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The Effect Of Water Application Timings On Yield, Water Use Efficiency And Profitability Of Roma Tomato VF Cultivar Grown Under Plastic Bottle Drip Water Irrigation System In Nyagatare District, Rwanda

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Abstract – The present study was aimed to assess the effect of water application timings on yield, water use efficiency and profitability of Roma tomato Vf cultivar grown under plastic bottle drip water irrigation system. Four treatments were used for the experiment, replicated four (4) times and arranged in Completely Randomized Design (CRD). Each replication plot contains 4 experiment units and 64 experiment units for entire experiment field of 4 plots. The results showed that the total benefit for the first year is 2,135,250.00 Rwf and the incremental benefit for the first year was -2,882,800.00 Rwf. The study findings showed that the net present value (NPV) was positive 51,821.63 at 30 per cent discount rate and has negative value at a discount rate of 31% with the NPV of (6,098.46), which indicates the financial soundness of the investment on Roma tomato production under greenhouse. The Internal Rate of Return (IRR) was found higher than the cost of capital which was 30.89% hence the Roma tomato production project under greenhouse is worthwhile to undertake. The Benefit cost ratio of the tomato production under greenhouse subjected to plastic bottle irrigation system was 1.0 greater than 1. So, it is concluded that tomato farming under greenhouse subjected to plastic bottle irrigation system is highly profitable, that is 1.01 times the investment. The profitability index calculated was 2.83. The PI is greater than 1 which shows that the Roma tomato production under plastic bottle drip irrigation system is always a profitable project. Based on the findings achieved in this study, where we examined the cost and profitability of greenhouse cultivation under plastic bottle drip irrigation system, we conclude that greenhouse farming yielded better results in terms of economic indicators.

Keywords – Water Application timings, Water Use Efficiency, Profitability analysis, Roma Tomato

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I. INTRODUCTION

Tomato belongs to the genus Lycopersicon under Solanaceae family. Tomato is one of the most important "protective foods" because of its special nutritive value. It is one of the most versatile vegetable with wide usage in Indian culinary tradition. Tomatoes are used for soup, salad, pickles, ketchup, puree, sauces and in many other ways it is also used as a salad vegetable. Tomato is the world's largest vegetable crop after potato and sweet potato, but it tops the list of canned vegetables (Duhan, 2016).

The quality and quantity of light radiation influence crop growth and productivity. Roofing materials make an essential contribution to the productivity of greenhouse crops, enabling the creation of a microclimate in which both temperature and relative humidity are modified. This, together with the introduction of other new cropping technologies, such as the use of greenhouse structures and other cover materials, that makes it possible to improve crop yields (del Amor *et al.*, 2008). Therefore, the choice of the greenhouse cover can influence not only the nutritional quality of the fruits but also their number and size, and this will have an immediate effect on the economic performance of the crop, which can be calculated from the value of the investment necessary and the adequate discount of the net cash flows. The latter is obtained as the difference between expected income and costs (del Amor et al., 2008).

Literature review showed that Cost-benefit analysis, Payback period, Net Present Value, Internal Rate of Return, Cost/return ratio, Income statement (profits or loss of the farm) and even the most common of descriptive method like Yield, without actual analysis are the parameters to perform the economic analysis of any crop (Danso *et al.*, 2003). There is therefore, variation observed in how researchers classify farming systems and the various indicators and measuring methods applied to assess economic and other impacts of agriculture (Danso et al., 2003). To compare profitability of one production technology with another, Enterprise Budgets have been used by various researchers like (Jones & Simms, 1997). Water application timings greatly influences water use efficiency and yield of tomato. Typically, the farmers produce tomato on the method of random supply of water to crop regardless when and how much water to apply, this method leads to yield loss due to crop water stress and reduce yield per unit water applied (Irmak & Rathje, 2008).

Keeping the importance of subject matter in view many researchers and scholar examines and conduct many studies time to time. Duhan (2016) conducted a study “Economic viability of cucumber cultivation under NVPH’’ which concluded that cost of fixed components and selling rate of produce were the two important factors. Uncertainty factor can also be handled smartly through a cluster approach by farmers. Chauhan and Grover (2015) examined “Comparative economics of cucumber cultivation under poly houses and open field conditions in Haryana’’. The study conclude that the cost of cultivation of cucumber under poly houses was higher compared to open field conditions and cucumber cultivation under poly houses has significantly contributed to the yield. Duhan (2016) studied “Protected Cultivation of Vegetables – Present Status and Future Prospects in India’’. In their study concluded that the greenhouse technology is still in its preliminary stage in India and concerted efforts are required from all concerned agencies to bring it at par with the global standards. Economically viable and technologically feasible greenhouse technology suitable for the Indian agro-climatic and geographical conditions is needed at the earliest. The present study has made an attempt to examine the of water application timings, Yield, Water Use Efficiency and Profitability of Roma Tomato Vf cultivar grown under plastic bottle drip water irrigation system in Nyagatare District, Rwanda.

