Global Scientific JOURNALS

GSJ: Volume 12, Issue 6, June 2024, Online: ISSN 2320-9186
www.globalscientificjournal.com

The effect of mulch tillage with various types of crop residues on the Bumba Technical Secondary School garden's soil quality; tomato growth and yield and their contribution to the school's feeding budget

Joseph Ndayisenga, Managing Director at Melius Farms, ndayisengajoseph@gmail.com
Pascal Ntawurikura, Operation Manager at Melius Farms, pascalntawurikura@gmail.com
Valens Ngerageze, School manager at Bumba Technical Secondary School, ngvalens@gmail.com
Vedaste Nzaramba, Career guidance officer at IPRC-WEST, vedast2050@gmail.com

Abstract

A field experiment was conducted at the Bumba Technical secondary school garden in Rutsiro District to study the effect of mulch tillage with various types of crop residues on the Bumba Technical Secondary School garden's soil quality; tomato (*Solanum lycopersicum*,L) growth and yield and their contribution to the school's feeding budget. Six treatments in the study included were crop residues of peas, wheat, soybeans, maize, common beans and no-mulch as control. Growth parameters (Number of leaves and plant Height), yield parameters (number of fruits and fruit weight) and soil quality parameters (Nitrogen, Phosphorus, Potassium, soil organic matter, Cation exchange capacity and PH) were determined in all treatments. Results revealed that mulch tillage did not significantly (P>0.05) influence the growth, yield and soil parameters except Potassium however with inconsistency. The maximum height (198.7cm), number of leaves (30.94) at 90days after transplanting, number of fruit (14.67) and fruit weight (63.45 $t.ha^{-1}$) were obtained with soybean crop residues while the maximum values of N (2.6g/Kg), SOM(61.0%) and CEC(88.3mmol+/Kg) were obtained with wheat crop residues, P(14.7g/Kg) and PH(5.5) with soybean crop residues and K(15.5g/Kg) with maize crop residues. On the other hand the minimum height (170.7cm) with peas, number of leaves (27.78) with wheat at 90 DAT. The number of fruit (9.25) and fruit weight ($39.03t.ha^{-1}$) was obtained with peas crop residues. The minimum values of N (1.7g/Kg) was obtained with soybean and common bean, P (4.5g/Kg) with control, K (12.4g/Kg) with peas; SOM (46.1%).), pH (5.2) and CEC (49.3 mmol+/Kg) with common bean. The price of yield of tomato was used to assess the contribution of the school garden to the school feeding budget. The total yield obtained from the school garden of 72 m^2 was 403Kg. At RWF1200 per kilogram on the current local market price, the total tomato crop contribution to the school budget was RWF483600. The minimum level of nitrogen into plot treated with soybean crop residues might be linked to quick decomposition and mineralization of organic matter which encouraged nitrogen uptake by tomato and later resulted into better growth and yield. Therefore, soybean crop residues were found

to be more effective for improving tomato growth, yield and soil quality. ***Keywords: Mulch tillage, school garden, soil fertility, tomato growth and yield, school feeding and crop residues.***

