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PRODUCTIVITY AND PROFITABILITY OF ONION (*ALLIUM CEPA L.*) GROWN UNDER DRIP FERTIGATION IN TROPICAL ZONE OF ODISHA

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ABSTRACT

Field experiments were conducted to assess the productivity and economic feasibility of onion (Allium cepa L.) cv. Agri found Light Red grown under drip fertigation. The trial was conducted during three consecutive rabi seasons of 2016-2019 at research farm of Precision Farming Development Centre, Odisha University of Agriculture and Technology, Bhubaneswar. The experiments were laid out in randomized block design (RBD) with ten treatments and three replicates. Three levels of irrigation @100, 80, 60% of ET_c and three levels of fertigation with water soluble fertilizers @ 100, 80, 60% of recommended dose were applied during experimentation. The results of the study showed that the onion cv. Agrifound Light Red, when cultivated in sandy loam soil during winter season recorded maximum yield of 25.96 t/ha for treatment with irrigation at 80 percent ET_c and fertigation at 100 percent recommended dose of fertilizer (RDF), but was at par with irrigation at 80% of ETc and fertigation at 80% of RDF. The economic analysis was done involving the net present value (NPV), internal rate of return (IRR), benefit cost ratio (BC ratio), payback period. The internal rate of return was observed maximum of 60.37% in case of irrigation at 80% of ETc and fertigation at 100% RDF. But BC ratio and Payback period were found to be 3.6 and 2.3 years both for treatment combination of irrigation at 80% of ETc and fertigation at 100% fertigation and treatment combination of 80% irrigation and 80% fertigation of NPK-RDF.

***Keywords**: CROPWAT 8.0, Penman-Monteith, NPV, IRR, BC ratio, Payback period*

INTRODUCTION

The natural resources and agro inputs like water and fertilizers have emerged as the most important factors for sustaining agricultural growth. India with 4% of world's renewable water resources and 2.4% of global land area has to feed 18% of world's human population (GoI, 2012). Since land is limited, this would require an improvement in productivity of crops. Water is scarce natural resources and has uneven spatial and temporal variation. In this context drip irrigation is considered as the most efficient and desirable technique of micro irrigation through which water can be applied precisely, judiciously and uniformly with help of regulatory system directly to the root zone of the crop and saves water significantly over surface irrigation practices (Tiwari *et al.*, 2003, Antony *et al.*, 2004, Zheng *et al.*, 2013, Satpute *et al*., 2013, Kahlon, M.S., 2017). As of now, there is import of 20% nitrogenous fertilizers, 30% phosphatic fertilizers and 100% potassic fertilizers to meet national demand. The judicious use of fertilizers in agriculture to save foreign exchange towards import and to reduce expenditure towards subsidy is need of hour. Fertilizers through drip irrigation system can efficiently place nutrients in wetted zone wherein the roots are at highest concentration. In fertigation, nutrient use efficiency could be as high as 90% compared to 40-60% in conventional method. The drip fertigation has proved to be useful in increasing yield and fertilizer use efficiency in number of crops by providing optimum nutrient availability. (Brahma, *et al*., 2010, Savitha, *et al*., 2010, Pawar *et al.*, 2013)

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Onion is very important vegetable crop not only for internal consumption but also a potential foreign exchange earner. It ranks second in importance after potato, among vegetables in India. It is cultivated widely during *kharif* and *rabi* seasons in different agro-ecological regions of the country. In India it covers 13.1 lakh hectares with average productivity of 17.2 t/ha as against the world productivity of 18.8 t/ha (FAO, 2018). In Odisha, onion is cultivated in 0.33 lakh hectare area with productivity of 11.3 t/ha. (GoI, 2018). The reason for lower bulb yield is mainly due to poor water and nutrient management. The crop has shallow root system and highly sensitive to soil water stress (Olalla *et al.*, 2004; Kadayifci *et al.*, 2005). Hence the present investigation was carried out to understand the influence of drip irrigation and fertigation levels on yield and economics of onion under open field situations in tropical climate of Odisha.