II. MATERIALS AND METHODS

2.1. Study area

The experiment was conducted under greenhouse growing conditions located at Nyagatare district, Rukomo sector and Rukomo II cell. The site is located 12.59km south west of Nyagatare city and 13.35km from the University of Rwanda, Nyagatare campus and 118km from the capital city of Rwanda-Kigali. It is geographically located on latitude N1.39005^{o} and longitude W 30.25829^{o}. The study site is characterized by short dry season starting from January to mid-March, long rainy season starting from Mid-March to Mid-May, Long dry season starting from Mid-May to Mid-September and short rainy season starting from Mid-September to December. The annual average temperature varying between 25.3°C to 27.7°C. Average annual rain falls are both very weak (827 mm/Year) and very unpredictable to satisfy the needs in agriculture and livestock. The predominant soil types in the area are loamy sand and sandy loam.

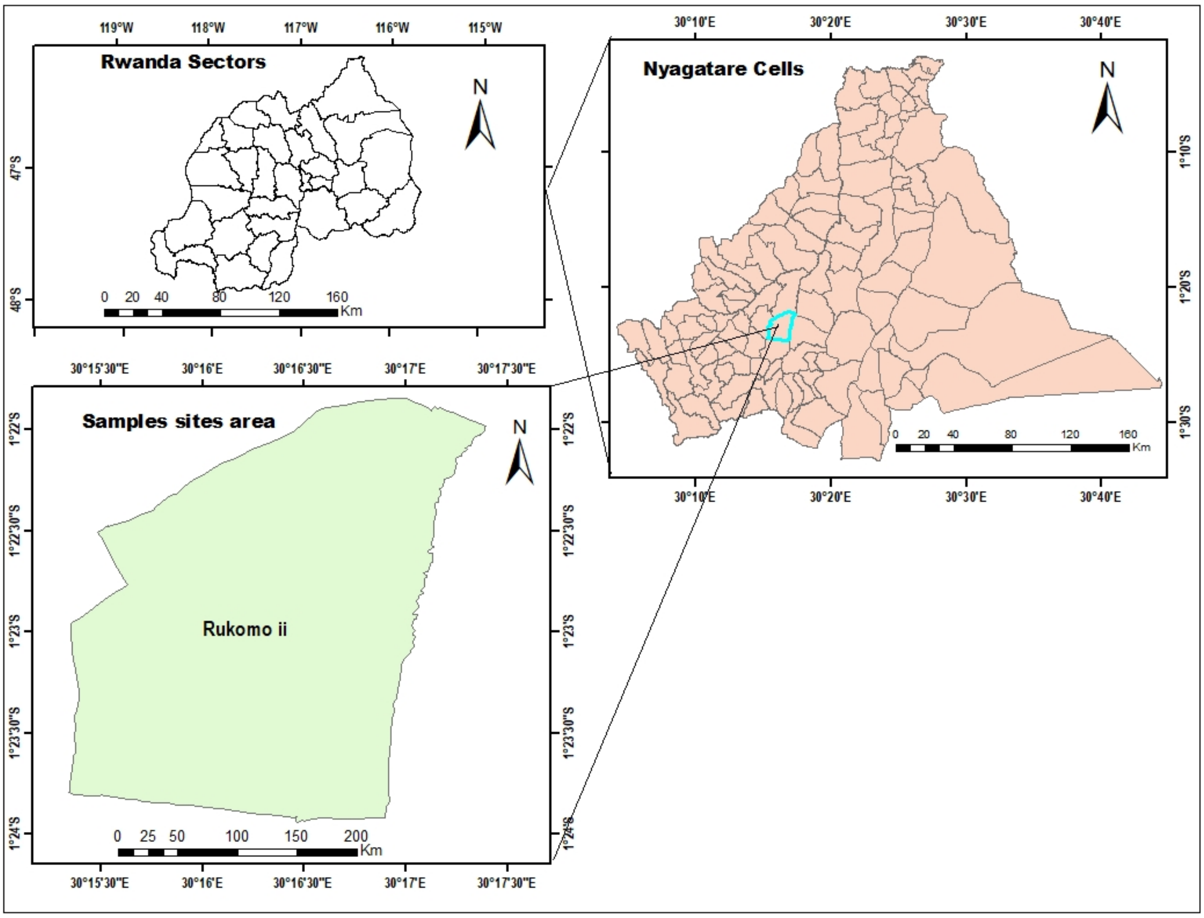

Figure 1: Geographical location of the experimental site
Source: Application of Arc GIS 10.5