INTRODUCTION

In Rwanda, school Feeding has been an integral part of the government's strategy to address children's hunger during the school day and expand access to educational opportunities to disadvantaged children, particularly orphans and vulnerable school learners. The school feeding program is an effective mechanism for addressing child nutrition issues, increasing educational enrolment, retention and performance (Mutimura 2019). The government of Rwanda set the 2020 goals to reduce poverty and hunger and raise average calorie intake in Rwanda from 1650 to 2100 Kcal per person per day and to help reach these goals, the Ministry of Education initiated a long-term school gardens and nutrition education program in primary and secondary schools (Ndahiro 2006). School gardening programs are increasingly used to promote health strategies and the intake of fruits and vegetables (Hoover, et al. 2021). In the past decade, multiple studies have shown that school gardens can improve dietary intake and dietary-related psychosocial variables in children (Hoover, et al. 2021) however; they also face challenges related to low soil fertility, disease and pests, erosion, water scarcity, weather fluctuation, unsustainable maintenance and many more, which can lead to their failure. Soil fertility decline is a major concern for agricultural development in Rwanda (ELD 2018). Human activities such as construction are at the forefront of causing soil erosion that result into losing the most fertile part of the soils. Topsoil layer has the highest biological activity, organic matter and plant nutrients hence, the onsite loss of this upper layer of soil nearly eliminates the soil's natural ability to provide nutrients, regulate water flow, and combat pests and disease (USDA 2000). There are number of measures that can be adopted to prevent and reduce the loss of the topsoil layer. One of them is the adoption and application of conservation tillage. Conservation tillage is defined as any tillage and planting system that covers 30 percent or more of the soil surface with crop residue after planting, to reduce soil erosion by water (Khursheed, et al. 2019). The four types of conservation tillage are Mulch tillage, Ridge tillage, No-till and reduced tillage (Bista, et al. 2017). Mulch tillage is a system in which crop residues are left on the surface, and subsurface tillage leaves them relatively undisturbed. In dry land areas, a maximum amount of mulch is left on the surface; in more humid regions, however, some of the mulch is buried (Stewart 2022). Many studies have revealed that conservation tillage practices give comparable yield to conventional tillage; therefore, it should be adopted in order to prevent adverse effects of conventional tillage on soils and environment. According to the Ministry of Education mandates regarding school feeding, in every portion each student should consume about 160g of tomato (Uwamariya 2019). With the price hike situation, it becomes so difficult for many schools to comply with this mandate. This study was conducted to assess the effect of mulch tillage with various types of crop residues on the Bumba Technical Secondary School garden's soil quality; tomato growth and yield and their contribution to the school's feeding budget. In this paper, we presented the results of our experiment, and we highlighted some positive effects of the application of various types of crop residues on soil quality and tomato production at Bumba Technical Secondary School.

METHODOLOGY

Site description: the study was conducted at Bumba Technical Secondary School, in Rutsiro district, Mushubati sector, Bumba cell, and Karambi village. Rutsiro district has a tropical climate with an average temperature of between 20 ° and 24 ° C. The relief of Rutsiro District is characterized by a chain of mountains and plateaus with an average altitude of 2,000 m and 1,600 m. Rainfall increases gradually as the district approaches the mountain range of Congo-Nile covered by Gishwati forest. (Times Reporter 2016). The district experiences four seasons of the year; namely small rainy season that runs from September to December, the short dry season that runs from December to March, the long rain season that runs from the end of March to the end of June, and the long dry season that runs from the end of June to September. (Ayinkamiye 2018). The District has an acidic soil with a soil pH ranging from 5 to 5.5 (MINAGRI 2018). Rutsiro soil is basaltic, generally permeable and rich in iron. It is an acidic soil with an average content of clay grouped as karyokinesis. In some places on Lake Kivu, there are sometimes derived phyllodessoils, clayey soils containing quartz crystals. The soils in Rutsiro District are very susceptible to erosion and therefore less fertile (Times Reporter 2016)

Experimental Design: the experiment was designed as factorial complete randomized block design (CRBD) with three replications. Six treatments included were crop residues of peas, wheat, soybeans, maize, common beans and no-mulch as control. Growth parameters (Number of leaves and plant Height), yield parameters (number of fruits and fruit weight) and soil quality parameters (Nitrogen, Phosphorus, Potassium, soil organic matter, Cation exchange capacity and PH) were determined in all treatments. Each treatment was assigned randomly in each replication. The plot size was $4m^2$ (2m*2m) and adjacent plots were separated by 60cm wide buffer zone to minimize border effects and allow easy movement during operations. The experiment was protected by a shade house covered with black shade net to prevent heavy rain or any physical damage from outside.

