

Original Research Article
**Doubling farmer income through cultivating
headed broccoli (*Brassica oleracea var. Itilica*)
under different Irrigation Regimes and Water
Saving Techniques**

ABSTRACT

Doubling Farmer Income through application of precision irrigation and water saving techniques in vegetable crops may be possible under change in climatic and water scarcity conditions by proper inclusive adaptation of the results of undertaken present investigation field experiment. Significantly superior IR treatment was I1.00 found on the basis of studied economic aspects, net returns and benefit cost ratio. Total cost of cultivation and benefit cost ratio basis noted significantly superior IR treatment was I0.75. Based on net returns and benefit cost ratio significantly superior WST treatment was MK and benefit cost ratio basis MC was recorded best. In general, the treatment combination I1.00 x MK and thereafter I0.75 x MBP was found superior among all the treatments. However, based on the IWM aspect to overcome the problem of irrigation water scarcity, and adaptation and mitigation of changed climate as well as projected future climate change through precision farming, increasing leaf area on land, decreasing ambient temperature and economic profitability factor i.e. net returns from the cultivation of headed broccoli, treatment combination I0.75 x MBP and I0.50 x MBP were observed significantly superior amongst all the treatments.

Keywords: Broccoli, IR, WST, economics, Doubling Farmer Income, BCR.

1. INTRODUCTION

Agriculture is highly vulnerable to seasonal weather variability, to climatic variability and to climate change and the growth, development and yield of crops as well as animal and fishery are depending on the prevailing extreme weather events. The significant change and future projection in Indian climate observing alike pattern of the global climate change. Certainly, cumulative impact of global climate change, increasing trend of temperature and climatic extremes has seen at continental as well as at regional level. In India, increased vulnerability, both locally and regionally, causing reductions in agricultural yields (Bhatta and Aggrawal, 2015; FAO, 2017; Ray, et al. 2019; Jaybhaye, 2021). Across the Indian region, change in temperature was not found uniform and annual mean temperature (average of maximum and minimum), maximum and minimum temperatures showed warming trends of 0.51, 0.72 and 0.27 °C per 100 year respectively during the period 1901-2007 (Ray et al., 2019; Jaybhaye, 2021; IPCC, 2022). The minor distracted earth water cycle or Earth atmosphere are affecting largely on ecosystem and which are utterly disrupt biodiversity/natural world on Earth; ultimately, which are affecting badly on food chain. Armstrong, 2022 noted akin statement, across the globe, 44 countries are projected to either extremely high or high water stress level (ratio of water withdrawals to water supply) in 2040 and India is one of them, having a high water stress level country.

In such a situation of environment, as increasing global population (10 billion) and Indian (1.67 billion); food grain production need to be increased by 70 % by 2050 compared to today for feed to the increase in population (world bank, 2022) and fresh vegetable production needs to be increased in the upcoming years to ensure a healthy diet for everybody (Krishna Bahadur et al., 2018). But now a days decrease in fresh water availability (a major input towards crop production) makes the problem even more challenging. Due to rapid urbanization and industrialization fresh water share to agricultural sector is decreasing day by day, and it's demand in India will be increased by 25 % and 40 %, the share of irrigation for fresh water will declined to 77.76 % and 69.25 % respectively by the year 2025 and 2050 (Kumar et al., 2015; world bank, 2022). Similarly, it was projected that gross per capita water availability in India will decline from 1820 m³/yr in 2001 to as low as 1140 m³/yr in 2050 (Ray et al., 2019). Thus, more food need to be produced with less available water resources.

Broccoli is nutritionally very high valuable a crop because of its properties of low fat, low in calories with rich energy, high protein, vitamins (B2,C,K) riboflavin, thiamine, niacin and minerals (Iron, magnesium), anti-carcinogenic properties resulting from glucosinolate synthesis in broccoli florets (Erken et al., 2013; Baidya et al., 2017). Recently broccoli is gaining popularity in big cities/metropolitan cities, among rich peoples, but not in sub urban and rural areas due to lack of awareness regarding nutritive value, consumption, recipe and taste etc. Commercial cultivation is still of broccoli on infancy stage because of lack of poor awareness in farming community and non availability of cultivation package of practice (Sharchandran et al., 2015; Baidya et al., 2017). Recently in India seen that expansion of the area consecrated to broccoli in Maharashtra, West Bengal and Jharkhand states to meet the increased demand of big city markets (Jaybhaye, 2019). Therefore, the Indian farmers have a huge scope, to cultivate broccoli well manner and marketing well to achieving target of 'Doubling Farmer Income' through 'Per Drop More Crop' technology mission by maximizing the productivity of crops and the income of farmers by use of precise water management.

