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Production Of Watermelon As Influenced By Different Spacing And Mulching Under Rubilizi Conditions In Rwanda

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ABSTRACT

The field experiment was conducted on watermelon (*Citrullus lanatus*) variety sugarbaby at Rubilizi farm, Kigali city during season B of 2014. This experiment had to study the effect of different spacing levels and mulching on growth and yield of watermelon. Three different spacing (1mx1m, 1mx1.5m and 1mx2m) and types of mulch (straw mulch and plastic mulch) were used. All treatments were laid out in a Randomized Completely Block Design (RCBD) with nine treatments replicated thrice. Main vine length, number of lateral branches, number of leaves on the main vine, number of fruit per plant, fruit weight and total yield of watermelon at harvest were observed. The results of the experiment have shown significant difference ($P<0.05$). The interaction between the treatments indicated that spacing 1m x 2m and plastic mulch gave the highest yield (28.59 tha^{-1}), the longest vine (208.3 cm), the highest number of lateral branches (4.67), the hihgest number of leaves per main vine (28.33), the highest fruit weight of 3.2 Kg. Therefore, based on these results, it is hereby recommended that the use of wider spacing of 1m x 2m under plastic mulch should be adopted by the farmers for a profitable watermelon production in Rubilizi farm area.

Keywords: Watermelon, spacing, plastic, fruits, interaction.

1. INTRODUCTION

Watermelon (*Citrullus lanatus*) belongs to the cucurbitaceae family. It is believed to have originated from the Kalahari and Sahara deserts in Africa [1]. In Rwanda this crop is new. It is now gradually gaining ground in the Eastern part of the country. It is a crop with huge economic importance to human being. The fresh fruit is relished by many people across the world because it is known not only to be low in calories but highly nutritious, sweet and thirst-quenching. It is commonly used to make a variety of salads, most notably fruit salad.

It is a popular cash crop grown by farmers during summer due to its high returns in investment, especially those residing near the urban areas. Watermelon contains Vitamin C and A in form of the disease fighting *beta-carotene*. Potassium is also available in it, which is believed to help in the control of blood pressure and possibly prevent stroke [2]. The

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numerous uses of watermelon in Rwanda notwithstanding, yield across the country is not encouraging not necessarily because of declining soil fertility only, but mainly due to failure to identify high yielding varieties well adapted or most suitable to each agro–ecological zone.

About 150 years ago, some of the essential plant nutrients were discovered and subsequently fertilizers containing essential plant nutrient are manufactured and applied to soils to increase fertility [3]. Report says that mulch conserves soil moisture, retained heat as well as it suppresses weed growth [4]. The greatest benefit from plastic mulch is that the soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest.

Black plastic mulch can give a harvest earlier by some 7-14 days, while clear plastic may advance the harvest date by 21 days. Soil water loss is reduced under plastic mulch. As a result, more uniform soil moisture is maintained and irrigation frequency can be reduced. The growth of plants on mulch can be twice that of plants in unmulched soil. Because larger plants will require more water, mulching is not a substitute for irrigation. Black and white on black mulches will reduce light penetration to the soil. Weeds cannot generally survive under such mulch. Excess water runs off the impervious mulch.

Fertilizer beneath the mulch is not lost by leaching, so that fertilizers are optimally used and not wasted. The soil under plastic mulch remains loose, friable and well aerated.

Agriculture is a sensitive sector in the economy of our country. Rwanda's agricultural sector contributes about 42.6% of Gross Domestic Product. There is a variety of vegetables grown in Rwanda such as Tomatoes and green paper, French beans, chilli, carrots, hot paper, etc. according to national agricultural export board [5]. Watermelon is a new crop in the Rwandan diet culture. But based on its economic benefits, it is gaining interest and this is what drove us this experience.