2.2. Experimental design and field layout

The field experiment was carried in the dry season. The crop was planted on raised beds (2cm high). Three treatments were used for the experiment, replicated four (4) times and arranged in Completely Randomized Design (CRD). Each replication plot contains 4 experiment units and 64 experiment units for entire experiment field of 4 plots. The total area of experimental field would be 5m x 5m = 25m^2. The separation of two successive plots is 0.5m and 1m between two plots apart. The treatment included: Multiple water application where required amount of water will be applied in multiple equal parts a day during irrigation and two remaining treatments of one complete set (single water application). The multiple water application treatments were the Morning Time (MT), Day Time (DT), Evening Time (ET) and the combination of Morning – Day – Evening time. The daily crop water requirement (ETc) of the crop was calculated for the four stages of growth using the CROPWAT 8.0 software. The Roma tomato VF seeds to be used were sourced from the Agro-Tech Limited, Kigali, Rwanda. Seeds of Roma tomato VF cultivars were sown in the nursery on the 1st July 2021. Before seeding in nursery, Organic manure was mixed with soil in order to provide all the nutrients required by seeds, so as to increases the fertility and productivity of the soil. Water was connected when basic after seeding. After four weeks, on 31st July 2021, the seedlings were transplanted to well get ready beds within the field. Mulching, weeding, insecticidal splashing, staking and other horticultural operations were done when essential.

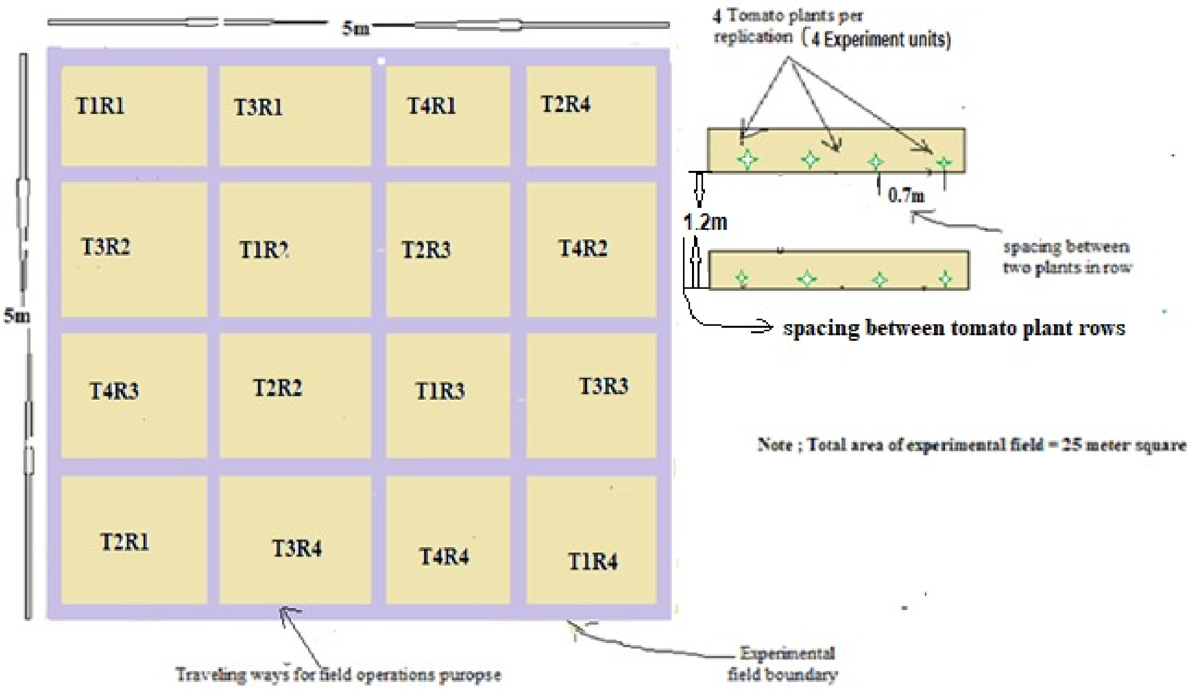

Figure 2: Layout of experiment field design

2.3. Design experiment of Plastic bottle drip water irrigation system

Half litre cool drink plastic bottles with lids were used to store water and provide water to the tomato plants. Small holes were drilled into the cap of the plastic bottles which aimed to discharge water from the holes of approximately 2 litres per hour. The bottom of each bottle were removed to enable the bottles to be filled with water. A hole was dug next to each plant and the bottle buried approximately one-third deep with the bottom facing up.