Data collection: The plant test was Tomato (*Solanum lycopersicum.* L), indeterminate Mrembo variety, F1. Each plot was planted with sixteen tomato plant and both growth and yield data were collected from four tomato plants from the center to minimize possible errors from the border effect. The growth parameters evaluated were number of leaves and plant height. The growth data were collected at 30, 60, and 90 days after transplanting. The plant height was measured using a measuring tape and the number of leaves was counted and recorded in a book. The evaluated yield parameters were number of tomato fruit and their weight. The weight was measured using electrical balance and tomato fruit were counted and recorded throughout the harvesting period. Soil data have been collected before land preparation and three months after planting. The soil parameters evaluated were soil P^H, soil organic matter, Nitrogen, Phosphorus and Potassium and cation exchange capacity. Composite sample has been collected before land preparation while the second soil samples have been collected in each plot to examine the change. All samples have been analyzed using soil scanner of AgroCares. The contribution of school garden to the school feeding budget has been evaluated by valuating the total yield according to the actual price of tomato at local market.

Table1.Soil properties status before land preparation

Selected soil properties						
Soil textture	soil PH	Organic Carbon (%)	Nitrogen(g/kg)	Phosphorus(g/kg)	Potassium (g/kg)	Cation Exchange capacity(mmol+/kg
Clay	5.4	48	1.6	0	14.6	87

Data analysis: the data on growth and yield parameter were subjected to analysis of variance using statistical software GenStat 15th Edition while the data on soil parameters were subjected to analysis of variance using statistical software SPSS 20.

Experimental field maintenance

Indeterminate Mrembo variety tomato F1 seeds have been purchased from Omni Agricultural. Seeds have been sown in trays for seedling production. After one month, on 3rd September 2022, seedlings have been transplanted from the nursery to plots within a shade house covered with 50% black shade net to reduce evapotranspiration and physical damage from heavy rain. The plant spacing was 50 cm between plants and 50cm between rows. Recommended animal manure was applied at a rate of 1.3t.ha^{-1}. At 2-, 8- and 12-weeks mineral fertilizers have been applied at a rate of 190 Kg.ha^{-1} of NPK, and 35Kg.ha^{-1} of Urea. One month after transplanting weeding, pruning and staking followed. Aphids, Redbugs and leaf miners are the pest identified in the field and they have been controlled with insecticide spray of Rocket (cypermethrin 4%+profenofos 40%) during vegetative growth and Dudu$^+$ (Abamectin 1.8%) during reproductive stage at 25ml in 20 litres of water dosage. Diseases such as powdery mildew, tomato early blight, tomato leaf curl virus disease and leaf spot also have been observed. Fungal diseases have been controlled by spraying fungicides such as Mancozeb 80%, copper oxychloride 60%, once a week during rainy days at 40g in 20L of water dosage. Viral diseases have been controlled by removing infected plants and throw them away. Irrigation was done by surface irrigation depending on the soil moisture content about twice a week. Pruning and regular cleaning have been performed to reduce competition and allow light penetration.

RESULTS

Effect of mulch tillage with various types of crop residues on soil quality

The results in Table2 reveal that all crop residues did not significantly influence the soil pH. The pH value varied from 5.2 to 5.5. Wheat, soybean and Maize crop residues increased the pH by 0.1, while beans and control decreased the pH by 0.2 and 0.1 respectively and peas' crop residues did not change the soil pH. The soil organic matter varied between 46.1% and 61.0%. The use of different crop residues as mulch influenced the soil organic matter content however with non-significant difference. Plot treated with wheat crop residues expressed the highest organic matter of 61% while the plot treated with beans crop residues showed the lowest level of organic matter of 46.1%. Applying different types of mulch did not significantly influence the soil nitrogen content. The nitrogen content varied from 1.7g/kg to 2.6g/kg. The highest Soil Nitrogen was obtained from the plot treated with wheat crop residues while the lowest soil nitrogen was obtained from the plot treated with soybeans and common beans crop residues. Phosphorus has been influenced by the application of different crop residues however with non-significant difference between all treatments at 5% level of significance. The highest soil phosphorus content has been observed from the plots treated with soybean crop residues with 14.7g/kg and the lowest was recorded in control where no mulch has been applied with only 4.5g/kg. The amount of potassium varied from 12.4g/kg to 15.5g/kg. The plots treated with maize and common beans exhibited an increase in the level of potassium with 15.0g/kg and 15.5g/kg respectively and the remaining plots treated with crop residues of peas, wheat, soybeans and the control exhibited a decrease in the level of potassium with 12.4, 13.4, 12.8 and 13.0 g/kg respectively. The cation exchange capacity (CEC) varied from 49.3mmol+/kg to 88.3mmol+/kg. The highest CEC has been recorded from the plot treated with wheat crop residues while the lowest CEC was recorded from the plots treated with common beans crop residues. The average results on different soil quality parameters are presented in the Table2 below.