Although the watermelon is a good source of vitamins, protein, minerals but still this crop is showing low productivity. Though few researches were done on this crop, but this low productivity is said be caused by poor agricultural practices, which is linked by the lack of maximum knowledge of the behavioral change of this crop during its development. Moisture is a very crucial part in the growing of this crop because it requires more water. It is also a heavy feeder of nutrients especially NPK.

Watermelon is a vine like crop. This means, its spacing also is a questionable matter to assure a successful production of this highly benefit making crop. The effect of spacing and mulching to the growth and yield of watermelon came as a way of finding different solution to the actual problem that the farmers of this new crop are facing. High leaching of water problem is solved as plastic mulch conserves water, spacing problem also solved as different spacing levels were under study. The study aimed at determining the best suitable spacing in terms of increasing growth and yield of watermelon and the best type of mulching to be used.

2. MATERIALS AND METHODS

The experiment was carried out at the Rubilizi farm, College of Agriculture, animal sciences and Veterinary medicine in Rwanda. The study area is located in the centre plateau within an altitude between 1500-2000 m, with the annual rainfall amounts that ranges between 1000-1200 mm and the average temperature ranges between 19-20 °c. The region is mainly used for agriculture purposes. The major crop that are grown there are maize, beans, banana, eggplants and tomatoes.

During this experience, maize straws and plastic mulch were used in order to evaluate the feasibility of each among the two types of mulching. The other plots under study were left for control, meaning there was no mulch at all.
The Watermelon seed used were the variety called Sugar Baby purchased from the Kenya Seed Company Rwanda.

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The experiment was laid out in RCBD with three replications and comprised two factors namely : Factor I: Spacing (S) which comprised: S1: 1 x 1m; S2: 1 x 1.5m; S3: 1 x 2m and Factor II: Mulch (M) which had: M1: No mulch; M2: Straw mulch; M3: plastic mulch.

Data collection and analysis:

Data regarding vine length, number of leaves and lateral branches on the main vine were recorded at a range of 30 DAS, 45 DAS and 60 DAS respectively on a sample of three plants per plot. Fruit number per plant, fruit weight and total yield (tons/hectare) were also recorded after the two harvests were completed. All recorded data were analyzed following the ANOVA technique and mean differences were done by Duncan's New multiple range test (DMRT) [6].

Three plant from each plot were tagged from which growth and yield parameters were recorded. The data were recorded for the main vine length (cm), number of lateral branches, number of leaves on the main vine, number of fruits per plant, fruit weight and yiled (tha^{-1}).

Vine length (cm) : Three plants from each plot were tagged from which growth of the main vine was recorded. The main vine length was measured from the 30, 45 and 60 days after sowing. Main vine length (cm) measured from the soil surface to the end tip of the plant using the ruler and a rope.

Number of leaves on the main vine : Number of leaves on the main vine from three plants of each plot was counted at 30, 45 and 60 days after sowing.

Number of lateral branches : Number of lateral branches was counted from the three plants of each plot at 30, 45 and 60 days after sowing.

Number of fruit per plant : number of fruit per plant was counted at each vine from the three plants selected in each plot.

Fruit weight (grams) : Fruits from the three plants selected in each plot were weighed one by one using a balance.

Yield (tha^{-1}) : the yield was worked out in tons per hectare. The mean yield from the plots treated with the same treatment was calculated.

Economic analysis

The price of inputs that were prevailing at the time of their use was considered for working out the cost of cultivation, gross returns, net returns and benefit-cost ratio.