Figure 3 the photos above shows the current experiment field status

2.4. Determination of tomato yield

At physiological maturity, the yield tomato at each experimental treatment plots were taken to determine the average yield per treatment, tomato fruit were harvested, the weights were measured using electronic weighing balance. It means that, the mean fruit yield per hectare was given by the mean fruit weight for each of the six record plants was used to calculate yield per hectare. This was expressed as Eq. below:

$$Yield/hectare = \frac{(Fruit\ yield\ per\ plot) \times 10{,}000m^2}{plot\ size}$$

2.5. Determination of Crop Water Use Efficiency

Water use efficiency (WUE) is defined as the amount of carbon assimilated as biomass or grain produced per unit of water used by the crop. The WUE of tomato crop under different water application timing was determined as described by Xu and Hsiao (2004) and Payero *et al.* (2008) using Eq. below.

$$WUE = \frac{(Tomato\ Yield)}{ET_C}$$

Where is the Water Use Efficiency of the crop expressed in Kg/ha/mm, Tomato yield in Kg/ha and ET (mm) is the seasonal crop Evapotranspiration. In this research, ETc is equal to seasonal Crop Evapotranspiration in mm. According to Xiukang and Yingying (2016), Water Use Efficiency (WUE) in greenhouse is given by

$$WUE = \frac{(Tomato\ Yield)}{ET_C} \times 100$$

And is expressed in percentage (Xiukang & Yingying, 2016). We know that ETc= Kc x ETo=12.49 x 5.32= 66.4468mm

2.6. Computing Economic feasibility parameters of Roma tomato under plastic bottle drip water irrigation

The economic feasibility parameters on Roma tomato production was assessed by computing the economic parameters, viz. Net Present Value (NPV), Benefit Cost Ratio (BCR), internal rate of return (IRR) Discount factor, Pay Back Period (PBP), and profitability index. Therefore the Sensitivity analysis for these five parameters was also carried out to assess the economic viability of Roma tomato under plastic bottle drip water irrigation.

2.7. Discount Factor

Discount Factor is used to convert the value of project fund in one date to an equivalent value in another date. The value of money is varying from one date to another.

The discount factor was worked by equation (11)

$$Discount\ Factor = \frac{1}{(1+i)^n}$$

Where i is the discount rate and n is the number of years.

2.8. Single payment present value factor (SPPV)

The present sum that is equivalent to 1 Frw after ‘n’ years. It is the number of Frw one must invest at i% interest to have 1 Frw after ‘n’ years. SPPV is worked out by equation (12):

$$\frac{P}{F} = \frac{1}{(1+i)^n}$$

Where P is the present value of money, F is the future value of money, i is the discount rate and n is the number of years.

1. Net present value (NPV)

The net present value of a project is the sum of the present values of all the cash flows positive as well as negative that are expected to occur over the life of the project. The NPV method is used for evaluating the desirability of investments or projects. The project is profitable or feasible if the calculated NVP is positive when discounted at the opportunity cost of capital. In the present study, NPV was computed as per Equation (13):

$$NPV = \frac{C_1}{(I+r)^1} + \frac{C_2}{(I+r)^2} + \frac{C_3}{(I+r)^3} + \cdots + \frac{C_2 \ldots I_0}{(I+r)^n}$$

Or

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(I+r)^t} - I_0$$

Where:

Ct = the net cash receipt at the end of year t, Io = the initial investment outlay, r = the discount rate/the required minimum rate of return on investment and n = the project/investment's duration in years.

Decision rules.

When NPV is used accept or reject decisions, the decision criteria are as follows:

If NPV is greater than zero accept the project

If NPV is less than zero reject the project

If NPV is greater than zero the firm will earn a return greater than its cost of capital. Such action enhance the market value of the firm and therefore he wealth of its owners.

Internal Rate of Return (IRR)

The IRR of a project is the discount rate which makes its NPV equal to zero. In other words, it's the discount rate which equates the present value of future cash flows with the initial investment. The IRR is that discounted rate at which NPV is zero. It is the value of r in the following equation (4)

$$Investment = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

Where C_t= cash flow at the end of year t, r = internal rate of return (IRR) and n = life of the project petition.

Steps involved in finding IRR using SPPV are:

a) Find total cost, total benefit and

b) Net benefit = Total Benefit – Total Cost

c) Assume Single payment Present Value (SPPV) discount rate of 15%.

$$Discount\ Factor = \frac{1}{(1+i)^n}$$

d) Net Present Value of Benefit (NPVB) for 31 % Discount NPVB = Discount factor x NPV

e) Find the sum of NPVB

f) Repeat the steps from step 3 to step 5 for 31% discount rate

g) Do the interpolation technique to find the IRR between 30% and 31%.

Benefit Cost Ratio (BCR)

It is the ratio of present worth of benefit stream to present worth of cost stream. It was worked out by using Equation (15):

$$BCR = \frac{Sum\ of\ the\ present\ worth\ of\ Benefits}{Sum\ of\ the\ present\ worth\ of\ costs}$$

Or

$$\mathrm{BCR} = {}^{\mathrm{PV(B)}}\!/_{\mathrm{PV(C)}} = (\sum_{t=0}^{T} {}^{\mathrm{B_t}}\!/_{(1+\mathrm{d})^t})/(\sum_{t=0}^{T} {}^{\mathrm{C_t}}\!/_{(1+\mathrm{d})^t})$$

Mathematically, it can be shown as

$$BCR = \frac{NPV\ of\ Net\ Benefits}{NPV\ of\ Net\ Capital\ Cost}$$

The investment is said to be profitable when the BCR is one or greater than 1. This method is widely used in economic analysis and not in private investment analysis. It implies that if the ratio reaches a value higher than one, the project can be classified as being advantageous. Although relying on the same parameters as NPV, this criterion implies some substantial problems: Costs might be regarded as negative benefit and vice versa benefits as reduced costs, resulting in different values of BCR.