Thus, along with the irrigation methods and levels, application of water saving techniques (WST) is today's urgent need, which can help to minimize the scarcity of water problem of agriculture sector. WST can reduce the evaporation loss and encourage transpiration and there by enhance the effective utilization of root zone water towards crop production. It happens by creating a barrier between the soil surface and atmosphere. Hence, environmental friendly, biodegradable and allied material is used in the present experiment for WST application, viz., hydrogel (MH), potassium nitrate (KNO₃), black polyethylene, paddy straw mulch (MPS) etc. Hydrogel has holding water during irrigation and releasing as when required to crop; KNO₃ used as a antitranspirant and osmoprotectants; black polyethylene and paddy straw used as a mulch treatment, and mulching minimizes evaporation loss and can influence root zone moisture distribution, which may enhance transpiration (Rust and Turral 3 chapter /Rijsberman, 2006; Jaybhaye and Mukherjee, 2020). Under condition of changing climate, current water scarcity and future water shortage required adaptation and implementation planning. The most common adaptations are on-farm water management, water storage, soil moisture conservation and irrigation responses are provide economic, institutional or ecological benefits and reduce vulnerability (high confidence). Large scale irrigation can also alter local to regional microclimate (high confidence) (IPCC, 2022). 'Per Drop More Crop' is new priorities research paradigm on water productivity, hence, in this thematic areas planned and designed present research experiment and worked out economics of broccoli crop under different irrigation regimes and water saving techniques which is described as below under different heads.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The research experiment was carried out during 2016-17 and 2017-18 (during the period of November to January) in the ‘C’ Block Research Farm of Bidhan Chandra Krishi Vishwavidyalaya, Kalyani, West Bengal, (India). Its geocoordinates are: longitude 88° 31' East, latitude 22° 58' North and its altitude is 9.75 m above mean sea level.

An irrigation-based research experiment was carried out to evaluate the yield response of headed broccoli to four seasonal levels of given water that ranged from 25 to 100 % of ETC in a field. To schedule irrigation, daily ET_c (AET) was calculated based on the product of daily ET_o (PET) times a crop coefficient. To calculate ET_o , the FAO-56 Penman–Monteith (FAO-56 PM) equation was used (Allen et al., 1998a). The agrometeorological observatory is located less than 500 m away from the experimental broccoli field (AICRP on Agrometeorology, Kalyani, B.C.K.V., Nadia) and from which climatic data was taken. Crop coefficient (K_c) values used for calculation of AET were: 0.7 during the rosette development (RSD) period; 1.05 during heading (HD) and 0.95 during the harvesting (HT) growth stage (Allen et al., 1998b; Lopez-Urrea et al., 2009). The 4 irrigation regimes (IR) main treatments distinct in this experiment were: (i) $IW/CAET = 1.0$ (I1.0), (ii) $IW/CAET = 0.75$ (I0.75), (iii) $IW/CAET = 0.50$ (I0.50) and (iv) $IW/CAET = 0.25$ (I0.25) and 5 water saving techniques (WST) as sub treatments were: (i) no water saving techniques application (MC – controlled), (ii) hydrogel (MH) @ 50 kg/ha, (iii) potassium nitrate (KNO_3) (MK) @ 1.5 % (iv) black polyethylene mulch (MBP) @ 30 μ thickness and (v) paddy straw mulch (MPS) @ 5 t/ha applied in sub-plots. The depth of irrigation on each occasion was 25 mm. After attainment 25, 33.3, 50 and 100 mm cumulative actual evapotranspiration (CAET) value, irrigations were given to I1.00, I0.75, I0.50 and I0.25 treatment, respectively. Irrigation was applied initially to the plant by a water can for initial establishment, which accounts in total 4.0 mm to each plot, followed by direct irrigation to each plot through a discharge pipe, for each plot an amount of 219.0 litres of water were applied during irrigation every time. During both the experimental years, mulching was imposed at the time of transplanting, Pusa hydrogel was applied the next day after transplanting at the root zone (10 cm soil depth) of each plant by ring method under the experimentations (Mandal et al., 2015) and applied weekly foliar spray of potassium nitrate. While, special care has been taken to keep the plant population (40,000 plants ha⁻¹) during the growing season.