3. RESULTS AND DISCUSSION

The results on vine length from 30 DAS to harvesting as influenced by spacing and type of mulch on growth and yield of watermelon are presented in the table No 1

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Table1 : ***Vine length as influenced by spacing and type of mulch on growth and yield of watermelon***

Vine length												
		At 30DAS				At 45 DAS				At 60 DAS			
S	**M**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**
S1		17.17d	20.43d	37.27bc	24.96a	52.5de	51.8de	86.9b	63.73a	79.3e	92.7de	134.7c	102.23c
S2		15.17d	34.2c	41.83ab	30.4a	43.3e	72.9cd	80.6bc	65.6a	77e	125.5c	147.4b	116.63b
S3		17.9d	36.33bc	47.03a	33.76a	46.3e	63.8bc	105.2a	71.76a	100.3d	123.1c	208.3a	143.9a
Mean		16.75c	30.32b	42.04a	29.7	47.37c	62.8b	90.9a	67.03	85.53c	113.77b	163.47a	120.9
Factors		**Sem±**	**CD**		**CV**	**Sem±**	**CD**		**CV**	**Sem±**	**CD**		**CV**
S		1.175	3.523		11.9	3.06	9.16		13.7	5.1	15.28		12.6
M		1.175	3.523		11.9	3.06	9.16		13.7	5.1	15.28		12.6
S*M		2.035	6.102		11.9	5.29	15		13.7	8.83	26.47		12.6

S1*: 1 x 1m,* ***S2****: 1 x 1.5m,* ***S3****: 1 x 2m,* ***M1****: No mulch,* ***M2****: Straw mulch,* ***M3****: Plastic mulch*

Means within column followed by the same letter are not significantly different according to LSD-test at P<0.05.

The effect of different levels of spacing and mulching on watermelon vine length at 30, 45 and 60 DAS (Days after Sowing) is shown in Table 1. In-row spacing at a level of 1mx2m (S3) at 30 DAS had the longest vine (33.76cm) and 1m x 1m (S1) produced the shortest vine length (24.96 cm). The differences between the treatment means at this stage of growth were highly significant ($p \leq 0.05$).

At 45 DAS, vine length was significantly more with S3 which recorded 71.8cm long followed by S2 which recorded 65.6cm and the less value recorded was at S1 with only 63.7cm length of the vine length. The treatment S1, S2 and S3 were statistically different with each other at this stage of watermelon plant growth. At 60 DAS, vine length was significantly increased with S3 which recorded the highest length of 143.9cm followed by S2 which recorded 116.6cm and the less value was observed in control with only 102.2cm length of the vine.

This result showed that as the spacing increased, the vine length also increased. The spacing of 1x2m showed that it is the best spacing. This is due to the fact that as we increase the plant population, the plant is able to intercept more solar radiation during the growth stage and this impact on the photosynthesis activity. The fact that during the growth stage the plant did not compete for nutrient, water and light has impacted on the increase in the growth of the vine and this explain the reason why the longest vine was observed on plant under 1x2 m in-row spacing.

The above results were in consonance with [7] who said that in-row spacing has positive effect on plant height. They were also supported by [8] who found that in-row plant spacing has a significant effect on the growth and yield of watermelon. [9] also reported an increase in watermelon vine length by increasing in-row plant spacing. Mulching was also found to have a significant effect on the vine length of watermelon.

The use of plastic mulch at 30 DAS had the longest vine (42.04cm), followed by straw mulch with 30.32cm and control had the shortest vine length (16.74 cm). The differences between the treatment means at this stage of growth were significant ($p \leq 0.001$). At 45 DAS, the longest vine was observed in the plot treated with plastic mulch with 90.9 cm and

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the shortest vine length was observed in control with 47.4. The influence of mulching on watermelon vine length at 45 DAS was significant ($p<0.001$).

The final vine length at 60 DAS showed that the plastic mulch had the longest vine (163.5cm) during the whole season followed by straw mulch with 113.8cm and shortest vine length (85.5 cm) was recorded in control. At 60 DAS, the effect of plastic mulch on watermelon vine length was significant ($p<0.05$). The results showed that plastic mulch increase watermelon vine length compared to straw mulches and control.

This increase in main vine length was attributed to sufficient soil moisture near the root zone and minimized evaporation loss due to plastic mulch. These results are supported by the work done by [10] who reported that the black plastic mulch enhance all plant growth and character were superior compare to the plant without mulch. This result was also in agreement with [11] who reported that plastic mulch had significant response on vegetative growth, yield and net profit [8].