MATERIALS AND METHODS

Experiments were conducted at the Precision Farming Development Center, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha for three years during winter seasons of 2016-17, 2017-18 and 2018-19.The field experiment consisted of design of drip irrigation system, installation of system along with fertigation unit, field preparation, transplanting of onion seedlings, irrigation scheduling, fertigation scheduling, recording of observations and analysis of data. The experimental site is situated at latitude of 20°16.724' N and longitude of 85° 47.297'E with an altitude of 55 m above mean sea level (Fig.1). The experimental area comes under east and south-eastern coastal plain zone of Odisha.

The normal annual rainfall of the area is 1408 mm per year. Most of the rainfall is received through south-west monsoon from June to September. The minimum and maximum temperature, minimum and maximum humidity,

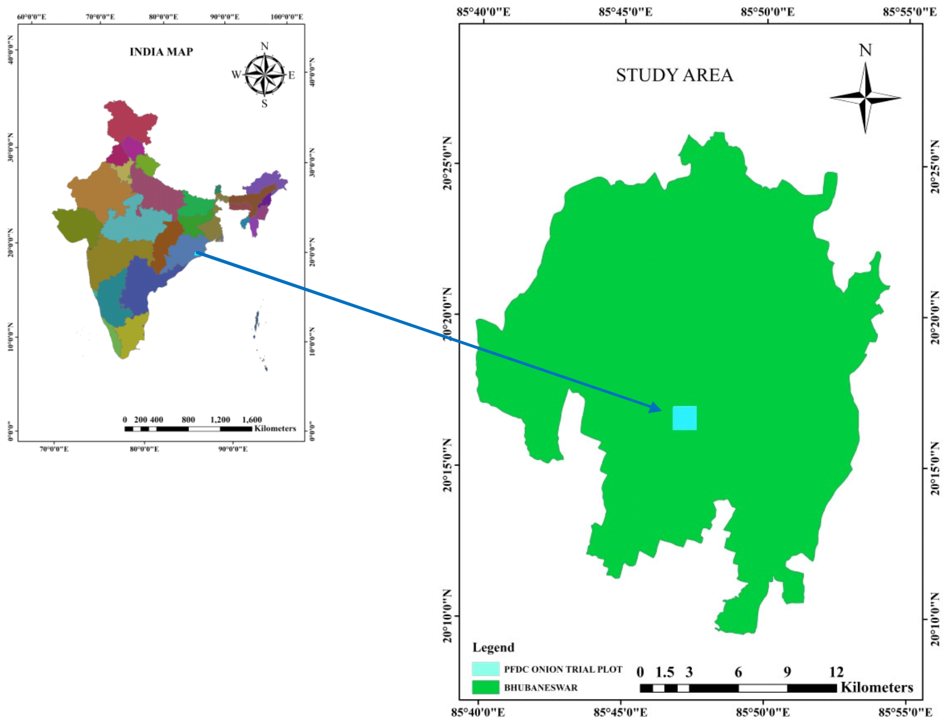

Fig. 1: Location map of experimental site

evaporation and sunshine hours during crop growth period varies from 13.0 to 14.5^{0}C, 37.3 to 38.3^{0}C, 28.9 to 38%, 92.4 to 95% and 5.3 to 8.4 hours, respectively. The physico-chemical properties of soil and irrigation water of the experimental site are given in Table 1.

Table 1: Physical and chemical properties of soil and water at the experimental site

Soil physical and chemical properties	
Sandy loam soil	
pH	4.7
EC (dSm^{-1})	0.07
Organic carbon(%)	0.37
N (kg/ha)	164.0
P_2O_5(kg/ha)	30.0
K_2O (kg/ha)	100.0
Bulk density (gm/cc)	1.52
Field capacity(%)	18.9
Permanent wilting point(%)	3.0
Water properties	
pH	4.36
EC (micro mhos/cm)	55.0
TDS (mg/L)	55.0
Iron (mg/L)	0.18
Nitrate (mg/L)	23.43
$CaCo_3$ (mg/L)	20.0
Calcium (mg/L)	6.0
Magnesium (mg/L)	1.215
Sodium (mg/L)	6.93
Potassium (mg/L)	0.5
Chloride (mg/L)	7.09
Sulphate (mg/L)	1.72