Field experiment statistical design was a split plot design with three replicated plots per treatment and each plot was comprised of a raised bed (100 cm) and furrow (30 cm) system. In each ridge, two rows of broccoli crop were transplanted. In the case of mulch a strip of 15 cm wide area at the middle part of the furrow remains uncovered for easy entry of irrigation and rainfall water respectively. Irrigation was applied in the furrows and water seeped into the root zone of the crop in a raised bed. Each plot size was 2.5 m x 3.5 m (8.75 m²) surrounded by 1.5 m wide buffer strip to control lateral seepage of water in-between connecting plots. The rotary power tiller with 100 mm tillage depth was used for land preparation and by two cross-wise passes land was prepared, followed by surface levelling was made with a wooden leveler. Twenty-five day old seedlings of broccoli (Cv. Centauro) were transplanted at 50 cm x 50 cm spacing on 9th and 6th November of 2016-17 and 2017-18 respectively. There were 4 plants m⁻², which is followed by the broccoli growers of the region. The fertilizers were given to the experimental plots through soil application before transplanting, during land preparation; prior to application of farm yard manure (@ 15.0 t ha⁻¹) it was properly mixed with the soil. Fertilizers were applied @ 180 kg N through urea, 80 kg P₂O₅ through SSP and 80.0 kg K₂O through MOP per hectare according to Thapa and Rai (2012); Tamang et al. (2017). Complete doses of phosphate and potassium were given as basal; whereas, nitrogen was given in three splits, 50 % as basal and 25 % at 30 DAT + 25

% at 50 DAT. Boron as a micronutrient @ 15.0 g/lit in the form of borax (20 %) was applied as a foliar spray on the plant at 30 and 50 DAT.

Broccoli was manual harvested four times, on 10,13,16 and 19 January 2017; 15,17,20 and 23 January 2018 plants with fully matured net head were harvested starting from 63 and 66 days after transplanting during the year 2017 and 2018 respectively. Most of the treatments reach marketable maturity 72-78 days after transplanting. A total of 4 harvestings at 2-3 day intervals were carried out. From each harvest and each treatment, the well-shaped net heads (head with 2-3 jacket leaf) which were green in color and appeared marketable (head with a portion of 5-10 cm of the main stem) were harvested and weighed (g plant⁻¹). The cumulated marketable net head fresh weight i.e, net head yield (NHY) was calculated and represented as t ha⁻¹.

Entire collected data was taken for analysis of statistical differences among irrigation regims and WST, and their interaction on net head yield was tested by using SAS (ver. 9.3, SAS, Inc., Cary, NC) computer package program. The mean values were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The means were compared using the critical difference (CD) test at 5% significance level.

Economic analysis in order to evaluate the most profitable treatment, economic analysis of treatments combination (Table-3) was worked out in terms of net returns and benefit cost ratio (BCR). Economic evaluation of different treatment combinations was done through partial budgeting as suggested by Perrins et al. (1979); Dhotra et al. (2019). Net return were calculated by deducing the total cost of cultivation from the gross return. Gross return and variable cost (total cost of cultivation) were calculated considering the rates of harvested fresh net head broccoli of Rs. 20000 per ton (2016-17) and Rs. 25000 per ton (2017-18). While, benefit cost ratio (BCR) was calculated using the following formula:

$$BCR = \frac{\text{Gross Return}}{\text{Total variable cost}}$$

3. RESULTS AND DISCUSSION

The market survey of price for broccoli purchase was made physically by visit to vegetable market, vegetable shellers, a roadside vegetable vendor, and visit to super market/super bazar (viz., Big Bazaar, More and D Mart) of Kalyani (West Bengal) and near by towns of Kalyani (viz., Kanchrapara and Jaguli of Nadia 24 Pargana district, Kolkatta), as well as visit to Pune and Ahmamaddnagar cities (Maharashtra). And it also done by digital market as well as by e-commerce through online stores (viz., Amazon and Flipcart etc.). While, in addition to this, adaptation for consomptaion survey was done in Kalyani and near to Kalyani towns from differ socioeconomic families. In the local vegetable market, vegetable shellers and a roadside vegetable vendor average price observed Rs. 15-60 per kg and Rs. 100-200 per kg in big cities as well as in online stores, digital market (data is not preented). It was also found very poor awareness in subregional town and rural area regarding daily use, recipe, taste, nutritional values, keeping quality and non willing to change in consumption instead of cauliflower. And ultimately it affected on market rate, due to which local (rural places) price was found lower than urban places (Baidya et al., 2017).

The actual costs were worked out for control treatments (Table 2a and 2b) which include production cost (nursery preparation, seed, field preparation, labour charges, fertilizer, insecticide/ pesticide, irrigation vcharges, miscellaneous etc.) and marketing cost. The actual costs of all other IR and WST treatments which includes control treatments cost plus application of WST treatments material and labour chargs (Table 2a and 2b). Gross returns

of all the treatments were varied from Rs. 364725 in I0.75 x MBP (IW/ CAET = 0.75 + black polyethylene mulch) treatment to Rs. 181350 in I0.25 x MC treatment (IW/ CAET = 0.25 + no water saving techniques application) treatment (Table 3). Which is also reported by others in cabbage (Narayanamma et al., 2007) [6], cauliflower (Mohamed El, 2011) [5] and Saha et al., 2010 [9]. The total cost of cultivation was ranged Rs. 163545 to Rs. 100362 including marketing cost but in B:C ratio we were include without marketing cost. The Table 3 revealed that total cost of cultivation per hectare was observed to be highest (Rs. 163545) in I1.00 x MH (IW/ CAET = 1.00 + hydrogel) treatment, whereas it was found to be lowest (Rs 100362) in I0.25 x MC. Cost and return analysis of broccoli cultivation produced in different treatments of IR and WST (Table 3) shown that net returns were highest (Rs. 251236) in treatment I1.00 x MK (IW/ CAET = 1.00 + potassium nitrate-KNO₃) and it was found on par (Rs. 231775) with I0.75 x MBP, whereas, it was found to be lowest (Rs. 25759) in treatment I0.25 x MH (IW/ CAET = 0.25 + hydrogel).

Though the highest net head yield was recorded under I0.75 x MBP treatment (16.21 t ha⁻¹) (Table 1), the highest net returns was observed under I1.00 x MK treatment and it was more by 8 %. It is because of yield under I1.00 x MK (15.99 t ha⁻¹) was found on par and low total cost of cultivation (18 %) as well as minor difference in gross return (1.4 %) in between these two treatments. Although the total cost of cultivation and gross return was recorded lowest under I0.25 x MC treatment, the lowest net return was noted under I0.25 x MH treatment, it is because of negligibale difference in net head yield and in gross return (3 %), more difference in total cost of cultivation (60 %) within I0.25 x MH and I0.25 x MC treatment were recorded.

On similar line benifit cost ratio (BCR) was recorded and it ranged from 1.16 in I0.25 x MH to 3.31 in I1.00 x MK. Nonsignificant and minor differenncee (4.7 %) in between highest value (3.31) of I1.00 x MK and 3.16 of I1.00 x MC (IW/ CAET = 1.00 + no water saving techniques application) treatments were recorded. It is because of the reons stated above under net return and gross return.

Similar results were obtained by (Rajput 2008) [8] who found that application of 30 ppm GA₃ gave highest net realization (Rs 167164). Results are also in consonance with the findings of Verma (2014) [11] who recorded the highest net realization (Rs 23460 per hectare) with a cost benefit ratio of 1: 7.53 as compared to control. .