Pay Back Period (PBP)

The Payback period is the length of time required for an investment to pay itself out. The payback period was calculated by the formula (Equation below):

$$PBP = \frac{I_0}{C_t}$$

Where Io is the initial investment and Ct = the projected net cash flows per year from the investment; and thus PBP = Pay Back Period expressed in number of years. Alternatively, to find the exactly when payback occurs, the following formula can be used:

$$Payback\ Period\ (PBP) = \frac{Initial\ Investment - Opening\ Cumulative\ Cash\ Flow}{Closing\ Cumulative\ Cash\ Flow - Opening\ Cumulative\ Cash\ Flow}$$

Applying the formula given above, in some cases due to high initial investment costs, there is a need to take the opening cumulative cash flow for the first year in absolute value

Decision rule.

If the payback period is less than the acceptable maximum acceptable payback period accept the project.

If the payback period is greater than the acceptable maximum acceptable payback period reject the project.

Profitability Index (PI)

Profitability index, also known as profit investment ratio and value investment ratio, is the ratio of payoff to investment of a proposed project. It is a useful tool for ranking projects because it allows you to quantify the amount of value created per unit of investment. Profitability index is an investment appraisal technique calculated by dividing the present value of future cash flows of a project by the initial investment required for the project. Profitability index is useful in capital rationing since it helps in ranking projects based on their per dollar return. This is a variant of the NPV method. The PI was worked out by equation (18):

$$PI = \frac{PV}{I_0} = \frac{Present\ Value\ of\ future\ cash\ flow}{Initial\ Cash\ investment}$$

Decision rule:

PI > 1; accept the project

PI < 1; reject the project

If NPV = 0, we have:

NPV = PV - Io = 0

PV = Io

Dividing both sides by Io we get:

$$\frac{PV}{I_0} > 1$$

Significance of IRR and BCR

Cost Ratio (BCR) is very useful as it reveals which projects would produce the most valuable outcomes per dollar spent. The BCR represents the benefits of a project divided by the costs of the project to calculate the expected level of benefits per dollar spent. This allows us to compare the merits of projects of different scales. An internal rate of return (IRR) is very useful in terms of evaluating whether or not to make an investment in equipment, or even in a business. This is helpful in identifying whether or not the investment will yield a return that warrants the investment.

III. Results and Discussion

Effect of irrigation timings on Roma tomato yield and Water Use Efficiency

Tomato harvested (Kg/m^2) and Crop Water Use Efficiency (Kg/m^2/mm) were studied and presented in table 2. There were significant differences increase in tomato yield and WUE among the treatments applied as indicated in table 2. The highest yield of 69.125 Kg/m^2 and WUE of 1.040 Kg/m^2/mm were recorded by T4 (Morning – Day – Evening) while the T3 (Evening) recorded the lowest yield of 65.03169.125 Kg/m^2 and WUE of 0.979 Kg/m^2/mm. Other treatments T2 (Day) recorded the yield of 66.969 Kg/m^2 and WUE of 1.008 Kg/m^2/mm while T1 (Morning) showed 65.781 Kg/m^2 and WUE of 0.990 Kg/m^2/mm. The overall total average of tomato harvested recorded was found to be 66.727±9.134 Kg/m^2. The coefficient of variation was found to be 0.137 and the standard deviation of 9.134. Due to value of CV=0.137 less than to 0.5, there is no appreciable change in Roma tomato yield by treatments as applied under greenhouse structures. The overall WUE was found to be 1.004±0.137 Kg/m^2/mm. The coefficient of variation was found to be 0.137 and the standard deviation of 0.137 respectively. Due to value of CV=0.137 less than to 0.5, there is no appreciable change in WUE for Roma tomato for all treatments. These findings are similar to the research findings of Romero-Aranda *et al.* (2001) who reported that WUE for tomato grown under greenhouse ranged from 0.19 to 1.031 Kg.m^{-2}.mm^{-1} and the total sum the sum of total tomato yield was 4270.5 Kgs. It is therefore concluded that all tomato yield by treatments could be statistically significant if $P < 0.05$., and thus these findings are similar to the research conducted by Biswas *et al.* (2015)

Table 1: Summary of descriptive of irrigation timings on Roma tomato yield and Water Use Efficiency