Methodology Flow Chart

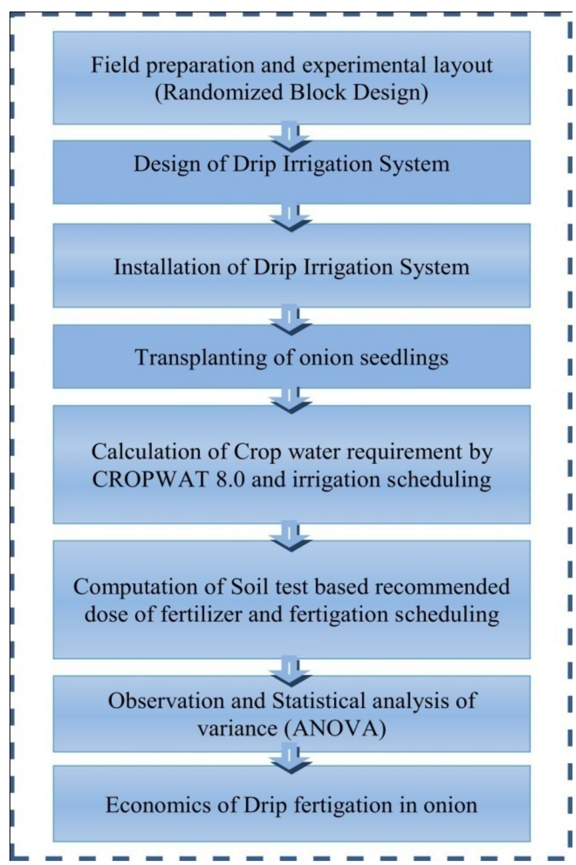

Fig. 2: Detailed methodology flow chart

The detailed process of the entire methodology adopted here is given in flow chart shown in Fig. 2.

Experimental Design

The experiment was laid out in randomized block design with ten treatments replicated thrice (Fig.3). There were 30 plots in total. The size of each plot was 30 sqm (6.0 m×5.0 m). The onion (Cv.Agrifound Light Red) seedlings of 45 days old were transplanted on raised beds. Four rows of plants were transplanted on each bed at 15 cm×10 cm spacing. The transplanting was done on 12th December, 10th December and 11th December of 2016, 2017, 2018, respectively. The irrigation treatments consist of three levels of irrigation viz.100% (I_1), 80% (I_2) and 60% (I_3) of the crop evapotranspiration (ET_c).Crop was subjected to three nutrient regimes by varying the fertigation rate. The three levels of fertilizer application were 100% (F_1), 80% (F_2) and 60% (F_3) of the recommended dose of fertilizer (RDF). The RDF was fixed on soil test based recommendations as 150 kg N, 60 kg P_2O_5 and 75 kg K_2O per hectare. The details of treatment combinations are shown in Table 2. The water soluble fertilizers viz. Urea (46:0:0), Mono-ammonium phosphate (12:61:0) and Sulphate of potash (0:0:50) were used for fertigation in the trial. The fertigation scheduling was done on weekly basis and the fertilizer dose was applied in 10 splits. The harvesting of onion was done after 115 days of transplanting in each case.

Table 2: Treatment combinations along with symbols

Sl. No.	Symbol	Treatment Detail
1	T_1 (I_1F_1)	100% of ETc with Fertigation with 100% RDF
2	T_2 (I_1F_2)	100% of ETc with Fertigation with 80% RDF
3	T_3 (I_1F_3)	100% of ETc with Fertigation with 60% RDF
4	T_4 (I_2F_1)	80% of ETc with Fertigation with 100% RDF
5	T_5 (I_2F_2)	80% of ETc with Fertigation with 80% RDF
6	T_6 (I_2F_3)	80% of ETc with Fertigation with 60% RDF
7	T_7 (I_3F_1)	60% of ETc with Fertigation with 100% RDF
8	T_8 (I_3F_2)	60% of ETc with Fertigation with 80% RDF
9	T_9 (I_3F_3)	60% of ETc with Fertigation with 60% RDF
10	T_{10} (Control)	100% ETc with soil application of 100% RDF