4. CONCLUSION

The total cost of cultivation was ranged Rs 163545 to Rs 100362 including marketing cost but in BCR we were include without marketing cost. The total cost of cultivation per hectare was observed to be highest 38 % (Rs 163545) in I1.00 x MH treatment, compared to lowest treatment of I0.25 x MC (Rs 100362). Gross returns of all the treatments were varied from Rs 364725 in I0.75 x MBP treatment to Rs 181350 in I0.25 x MC treatment and difference between highest and lowest gross return recorded 50 %. Net returns were recorded highest in treatment I1.00 x MK (Rs 251236) and it was found to be lowest by 90 % (Rs. 25759) in treatment I0.25 x MH. The BCR ranged from highest (3.31) in I1.00 x MH to lowest (1.16) in I0.25 x MH and difference within these treatments was observed 65 %.

Based on the net returns and BCR study and obtained results may be concluded that applied irrigation regims (IR) and water saving techniques (WST) I1.00 x MK treatment (IW/ CAET = 1.00 + potassium nitrate) was superior among all other treatments. And thereafter, application of IR and WST I0.75 x MBP as well as I0.75 x MBP treatment and I1.00 x MC was best among all other treatments. The application of irrigation regims I0.25, and WST MC and MH treatment (i.e. I0.25 x MC and I0.25 x MH treatment) was poor among all other treatments.

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Table 1a: Effect of different irrigation regimes and on net head fresh yield (t ha⁻¹) of broccoli during 2016-17 and 2017-18

Irrigation Regimes	2016-17	2017-18	Pooled	Water Saving	2016-17	2017-18	Pooled
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				Techniques			
I _{1.00}	17.19	13.15	15.17	M _C	13.06	10.08	11.57
I _{0.75}	16.58	12.02	14.30	M _H	14.11	10.56	12.34
I _{0.50}	14.45	9.99	12.22	M _K	14.14	11.74	12.94
I _{0.25}	11.91	7.74	9.82	M _{BP}	18.49	12.40	15.45
SE (m) ±	0.45	0.21	0.43	M _{PS}	15.35	8.85	12.10
CD (P=0.05)	1.56	0.74	1.33	SE (m) ±	0.57	0.23	0.54
				CD (P=0.05)	1.66	0.66	1.51

M_C: no water saving techniques (Control);

M_H : hydrogel application;

M_K: KNO₃ application;

M_{BP}: black polyethylene mulch;

M_{PS}: paddy straw mulch.

Table 1b: Interaction effect of different irrigation regimes and water saving techniques on net head yield (t ha⁻¹) of broccoli during 2017 and 2017-18

IR x WS	Net head yield (t ha ⁻¹)		
	2016-17	2017-18	Pooled
I _{1.00} x M _C	16.50	12.30	14.40

$I_{1.00} \times M_H$	18.21	12.71	15.46
$I_{1.00} \times M_K$	16.70	15.27	15.99
$I_{1.00} \times M_{BP}$	17.58	14.25	15.91
$I_{1.00} \times M_{PS}$	16.97	11.25	14.11
$I_{0.75} \times M_C$	15.58	12.08	13.83
$I_{0.75} \times M_H$	16.43	11.82	14.12
$I_{0.75} \times M_K$	15.95	13.44	14.70
$I_{0.75} \times M_{BP}$	18.67	13.75	16.21
$I_{0.75} \times M_{PS}$	16.26	9.03	12.64
$I_{0.50} \times M_C$	11.33	8.70	10.01
$I_{0.50} \times M_H$	13.67	9.25	11.46
$I_{0.50} \times M_K$	12.75	11.29	12.02
$I_{0.50} \times M_{BP}$	20.05	12.22	16.14
$I_{0.50} \times M_{PS}$	14.43	8.50	11.46
$I_{0.25} \times M_C$	8.84	7.27	8.06
$I_{0.25} \times M_H$	8.14	8.48	8.31
$I_{0.25} \times M_K$	11.17	6.92	9.04
$I_{0.25} \times M_{BP}$	17.66	9.40	13.53
$I_{0.25} \times M_{PS}$	13.73	6.62	10.17
SE (m) \pm	1.15	0.46	1.07
CD (P=0.05)	3.31	NS	NS
SE (m) \pm	1.12	0.46	1.05
CD (P=0.05)	3.34	NS	NS
GM	15.03	10.73	12.88
CV (%)	13.25	7.41	11.77