Table2 : *Number of lateral branches as influenced by spacing and type of mulch on growth and yield of watermelon*

Number of lateral branches

		At 30DAS				At 45 DAS				At 60 DAS			
S	**M**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**
	S1	1.67b	2a	2.67a	2.11a	2b	2c	2.667bc	2.22c	2c	2.33bc	2.67c	2.22c
	S2	2.67a	2.33a	2.67a	2.56a	2b	3a	3a	2.667b	2c	3a	3.33b	2.67b
	S3	2a	2.33a	2.67a	2.33a	2.667a	3a	4a	3.22a	3a	3a	4.67a	3.56a
	Mean	2.11a	2.22a	2.67a	2.33	2.22a	2.67	3.22a	2.7	2.22c	2.67b	3.56a	2.8
Factors		**Sem±**	**CD**		**CV**	**Sem±**	**CD**		**CV**	**Sem±**	**CD**		**CV**
	S	0.245	0.735		31.5	0.245	0.28		10.4	0.245	0.619		22
	M	0.245	0.735		31.5	0.245	0.28		10.4	0.245	0.619		22
	S*M	0.425	1.27		31.5	0.425	0.48		10.4	0.425	1.073		22

S1*: 1 x 1m,* ***S2****: 1 x 1.5m,* ***S3****: 1 x 2m,* ***M1****: No mulch,* ***M2****: Straw mulch,* ***M3****: Plastic mulch*

Means within column followed by the same letter are not significantly different according to LSD-test at P<0.05.

The effect of different levels of spacing and mulching on watermelon number of lateral branches at 30, 45 and 60 DAS (Days after Sowing) is shown in Table 2.

At 30 DAS, spacing of 1x1.5m presented the highest number of lateral branches (2.56) and it was followed by 1mx1.5m with 2.33 and 1mx1m (S1) produced the lowest mean number of lateral branches (2.11). The differences between the treatment means at this stages of growth were not significant ($p>0.05$). The number of lateral branches at 60 DAS showed that the spacing of 1mx2m (S3) had the highest mean number of branches (3.56) and it was followed by 1mx1.5m with 2.67 and the lowest mean number of latersl branches (2.22) was recorded in 1mx1m.

At 60 DAS, the effect of different levels of Spacing on watermelon number of lateral branches was significant ($p<0.05$). These results showed that as spacing increased, the watermelon number of lateral branches increase. This is due to low competition in water, nutrient and light between crops which allow the plant to use efficiently the available soil nutrient and water. [8] supported these results when he reported that in-row plant spacing has a significant effect on the growth and yield of watermelon.

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Also, the vine length, diameter, number of leaves and number of branches linearly increased with increase in spacing reported by [8], [12]. The plastic mulch at 30 DAS gave the highest number of lateral branches (2.67) followed by straw mulch with 2.22 and control produced the lowest mean number of branches (2.11).

The differences between the treatment means at this stages of growth was not significant ($p > 0.05$). At 60 DAS, the results showed that plastic mulch had the highest mean number of lateral branches (3.56) during the whole season followed by straw mulch with 2.67 and the lowest mean number of lateral branches (2.22) was recorded in control.

At 60 DAS, the effect of different mulching on watermelon number of lateral branches was significant ($p < 0.05$). The results showed that plastic mulch has a significant effect on watermelon number of lateral branches compare to straw mulch and control.

This results can be explain by the fact that the changes in soil temperatures below PE mulch (especially black) is attributed to different manners of heat and heat transfer to soil and also to heat accumulation during day and loss during night.

This favors good growing conditions and good root uptake of the nutrients in the soil. These same findings was reported by [13], [10]. This result was also in agreement with [11] who reported that plastic mulch had significant response on vegetative growth, yield and net profit.

Table 3: The results of number of leaves on the main vine as influenced by spacing and types of mulch on growth and yield of watermelon.