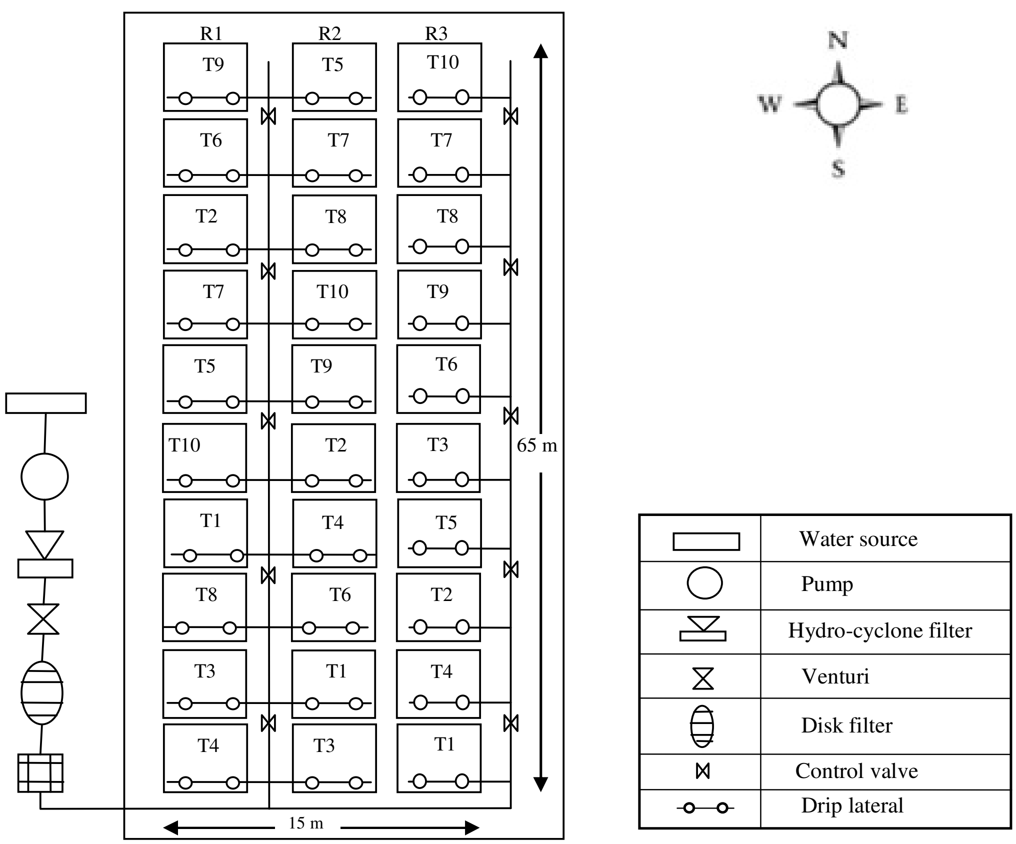

Fig. 3: Layout of experimental plot

The drip irrigation system was installed for the trial with tubewell as source of water. The PVC pipes of different diameters viz.63 mm and 50 mm were laid in trenches as main and sub-main line. The 16 mm integral lateral line having inline drippers of 2 lph at spacing of 40 cm were used in the system. For successful imposition of treatments, control valves were provided for each plot. The different filters viz. hydrocyclone filter and disk filter were used in the system for cleaning of irrigation water impurities. The ventury injector with manifold was installed as fertigation unit. Two inline drip laterals were provided for four rows of onion plants. The amount of irrigation water was computed by using the formula (Reddy *et al*., 2012),

$$ETc= \frac{A\times B\times C}{E} \quad (1)$$

where, ET_c is crop evapotranspiration or the quantity of water required (mm/day),

A is daily reference crop evapotranspiration (mm), ET_0; B is canopy factor,

C is crop co-efficient and E is efficiency of drip irrigation system (percent).

Daily reference evapotranspiration (ET_0) was calculated using CROPWAT 8.0 software, which is based on Penman-Monteith equation (Onyancha *et al.,* 2017). Alternate day irrigation was scheduled considering crop factors for different growth stages. The crop factors for different crop stages were chosen as 0.52, 0.85, 1.04 and 0.87 for intial stage, crop development stage, mid season stage and late season stage, respectively.(Bandyopadhyay *et al*., 2003).The average water requirement of onion over three consecutive experimental years was found to be 300 mm. The irrigation was stopped before 15days from harvest when tips of leaves fell down. The yield and yield attributes like bulb weight, equatorial and polar diameter were recorded treatment wise over three experimental years.