)		0					00	00	00	00	0	0	0	0	0	0	0
		g									0	0	0	0	0	0	0
		m									0	0	0	0	0	0	0
C	Fungicide for seed treatment (Ridomil/Mancozeb)						3000	3000	3000	3000	300	300	300	300	300	300	300
D	Plastic tunnel (made from Bamboo structure) for protection of seedlings from aberrant weather (viz., fog, unseasonal rain, hailstorm, heavy winds, high temperature etc .	6									9000	9000	9000	9000	9000	9000	9000
i	Throughout experiment agricultural inputs:																
A	Treatment application inputs:																
a	M _C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b	M _H	6000					6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
c	M _K	3000					3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
d	M _{BP}	3000					3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
e	M _{PS}	2000					2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
B	Plant protection: At the	1					14	14	14	14	1	1	1	1	1	1	1

)						00	00	00	00	0	0	0	0	0	0	0	0
										0	0	0	0	0	0	0	0
										7	7	7	7	7	7	7	7
										0	0	0	0	0	0	0	0
										0	0	0	0	0	0	0	0
										0	0	0	0	0	0	0	0
										0	0	0	0	0	0	0	0
										2	1	1	1	1	1	1	1
										1	0	6	1	3	2	2	2
										8	5	6	1	6	6	9	2
										7	2	1	1	7	9	2	4
										2	8	3	3	0	9	4	8
										0	5	0	5	0	0	0	0
										5							
										21	21	21	21	21	21	21	21
										41	30	24	18	18	41	30	24
										82	18	36	54	54	82	18	36

UNDER PEER REVIEW

I	allied activities:														
i)	Field preparation by tractor	2						970	975	970	975	970	975	970	975
ii)	Hired labour for :														
A)	preparatory tillage (ridges making and layout) FYM/ Fertilizer application	20						570	570	570	570	570	570	570	570
B)	Transplanting	21						585	595	585	595	585	595	585	595
C)	Hoeing and weeding	45						125	128	125	128	125	128	125	128
D)	Fertilizer application, boron spray	5						850	855	850	855	850	855	850	855
E)	Plant protection measures	30						145	142	145	142	145	142	145	142
F)	Irrigation:														
a)	For pre-transplanting	2						570	570	570	570	570	570	570	570
b)	After transplanting for standings	9						256	255	256	255	256	255	256	255

	in field (2-3 days interval watering by can)							5	5								
c)	For throughout crop going period (Through flood irrigation method)	1 2	8		6	4	3	2	3 4 8	2 2 0	17 11 37	10 40 .5	21 85 85	85 85 85	85 85 85	85 85 85	85 85 85
G)	For treatment application used labour																
a)	M _C	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
b)	M _H	3	3		3	3	3	5	8 5	8 5	85 5	85 5	85 5	85 5			85 5
c)	M _K	1 0	10		1 0	1 0	1 0	5 0	2 8 8	2 8 0	28 50	28 50	28 50		28 50		28 50
d)	M _{BP}	5	5		5	5	5	5	1 4 2	1 4 2	14 25	14 25	14 25		14 25		14 25
e)	M _{PS}	6	6		6	6	6	0	1 7 1	1 7 1	17 10	17 10	17 10			17 10	17 10
H)	Harvesting (3 harvest taken)	2 0											57 00	57 00	57 00	57 00	57 00
I)	Irrigation charges :3 HP electric pump; 0.5 unit; 1 unit @ Rs. 4.0																
a)	Pre	0											0	0	0	0	0

Table 3: Economics of broccoli as influenced by different irrigation regimes and water saving Techniques.

Sr. No.	IRX WS	Total cost of cultivation / ha (Rs)			Gross return (Rs/ ha)		Average	Net return (Rs/ ha)			B: C Ratio	2017-18	Average
		2016-17	2017-18	Average	2016-17	2017-18		2016-17	2017-18	Average			
1	I _{1.00} x M _C	100042	105337	102690	330000	307500	324000	229958	202163	221311	3.30	2.92	3.16
2	I _{1.00} x M _H	160897	166192	163545	364200	317750	347850	203303	151558	184306	2.26	1.91	2.13
3	I _{1.00} x M _K	105892	111187	108540	334000	381750	359775	228108	270563	251236	3.15	3.43	3.31