Number of Leaves on the Main Vine

		At 30DAS				At 45 DAS				At 60 DAS			
S	**M**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**
	S1	3.33	3.77	5.67	4.26a	7.67e	9.67e	15.67 d	11c	13.67e	16.33d	22.67b	17.56b
	S2	3.67	4.67	5	4.44a	10.67d e	16.33 b	17.33 c	14.78 b	19cd	20.67b c	24.67a b	21.44a b
	S3	4.2	4.3	6.43	4.98a	17ab	16.33 b	22.67 a	18.67 a	20.33b c	24ab	28.33a	24.22a
	Mean	3.73a	4.24a	5.7 a	4.56	11.8c	14.11 b	18.56 a	14.83	17.67c	20.33b	25.22a	21.05
Factors		**Sem ±**	**CD**		**CV**	**Sem±**	**CD**		**CV**	**Sem±**	**CD**		**CV**
	S	0.57	1.724		37.8	0.61	1.831		12.4	0.71	2.122		10.1
	M	0.57	1.724		37.8	0.61	1.831		12.4	0.71	2.122		10.1
	S*M	0.996	2.985		37.8	1.056	3.171		12.4	1.23	3.676		10.1

***S1**: 1 x 1m, **S2**: 1 x 1.5m, **S3**: 1 x 2m, **M1**: No mulch, **M2**: Straw mulch, **M3**: Plastic mulch*

Means within column followed by the same letter are not significantly different according to LSD-test at P<0.05.

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Different means regarding number of leaves on main vine were not significantly ($p > 0.05$) different at 30, 45 and 60 DAS. The use of spacing at a level 1mx2m (S3) at 30 DAS had the highest number of leaves (4.98), the second level of spacing 1mx1.5m (S2) had 4.44 leaves and 1mx1m (S1) produced the lowest number of leaves (4.26 leaves). At 45 DAS, the highest number of leaves (18.67) was observed in the plot treated with 1mx2m, followed by 1mx1.5 m (14.78) and the spacing of 1mx1m had the lowest number of leaves (11).

At 60 DAS, the results showed that the spacing of 1mx2m (S3) had the highest mean number of leaves (24.22). It was followed by 1mx1.5m with 21.44 leaves and the lowest number of leaves (17.56) was recorded in 1mx1m. At 60 DAS, the effect of different levels of Spacing on watermelon number of leaves on the main vine was significant ($p>0.05$).

These results showed that spacing has a significant effect on the number of leaves. As spacing increases, the number of leaves on the main vine of watermelon increases too. This is due to the fact that a wide spacing gives the space to the crop so that it fully intercept the solar radiation, water use efficiency in crops that are apart one another is higher than those crops.

This has a positive impact on the crop nutrient absorption of nutrients and hence this good vegetative growth condition impart on the increase in the number of leaves. These results were supported by the work done by [8], [12] reported that the vine length, diameter, number of leaves and number of branches linearly increased with increase in spacing.

The result of the different means of the number of leaves on main vine (Table 3) was significantly ($p > 0.05$) different at 30, 45 and 60 DAS. At 30 DAS, plastic mulch gave the highest number of leaves (5.7) and 1mx1.5m (S2) produced 4.24 leaves and the lowest number of leaves in 1x1 m (3.73). At 45 DAS, the highest number of leaves (18.56) was observed in the plot treated with 1mx2m, followed by 1mx1.5m (14.11) and the spacing of 1mx1m had the lowest number of leaves (11.8).

The final number of leaves at 60 DAS under the spacing of 1mx2m (S3) had the highest mean number of leaves (25.22) followed by 1mx1.5m with 20.33 and the lowest (17.67) was recorded under 1mx1m. The results showed that plastic mulch increase watermelon number of leaves compare to control due to the fact that under plastic mulches, the moisture is retained longer than in any other mulching. The availability of moisture leads to higher uptake of nutrients for proper growth and development of plant. This results in higher number of leaves on the main vine as compared to other mulching and control.