Economic Analysis

Economic analysis of drip fertigated onion under various irrigation and fertigation levels was done considering the initial investment, cost of cultivation, present rate of bank interest, inflation rate, yield and returns from yield by adopting present worth analysis method for various treatments. The initial investment consists of tube well construction with pumping unit and installation of drip irrigation system. The life of drip irrigation system is taken as ten years. The cost of cultivation includes seasonal expenditure for land preparation, seed, fertilizer, plant protection chemicals, labour wages from seedling raising to harvesting, electricity charges and maintenance expenditure. All the cash flows (inflows and outflows) over the life span of the project involving drip irrigation system were converted to an equal and equivalent present value using appropriate factors to account for interest and inflation. Here, the present inflation rate of 6% and bank interest of 11% were taken into consideration. The repair and maintenance of drip system was taken as 2% of initial investment value in each year. The electrical charges for operation of 2 HP pump set for drip irrigation of onion during growing season was taken into consideration. Economic indicators like net present value (NPV), internal rate of return (IRR), benefit-cost ratio (BCR) and payback period (PBP) were determined for all the treatments**.**

Net Present Value (NPV)

This is the present worth of the cash flow stream. Sometimes, it is referred to as net present worth (NPW). The selection criteria of the project depend on positive value of NPV when discounted at the opportunity cost of capital. The NPV of the project is estimated using the following equation (Reddy *et al.,* 2008):

$$NPV = \frac{P_1}{(1+i)^{t1}} + \frac{P_2}{(1+i)^{t2}} + \ldots + \frac{P_n}{(1+i)^{tn}} - C \quad (2)$$

Where

P_1 = Net cash flow in first year,

i = Discount rate,

t = Time period and

C = Initial investment cost

Internal Rate of Return (IRR)

The IRR is defined as the discount rate at which the present values of net cash flow are just equal to zero *i.e* NPV = 0. The internal rate of return is a very useful measure to decide whether the project is economically viable or not.

The following formula is used for determining the IRR (Suresh, 2009):

$$IRR = I_L + (I_H - I_L) \frac{(NPV \text{ at } I_L)}{(NPV \text{ at } I_L + NPV \text{ at } I_H)} \quad (3)$$

Where,

I_L = lower discount rate

I_H = higher discount rate

Benefit Cost Ratio (BCR)

The benefit-cost analysis is a technique for determining the feasibility and profitability of the treatments. We compared the present worth of cash outflow with present worth of net returns and calculated BCR as (Reddy *et al,* 2008):

$$BCR = \frac{\sum_{t=}^{n} \frac{B_t}{(1+i)^n}}{\sum_{t=}^{n} \frac{C_t}{(1+i)^n}} \quad (4)$$

Where,

B_t = Present worth of gross return in time period‘t’

C_t = Present worth of cost in time period‘t’

Payback period (PBP):

It is the length of time from the beginning of the project to the time till the net value of incremental production (net increment income) reaches the total amount of capital investment. It is given as (Reddy *et al,* 2008):

$$PBP = \frac{Inv}{\sum_{t=1}^{n} (A_{ai} - A_v)_t (1+f)^{t-1} (1+i)^{-t}} \quad (5)$$

Where,

Inv = initial investment

A_{ai} = annual return (calculated by multiplying the yield with market rate of produce)

A_v = annual variable cost

t = 1, 2.............n

f = inflation rate (taken as 6%)

i = interest (discount) rate (taken as 11%) and

n = life span of drip irrigation system (taken as 10 years).

RESULTS AND DISCUSSION

Yield and yield attributes

The pooled data of three years on yield and yield attributing characters were subjected to statistical analysis of variance (ANOVA) and shown in Table 3.

The average bulb weight, equatorial and polar diameter of onion were having the maximum values of 78.6 g, 5.49 cm and 5.3 cm respectively in case of 80% irrigation with 100% RDF fertigation, but at par with treatment having 80% irrigation level with 80% RDF fertigation. The yield data of onion pooled over three years has been shown in Table 3.The maximum value of 25.96 t/ha resulted due to 80% irrigation with fertigation at 100% RDF, but at par with 25.47 t/ha as indicated in treatment with 80% irrigation and 80% RDF fertigation and significantly higher value over other treatment combinations. Similar results were reported by Patel (2007) for research work carried out at PAU, Ludhiana where drip fertigation in onion resulted yield of 51 t/ha with saving of 20% fertilizers.