4	$I_{1.00}$ x M_{BP}	131 467	136 762	134 115	3516 00	3562 50	357 975	220 133	219 488	223 861	2.67	2.6 0	2.6 7
5	$I_{1.00}$ x M_{PS}	121 752	127 047	124 400	3394 00	2812 50	317 475	217 648	154 203	193 076	2.79	2.2 1	2.5 5
6	$I_{0.75}$ x M_C	988 78	104 173	101 526	3116 00	3020 00	311 175	212 722	197 827	209 650	3.15	2.9 0	3.0 6
7	$I_{0.75}$ x M_H	159 733	165 028	162 381	3286 00	2955 00	317 700	168 867	130 472	155 320	2.06	1.7 9	1.9 6
8	$I_{0.75}$ x M_K	104 728	110 023	107 376	3190 00	3360 00	330 750	214 272	225 977	223 375	3.05	3.0 5	3.0 8
9	$I_{0.75}$ x M_{BP}	130 303	135 598	132 951	3734 00	3437 50	364 725	243 097	208 152	231 775	2.87	2.5 4	2.7 4
10	$I_{0.75}$ x M_{PS}	120 588	125 883	123 236	3252 00	2257 50	284 400	204 612	998 67	161 165	2.70	1.7 9	2.3 1
11	$I_{0.50}$ x M_C	982 96	103 591	100 944	2266 00	2175 00	225 225	128 304	113 909	124 282	2.31	2.1 0	2.2 3
12	$I_{0.50}$ x M_H	159 151	164 446	161 799	2734 00	2312 50	257 850	114 249	668 04	960 52	1.72	1.4 1	1.5 9
13	$I_{0.50}$ x M_K	104 146	109 441	106 794	2550 00	2822 50	270 450	150 854	172 809	163 657	2.45	2.5 8	2.5 3
14	$I_{0.50}$ x M_{BP}	129 721	135 016	132 369	4010 00	3055 00	363 150	271 279	170 484	230 782	3.09	2.2 6	2.7 4
15	$I_{0.50}$ x M_{PS}	120 006	125 301	122 654	2886 00	2125 00	257 850	168 594	871 99	135 197	2.40	1.7 0	2.1 0
16	$I_{0.25}$ x M_C	977 14	103 009	100 362	1768 00	1817 50	181 350	790 86	787 41	809 89	1.81	1.7 6	1.8 1

17	$I_{0.25} \times M_H$	158 569	163 864	161 217	1628 00	2120 00	186 975	423 1	481 36	257 59	1.03	1.2 9	1.1 6
18	$I_{0.25} \times M_K$	103 564	108 859	106 212	2234 00	1730 00	203 400	119 836	641 41	971 89	2.16	1.5 9	1.9 2
19	$I_{0.25} \times M_{BP}$	129 139	134 434	131 787	3532 00	2350 00	304 425	224 061	100 566	172 639	2.74	1.7 5	2.3 1
20	$I_{0.25} \times M_{PS}$	119 424	124 719	122 072	2746 00	1655 00	228 825	155 176	407 81	106 754	2.30	1.3 3	1.8 7
G M		122 701	127 996	125 348	3006 00	2682 50	289 800	177 900	140 255	164 452	2.45	2.1 0	2.3 1

Table 4: Economics of broccoli as influenced by different irrigation regimes and water saving Techniques.

Sr. No	IRX WS	Total cost of cultivation (Rs / ha)			Gross return (Rs/ ha)			Net return (Rs/ ha)			B: C Ratio	2017-18	Average
		2016-17	2017-18	Average	2016-17	2017-18	Average	2016-17	2017-18	Average			
1	$I_{1.00} \times M_K$	105 892	111 187	108 540	3340 00	3817 50	359 775	228 108	270 563	251 236	3.15	3.4 3	3.3 1
2	$I_{0.75} \times M_{BP}$	130 303	135 598	132 951	3734 00	3437 50	364 725	243 097	208 152	231 775	2.87	2.5 4	2.7 4
3	$I_{0.50} \times M_{PS}$	129	135	132	4010	3055	363	271	170	230	3.09	2.2	2.7

	M _{BP}	721	016	369	00	00	150	279	484	782		6	4
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UNDER PEER REVIEW