Treatments	stats	Tomato yield (Kg/m^2)	WUE (Kg/m^2/mm)	WUE (%)
T1 (Morning)	Mean	65.781	0.99	98.998
	Sum	1052.5	-	-
T2 (Day)	Mean	66.969	1.008	100.786
	Sum	1071.5	-	-
T3 (Evening)	Mean	65.031	0.979	97.87
	Sum	1040.5	-	-
	Mean	69.125	1.04	104.031
T4 (Morning-Day-	Sum	1106	-	-
Total overall average	Mean	66.727	1.004	100.421
	SE(Mean)	1.142	0.017	1.718
	SD	9.134	0.137	13.746
	Min	50.5	0.76	76.001
	Max	88	1.324	132.437
	CV	0.137	0.137	0.137
	Sum	4270.5	-	-

	N	64	64	64
	$LSD_{0.05}$	2.86		

Profitability analysis of Roma tomato under plastic bottle irrigation system in greenhouse

This objective discusses the various calculations needed to find out the results of economic analysis of the present research. It includes the computation of different economic feasibility parameters like total cost, financial benefit, incremental benefit, different discount rates and net present values of the project at different discount factors. It also includes Internal Rate of Return (IRR), Benefit Cost Ratio (BCR), Payback Period (PBP) and Profitability Index (PI) to appraise the tomato production project under greenhouse.

Capacity of Roma tomato production under greenhouse

The commercial Roma tomato production capacity under greenhouse planned is 4270.5 Kgs per year. Different cost worked in the present study is for this planned capacity.

Computation of Fixed cost

The fixed costs of Roma tomato farming considered greenhouse renting, storage tanks and other accessories.

Table 2: Estimated fixed costs (Hiring cost) for greenhouse tomato production in Rukomo II cell, Nyagatare

I.	**Fixed costs**	**Description of items**	Items #	Unit Cost	Total Cost
1	Hiring Greenhouse frame structures	Size (8m x 15m)	1	3,700,000	3,700,000
2	Storage tank	Size (10,000 Litres)	1	150,000	150,000
3	Backpack sprayer	Plastic sprayer	1	10,000	10,000
	Sub - Total (A)				**3,860,000**

Regarding investment on buildings, irrigation facilities and equipments estimated in hiring the full installed greenhouse, the total fixed cost of the tomato production was worked out to be 3,860,000 Rwf.

Computation of operating cost.

Operation cost share is the largest amount in the total cost of Roma tomato production. An operation cost encompasses the cost of hired labour, raw materials, water costs, and other needed operational costs to implement the project.

Table 4: Estimated operating costs for greenhouse tomato production in Rukomo II cell, Nyagatare

II.	**Operating costs**	**Items description**	**Qty**	**Unit price**	**Total cost**
1	Labor	Man - days	4	1,500	810,000
2	Seeds	Grams	1	10,000	10,000
3	Fertigation (Organic & Inorganic manure)	Pcs	150	850	127,500
4	Fungicide	Pcs	2	15,000	30,000
5	Insecticide	Pcs	1	30,000	30,000
6	Hand Hoe	Pcs	5	2,000	10,000
7	Boots	Pcs	4	5,000	20,000
8	Mulches	Pcs	6	2,500	15,000
9	Measuring tape	Pcs	1	5,000	5,000
10	Watering can	Pcs	6	4,000	24,000

11	Wheelbarrow	Pcs	1	10,000	10,000
12	Plastic bottles	Pcs	30	300	9,000
13	20 litre Jerry can	Pcs	3	1,500	4,500
14	GPS Latex	Pcs	1	20,000	20,000
15	1 Filter	Pcs	1	7,000	7,000
16	Woven Basket	Pcs	5	2,000	10,000
17	Electronic weighing scale	Pcs	1	15,000	15,000
18	Note book and pen	Pcs	3	350	1,050
	Sub - Total				**1,158,050**

The results showed that the total cost of operation was 1,158,050 Rwf per season of 2021B. Thus, expenditure on raw materials accounts the least share compared to the hiring cost of greenhouse structures.

Computation of total cost, financial benefit and incremental benefit

The total cost of tomato production under hired greenhouse included; fixed cost (hiring cost) and operation costs. The benefit is the revenue from sales of Roma tomato. Fresh tomato were sold by Sibomana Valens (Final student in Msc program in AE with specialization of Soil and Water Engineering) who is the owner of the project. The cost of 1 kg of fresh tomato was 500 Rwf per Kilogram. The incremental benefit was between the benefit and total costs. The project of Roma tomato production under greenhouse will be pooled for 10 years life time for projected financial analysis.

