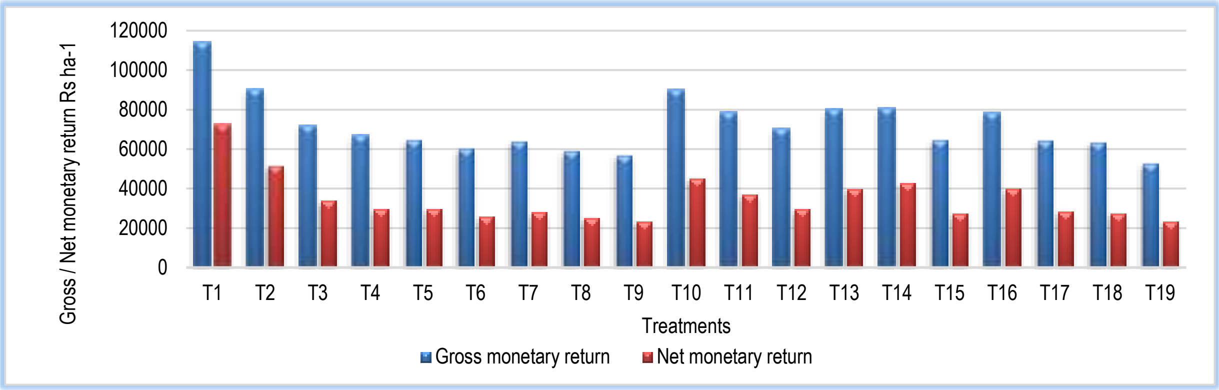

Fig-3 Pooled mean gross and net monetary returns of wheat crop under different treatment combinations

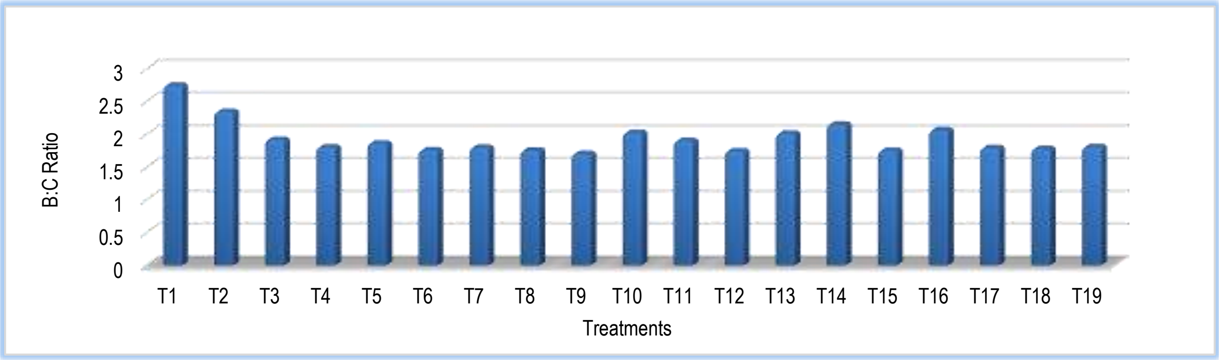

Fig-4 Pooled mean benefit cost ratio of wheat cultivation under different treatment combinations

subsurface drip irrigation with 100 cm lateral spacing and 40 cm emitter spacing. While lowest gross and net monetary returns 53120 Rs ha^{-1} and 23813 Rs ha^{-1} respectively were recorded in check basin irrigation method. From [Fig-3] and [Table-4] it was observed that the gross and net monetary returns increased with the decrease in lateral and emitter spacings except in treatment T14-S2L2E2 *i.e.* subsurface drip irrigation with 80 cm lateral spacing and 30 cm emitter spacing.

Benefit Cost Ratio (B:C)

The benefit cost ratio is the share of profit per rupee spends on raising wheat crop under a particular treatment combination. The data on the benefit cost ratio is presented in [Table-4]. Surface drip irrigation with 60 cm lateral spacing and 20 cm emitter spacing (T1-S1L1E1) recorded maximum benefit cost ratio (2.75) followed by surface drip irrigation with 60 cm lateral spacing and 30 cm emitter spacing (2.35) *i.e.* T2-S1L1E2. However, it was recorded minimum (1.71) in treatment combination T9-S1L3E3 *i.e.* surface drip irrigation with 100 cm lateral spacing with 40 cm emitter spacing. In case of subsurface drip irrigation with 60 cm lateral spacing and 20 cm emitter spacing (T10-S2L1E1) recorded maximum benefit cost ratio (2.03). However, it was recorded minimum (1.75) in treatment combination T12-S2L1E3 and T15-S2L2E3. Lower value of benefit cost ratio was recorded in check basin irrigation method (1.81) as compare to surface and subsurface drip irrigation method. The benefit cost ratio was influenced by irrigation methods, and different lateral and emitter spacings. It was increased with the decrease in lateral and emitter spacings as shown in [Fig-4]. The initial cost of installing the drip irrigation system for wheat crop is high but over a period of time the cost could be recovered and the benefits derived would be higher than check basin irrigation method. During both years of the study and pooled mean analysis the maximum gross monetary, net monetary return and benefit cost ratio was found in 60 cm lateral spacing with 20 cm emitter spacing in surface drip irrigation method as compare to other treatment combinations of surface and subsurface drip irrigation method and check basin method of irrigation.

Conclusion

Considering the performance of surface drip irrigation system with 60 cm lateral spacing and 20 cm emitter spacing combination it can be adopted by the farmers for commercial cultivation of wheat crop for getting higher net monetary returns and benefit cost ratio.

Application of research: Study of drip irrigation systems for wheat crop

Research Category: Drip irrigation

Acknowledgement / Funding: Authors are thankful to Jain Hi-Tech Agri. Institute, Jain Irrigation Systems Ltd., Jalgaon, Maharashtra. Authors are also thankful to Department of Irrigation and Drainage Engineering, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104, MS, India

***Research Guide or Chairperson of research: Dr M. M. Deshmukh**
University: Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104, MS
Research project name or number: Research station trials

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Jain Irrigation Systems Ltd., Jalgaon, Maharashtra

Cultivar / Variety / Breed name: Wheat

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

References

[1] Singh S.K. (2018) GAIN Report number IN8100
[2] Krishi Vibhag Maharashtra Shasan, (2017-18) http://krishi.maharashtra.gov.in/1001/Home
[3] FAO (1986) http://www.fao.org/tempref/agl/AGLW/fwm/Manual3.pdf
[4] Narayanamoorthy A. (1997) *Ind J. of AgriL Econ*., 52(4), 728-739.

[5] Abdelraouf R.E., Refaie K.M., Hegab I.A. (2011) *J. of App Sci Res*., 9(2), 1116- 1125.
[6] Arafa Y.E., Essam A.W., Hazem E.M. (2009) *Australian J of Basic and Applied Sci*., 3(2), 790-796.
[7] Rahman G.A. (2009) *American-Eurasian J. Agric. & Environ. Sci*., 5 (5), 664-670.
[8] Palaniappan S.P. (1985) *Wiley Eastern Ltd., New Delhi*, 215.
[9] Rao K.V.R., Bajpai A., Gangwar S., Chourasia L. and Soni K. (2015) *Res. on Crops*, 17(1), 163-168.