Economics:

The comparative economics of different treatments involving three levels of irrigation and three levels of fertigation is shown in Table-4.The maximum average annual gross return of Rs.2,59,620/- was observed, when onion was cultivated with 80% of ETc applied on alternate day basis and 100% RDF was applied through weekly fertigation. This value was followed by Rs.2,54,710/- for treatment combination of irrigation at 80% of ETc and fertigation at 80% RDF. The Internal rate of return found to be maximum value of 60.37% for treatment combination comprising irrigation at 80% level and fertigation at 100% of RDF followed by 59.7%. Considering benefit cost ratio the treatments with 100% and 80% fertigation has shown

Table 3: Yield and yield attributing characters of onion as influenced by irrigation and fertigation levels (pooled over three years)

Treatments	Bulb weight, g	Equatorial diameter, cm	Polar diameter, cm	Yield, t/ha
T_1(Irrigation at 100%ETc with 100% RDF fertigation)	67.1	4.9	4.8	24.55
T_2(Irrigation at 100%ETc with 80% RDFfertigation)	65.4	4.9	4.6	24.24
T_3(Irrigation at 100%ETc with 60% RDF fertigation)	61.5	4.81	4.6	22.06
T_4(Irrigation at 80%ETc with 100% RDF fertigation)	78.6	5.49	5.3	25.96
T_5(Irrigation at 80%ETc with 80% RDFfertigation)	72.9	**5.27**	4.9	25.47
T_6(Irrigation at 80%ETc with 60% RDF fertigation)	61.8	4.9	4.3	22.74
T_7(Irrigation at 60%ETc with 100% RDFfertigation)	63.9	4.43	4.4	21.88
T_8(Irrigation at 60%ETc with 80% RDFfertigation)	61.0	4.16	4.1	21.38
T_9(Irrigation at 60%ETc with 60% RDFfertigation)	54.9	4.11	3.9	18.90
T_{10}(Irrigation at 100%ETc with 100% RDF soil application)	49.7	3.63	3.8	17.44
S.E (m ±)	2.8	0.12	0.145	0.19
CD at 5 %	8.3	0.35	0.43	0.57

Table 4: Comparative economics of different levels of irrigation and fertigation in onion

Treatments	Initial investment	Cost of cultivation	Gross return	NPV	IRR	BC ratio	PBP
T_1 (I_1F_1)	222000	133324	245540	571840	53.45	3.2	2.6
T_2 (I_1F_2)	222000	129785	242430	575008	53.62	3.2	2.6
T_3 (I_1F_3)	222000	126248	220640	440454	44.71	2.7	3.1
T_4 (I_2F_1)	222000	133144	259620	678491	60.37	3.6	2.3
T_5 (I_2F_2)	222000	129605	254710	668365	59.70	3.6	2.3
T_6 (I_2F_3)	222000	126068	227420	492929	48.27	2.9	2.9
T_7 (I_3F_1)	222000	133113	218880	378050	40.63	2.4	3.4
T_8 (I_3F_2)	222000	129574	213790	366595	39.85	2.4	3.5
T_9 (I_3F_3)	222000	126037	189010	209698	28.61	1.8	4.7
T_{10} (Control)	222000	121431	174420	134399	22.73	1.5	5.7

I_1, I_2, I_3 =Irrigation at100,80,60% of ETc

F_1, F_2,F_3 = Fertigation at 100%,80%,60% of RDF same value of 3.6 when irrigation was applied at 80% of ETc on alternate day basis. Similarly the payback period of 2.3 years was observed in both treatment of T_4 and T_5.

CONCLUSION

Drip fertigation with water soluble fertilizers resulted higher productivity and economically viable for onion cultivation. On the basis of the results of three year study, it observed that onion, (var. Agrifound Light Red) cultivated in sandy loam soil during winter season recorded maximum yield of 60.3% and internal rate of return, of 25.96 t/ha, 60.37% respectively due to treatment combination of irrigation at 80% ET_c and fertigation at 100% RDF but at par with treatment combination of 80% irrigation and 80% fertigation. The economic parameters like BC ratio and payback period was found to be 3.6 and 2.3 years, both for treatments T_4 and T_5.Thus considering yield, benefit cost ratio and payback period ,it can be concluded that winter onion can be cultivated with irrigation at 80% of ETc and fertigation at 80% of NPK-RDF profitably with saving of 20% water and fertilisers in drip irrigation system.

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