Table 3: Computation of total cost, financial benefit and incremental benefit

Year	Fixed cost	Operating Cost	Total cost	Benefit	Incremental Benefit
1	3,860,000	1,158,050.00	5,018,050.00	2,135,250.00	-2,882,800.00
2		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
3		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
4		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
5		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
6		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
7		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
8		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
9		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00
10		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00

The total cost of tomato production worked out was 5,018,050.00 Rwf for the first year. The total fixed cost 3,860,000 Rwf for the first year in which was estimated as hiring cost of the greenhouse structures, the benefit for the first year is 2,135,250.00 Rwf and the incremental benefit for the first year was -2,882,800.00 Rwf. The second year onwards the project showed positive incremental benefit of 977,200.00 Rwf/year.

Computation of IRR for Roma tomato under greenhouse

Table 4: Computation of IRR for Roma tomato under greenhouse

Year	Fixed cost	Operating Cost	Total cost	Benefit	Incremental Benefit	Disc@30 %	NPV@30%	Disc@31 %	NPV@31%
1	3,860,000	1,158,050.00	5,018,050.00	2,135,250.00	-2,882,800.00	0.769231	-2,217,538.46	0.763359	-2,200,610.69
2		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.591716	578,224.85	0.582717	569,430.69
3		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.455166	444,788.35	0.444822	434,679.91
4		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.350128	342,144.88	0.339559	331,816.73
5		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.269329	263,188.37	0.259205	253,295.21
6		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.207176	202,452.59	0.197866	193,355.12
7		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.159366	155,732.76	0.151043	147,599.33
8		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.122589	119,794.43	0.1153	112,671.24
9		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.0943	92,149.56	0.088015	86,008.58
10		1,158,050.00	1,158,050.00	2,135,250.00	977,200.00	0.072538	70,884.28	0.067187	65,655.41
Total							**51,821.63**		**-6,098.46**

The above table shows that NPV is positive value at 61% discount rate and the same NPV is negative value for 62% discount rate. It means the exact IRR lies between 61 and 62%. The exact IRR is worked out by interpolation method as given below:

$$IRR = Discount\ Rate\ 30\% + \frac{\sum NPV\ at\ 30\%\ (31\% - 30\%)}{\sum NPV\ at\ 30\% - \sum NPV\ at\ 31\%}$$

$$IRR = 30 + \frac{51{,}821.63\ \times (31\% - 30\%)}{51{,}821.63 - (-6{,}098.46)}$$

$$IRR = 30 + \ 0.89$$

$$IRR = 30.89\%$$

It is evident from the results that the net present value (NPV) was positive 51,821.63 at 30 per cent discount rate and has negative value at a discount rate of 31% with the NPV of (6,098.46), which indicates the financial soundness of the investment on Roma tomato production. The current project of Roma tomato production will earn a return greater than its cost of capital, hence the market value of the project. The Internal Rate of Return (IRR) was found higher than the cost of capital which was 30.89% hence the Roma tomato production project under greenhouse is worthwhile to undertake. This guarantee that the tomato production project earns at least its required return and this will enhance the market value of the tomato production project.

Benefit Cost Ratio (BCR)

Benefit Cost Ratio is the ratio of present worth of benefit stream to present worth of cost stream. The detailed worksheet for the computation of BCR is given in Table 5.

Table 5: Detailed worksheet for the computation of BCR for tomato production in greenhouse

Year	Fixed cost	Disc@12%	NPV of F. cost	Benefit	Net Benefit	NPV of Net Benefit
1	3,860,000.00	0.89	3,446,428.57	2,135,250	-1,311,178.57	-1,170,695.15
2		0.80	0.0	977,200	977,200.00	779,017.86
3		0.71	0.0	977,200	977,200.00	695,551.66
4		0.64	0.0	977,200	977,200.00	621,028.27
5		0.57	0.0	977,200	977,200.00	554,489.52
6		0.51	0.0	977,200	977,200.00	495,079.93
7		0.45	0.0	977,200	977,200.00	442,035.65
8		0.40	0.0	977,200	977,200.00	394,674.69
9		0.36	0.0	977,200	977,200.00	352,388.12
10		0.32	0.0	977,200	977,200.00	314,632.25
	3,860,000.00		**3,446,428.57**	**10,930,050**	**7,483,621.43**	**3,478,202.79**
						BCR= 1.01≈1 (rounded to whole number)

The Benefit cost ratio of the tomato production under greenhouse subjected to plastic bottle irrigation system was 1.0. Hence the BCR is one or greater than 1. This means for 1 Frw spent we will get 1 Rwf as incremental income. So, it could be concluded that tomato farming under greenhouse subjected to plastic bottle irrigation system is highly profitable, that is 1.01 times the investment.