These results are in conformity with the work done by [10] where he reported that increase in growth parameters was attributed to sufficient soil moisture near the root zone and a minimized evaporation loss due to mulching.

Table 4: The results of number of fruit per plant, fruit weight and fruit yield as influenced by spacing and mulching of watermelon.

	Number of fruit per plant				**Fruit weight (grams)**				**Fruit yield** (tha^{-1})			
Mulching	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**
S1	2.733ab	2.567b	2.933a	2.744a	1.033^{e}	1.25de	2.367c	1.55d	3.2d	5.08d	13.83c	7.37c
S2	2.3bc	2.367bc	2.133c	2.267b	1.433d	2.633bc	2.933b	2.333b	4.67d	12.5c	20.65b	12.6b
S3	2c	2.167c	2.333b	2.167c	2.667c	3b	3.283a	2.983a	7.58c	16.18bc	28.59a	17.45a

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Mean	2.344b	2.367c	2.467 a	2.392	1.71d	2.294b	2.861 a	2.288	3.2d	5.08d	13.83 c	7.37c
	SEm±	**CD**		**CV**	**SEm ±**	**CD**		**CV**	**SEm ±**	**CD**		**CV**
S	0.0889	0.266		11.1	0.0595	0.178		7.8	0.875	2.624		11.8
M	0.0889	0.266		11.1	0.0595	0.178		7.8	0.875	2.624		11.8
S*M	0.153	0.461		11.1	0.103 1	0.309		7.8	1.516	4.545		11.8

***S1**: 1 x 1m, **S2**: 1 x 1.5m, **S3**: 1 x 2m, **M1**: No mulch, **M2**: Straw mulch, **M3**: Plastic mulch*

Means within column followed by the same letter are not significantly different according to LSD-test at P<0.05.

Highly significant ($p \leq 0.001$) results regarding number of fruits per plant (Table4) showed that maximum (2.744) number of fruits per plant was recorded in 1mx1m, followed by 1mx1.5m (2.267) and the minimum (2.167) fruits per plant were recorded in 1mx2m. These results were due to the fact that high crop density results in an advanced number of plants per area. Mathematically speaking, the number of fruit will be higher in shorter spacing than in wider spacing.

This does not mean that the plant that grow better generates more fruit than the one that grew slow or short, but this is linked to the number of fruit, flowers and nodes which explains the shorter spacing having a higher number of fruits per plant on average. Proper spacing enhances vigorous growth of watermelon, which increases the number of fruits per plant. This was supported by the observation of [14], [15] who reported that when the number of plants per area is increased (high crop density), the fruit number per area is also increased, but the total yield and fruit number per plant is reduced.

The results regarding the number of fruit per plant showed that maximum fruits per plant (2.467) were recorded in plot treated by plastic mulch, followed by straw mulch (2.367) and the minimum (2.344) fruits per plant were recorded in control (no mulching). These results showed that, there was a significant effect of mulching on the number of fruit per plant of watermelon.

Result showed that plastic mulch promotes vigorous growth of watermelon plant, which increases the number of fruits per plant, which is supported by the observation of [16] who reported that the fruit number per area and plant were affected by film colored plastic mulch in the same manner as an early yield. Plastic mulch had significant response on vegetative growth, yield and net profit.

In-row spacing had a significant ($p<0.05$) effect on fruit weight. The results showed that when you increase the plant spacing in watermelon field, the fruit weight also increased. Higher fruit weight was observed in 1 m x 2 m with 2.983 Kg followed by 1 m x 1.5 m with 2.33 Kg. The results are presented in Table 4. The lowest value of the fruit weight (1.71 Kg) was observed in 1 m x 1 m. The results showed that when you increase in-row spacing the fruit weight also increases gradually.