Pay Back Period

The Payback period is the length of time required for an investment to pay itself out. The Payback period in capital budgeting refers to the time required to recoup the funds expended in an investment, or to reach the break-even point. Due to high profit loss accrued in the first year of tomato production, the payback period was calculated by the formula:

Table 6: Computation of the Pay Back Period

Year	Fixed cost	Disc@12%	NPV of F. cost	Benefit	Net Benefit	Cum. Net Benefit
1	3,860,000.00	0.89	3,446,428.57	2,135,250	-1,311,178.57	-1,311,178.57
2		0.80	0.0	977,200	977,200.00	-333,978.57
3		0.71	0.0	977,200	977,200.00	643,221.43
4		0.64	0.0	977,200	977,200.00	1,620,421.43
5		0.57	0.0	977,200	977,200.00	2,597,621.43
6		0.51	0.0	977,200	977,200.00	3,574,821.43
7		0.45	0.0	977,200	977,200.00	4,552,021.43
8		0.40	0.0	977,200	977,200.00	5,529,221.43
9		0.36	0.0	977,200	977,200.00	6,506,421.43
10		0.32	0.0	977,200	977,200.00	**7,483,621.43**

$$Payback\ Period\ (PBP) = \frac{3{,}860{,}000 - 1{,}311{,}178.57}{7{,}483{,}621.43 - 1{,}311{,}178.57} = 0.4129\ years$$

Based on findings illustrated in table 7, it was worked out that Pay Back period is 0.4129 years. The payback period of the initial fixed investment cost is 4.95 months, rounded to 5 months. Therefore the tomato production has a short PBP to recover the initial investment.

Profitability index

As explained by different scholars, the profitability index (PI) is a measure of a project's or investment's attractiveness. The PI is calculated by dividing the present value of future expected cash flows by the initial investment amount in the project. Profitability index is an investment appraisal technique calculated by dividing the present value of future cash flows of a project by the initial investment required for the project. It should always be >1.

Table 7: Computation of Profitability index for Roma tomato farming project under greenhouse

Year	Fixed cost	Disc@12%	NPV of F. cost	Benefit	Net Benefit
1	3,860,000.00	0.89	3,446,428.57	2,135,250	(1,311,178.57)
2		0.80	0.0	977,200	977,200.00
3		0.71	0.0	977,200	977,200.00
4		0.64	0.0	977,200	977,200.00
5		0.57	0.0	977,200	977,200.00
6		0.51	0.0	977,200	977,200.00
7		0.45	0.0	977,200	977,200.00
8		0.40	0.0	977,200	977,200.00
9		0.36	0.0	977,200	977,200.00
10		0.32	0.0	977,200	977,200.00
	3,860,000.00	**5.65**	**3,446,428.57**	**10,930,050**	**7,483,621.43**
					PI=2.83

PI= 7,483,621.43/3,860,000.00= 2.83. The profitability index calculated was 2.83. The PI is greater than 1 which shows that the Roma tomato production under plastic bottle drip irrigation system is always a profitable project. Based on the findings achieved in this study, where we examined the cost and profitability of greenhouse cultivation under plastic bottle drip irrigation system, we partially conclude that greenhouse farming yielded better results in terms of economic indicators. The overall profitability of the venture covered in the study was satisfactory, and this high profitability leads to the expansion of greenhouse agriculture in the region. In conclusion, the practice of greenhouse cultivation in the region is of vital importance, as it promotes effective use of regional sources, increases the income of people in the region, and creates employment, thus reducing migration from rural areas; and thus these finding are similar to the research work done by Başbuğ and Gül (2016) who concluded that greenhouse cultivation is a viable agribusiness project that leads to increased households income.

IV. Conclusion and Recommendations

This study evaluated the effect of different irrigation timings on tomato yield, water efficiency, and economic profit from Roma tomato under plastic bottle irrigation system in greenhouse at Nyagatare district. During both irrigation timings, irrigation significantly affected yields and water use efficiency. The highest yield of 69.125 Kg/m^2 and WUE of 1.040 Kg/m^2/mm were recorded by T4 (Morning – Day – Evening) while the T3 (Evening) recorded the lowest yield of 65.03169.125 Kg/m2 and WUE of 0.979 Kg/m^2/mm. The overall total average of tomato harvested recorded was found to be 66.727±9.134 Kg/m^2. The overall WUE was found to be 1.004±0.137 Kg/m^2/mm. Yields increased linearly with frequency of irrigation with similar relationships observed in the study conducted by Doorenbos and Kassam (1979), which indicates the effect of irrigation water on crop yield. The Benefit cost ratio of the tomato production under greenhouse subjected to plastic bottle irrigation system was 1.0. Hence the BCR is one or greater than 1. This means for 1 Frw spent we will get 1 Rwf as incremental income. So, it could be concluded that tomato farming under greenhouse subjected to plastic bottle irrigation system is highly profitable, that is 1.01 times the investment. The profitability index calculated was 2.83. The PI is greater than 1 which shows that the Roma tomato production under plastic bottle drip irrigation system is always a profitable project. Based on the findings achieved in this study, where we examined the cost and profitability of greenhouse cultivation under plastic bottle drip irrigation system, we conclude that greenhouse farming yielded better results in terms of economic indicators.

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CONFLICTS OF INTERESTS

The authors declare that there are no conflicts of interest.

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