[17] faced the same results and reported that with increase in spacing, the average fruit weight of watermelon and fruit size distribution increases too. Mulching had a significant ($p<0.001$) effect on the fruit weight of watermelon plant. A significant ($p<0.001$) increase in fruit weight was observed under plastic mulch with 2.861kg followed by straw mulch with 2.294 Kg. The results of fruit weight are presented Table4. The least fruit weight (1.71 Kg) was observed in control.

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The results showed that different mulching have a significant effect on fruit weight, as plastic mulch give maximum fruit weight. This is due to the favorable soil condition that the plant grew in, the moisture condition that is created by the plastic mulch, the weed control ability of plastic mulch compared to other types of mulching and the pest and disease control. All of this factors combined results in an increase in fruit weight of watermelon.

These above results were in consonance with those of [10] who said that the plastic mulch especial black plastic mulch have high average fruit weight (kg) than other mulch and control. [11] noticed the same results in watermelon using plastic mulch and found a high average fruit weight under plastic compared to no mulch treatment.

According to the above results, Spacing had a significant ($p<0.001$) effect on the yield of watermelon. Spacing treatment of level 1 m x 2 m increased the yield up to 17.45 tha^{-1}, followed by 1 m x 1.5 m with 12.61tha^{-1}, whereas 1 m x 1 m showed produced the least value (7.37 tha^{-1}) (Table 4). Spacing levels had a significant effect on yield (tha^{-1}). Spacing 1 m x 2 m produced the highest yield (tha^{-1}) compared to other levels of spacing.

This was due to high growing and favorable condition during the whole period of growth of the watermelon grown under spacing 1mx2 m. As on one hand the fruit number per plant increases as spacing decreases, the fruit weight on another hand increasing as the spacing increases according to this study, spacing level of 1mx2m has presented the increased total yield compared to other levels of spacing. It was followed by spacing 1mx1.5m and 1mx1m spacing came as the least among other treatment of spacing.

These results are in agreement with the findings of [18] who reported that increased spacing may decrease crowding and increase yield of watermelon. Mulching had shown a significant ($p<0.001$) effect on the yield of watermelon. Plastic mulch presented the highest yield of 21.03tha^{-1}. It was followed by straw mulch with 11.25 tha^{-1}, whereas 1 m x 1 m produced the least (5.15 tha^{-1}) of watermelon (Table 4).

Mulching treatment (plastic mulch) produced highest yield. This was due to better plant growth conditions and to favorable hydro-thermal regime of soil and complete weed free environment created by plastic mulch in the growing area of watermelon. This result was in with those of [10] who said that yield of watermelon was higher in plants mulched with silver on black polyethylene, which was higher as compare to other mulch and no mulch.

These above results were in agreement those of [14] in watermelon. This result also was confirmed by [11] who noticed that watermelon in plastic mulch treatment had higher yields ascribed due to higher length of vine, number of branches, number of fruits per plant and average fruit weight.

In order to achieve maximum watermelon fruit yield, net return and benefit cost ratio from, the results from economic analysis revealed that interactions between the treatments spacing of 1m × 2 m and plastic mulching have given the higher net returns (14,050,835 Rwf) with higher benefit cost ratio of 2.77. This was mainly due to the the highest weight of fruits and yield recorded from this practice. These findings are supported with [10] who noticed that the higher net returns and BCR was noticed in the black plastic mulch.

4. CONCLUSION

The results observed after analysis of the recorded data have shown that both spacing and mulching has a significant effect on growth and yield of watermelon. After statistical analysis done on growth parameters (main vine length, number of lateral branches, number of leaves on the main vine, number of fruit per plant, fruit weight and yield), it was found that spacing of 1mx2m has a significant effect on growth parameters and on total yield. Black plastic mulch has shown that it has a significant effect on growth parameters and on total yield. The interaction between spacing and mulching has revealed that wider spacing and black plastic mulch has a significant effect on growth and total yield of

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watermelon and this pratice could be advisable to watermelon growers in this area since it showed too generate high net return.

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