Table2.Effect of mulch tillage with various types of crop residues on soil quality

	Soil properties					
Treatment (crop residues)	soil PH	Organic matter (%)	Nitrogen(g/Kg)	Phosphorus(g/Kg)	Potassium (g/Kg)	CEC (mmol+/Kg)
PEAS	5.4	54.4	1.8	11.7	12.4	84.0
Wheat	5.5	61.0	2.6	9.8	13.4	88.3
Soybeans	5.5	47.5	1.7	14.7	12.8	80.7
Maize	5.5	49.1	1.8	14.5	15.0	88.0
Beans	5.2	46.1	1.7	10.0	15.5	49.3
control (no mulch)	5.3	53.2	2.4	4.5	13.0	83.0

Effect of mulch tillage with various types of crop residues on tomato growth parameters

The average results on plant height at 30, 60, and 90 days after transplanting are presented in the Table 3. The tomato height varied from 52.67cm to 38.0cm, 156.0cm to 132.0cm and 198.7cm to 170.7cm at 30, 60 and 90 days respectively after transplanting. At 30 days after transplanting, the analysis of variance showed that the effect of mulch tillage with different type of crop residues on tomato plant height was non-significant (*P*-value>0.05) at 5% level of significance. At 60 days after transplanting, the analysis of variance showed that the effect of mulch tillage with various type of crop residues tomato plant height was non-significant (*P*-value>0.05) at 5% level of significance. At 90 days after transplanting, the analysis of variance showed that the effect of mulch tillage with different type of crop residues tomato plant height was non-significant (*P*-value>0.05) at 5% level of significance. The average results on the number of tomato plant leaves at 30, 60 and 90days after transplanting are presented in the Table4. The number of leaves varied from 11.92 to 10.67, 22.92 to 21.03 and 30.94 to 27.78 at 30, 60 and 90days respectively after transplanting. At 30 days after transplanting, the analysis of variance showed that the effect of mulch tillage with different type of crop residues on tomato plant leaves was non-significant (*P*-value>0.05) at 5% level of significance. At 60 days after transplanting, the analysis of variance showed that the effect of mulch tillage with different type of crop residues on tomato plant leaves was non-significant (*P*-value>0.05) at 5% level of significance. At 90days after transplanting, the analysis of variance showed that the effect of mulch tillage with different type of crop residues on tomato plant leaves was non-significant (*P*-value>0.05) at 5% level of significance.

Table 3Effect of Mulch Tillage with various types of crop residues on Tomato plant height at 30, 60 and 90 days after transplanting

	Height		
Treatments	**30DAT**	**60DAT**	**90DAT**
Peas	44.33 ab	136.3a	170.7a
Wheat	38.00a	134.0a	183.3a
Soybeans	52.67b	156.0a	198.7a
Maize	46.67ab	132.0a	175.3a
Beans	51.67b	145.3a	186.3a
Conventional Tillage(no mulch)	48.67ab	156.0a	187.3a

DAT: Days After Transplanting

Table4.Effect of Mulch Tillage with various types of crop residues on Tomato plant leaves at 30, 60 and 90 days after transplanting

	Number of leaves		
Treatment	**30DAT**	**60DAT**	**90DAT**
Peas	11.33 a	22.08a	28.39ab
Wheats	10.67a	21.03a	27.78a
Soybeans	11.92a	22.92a	30.94b
Maize	11.53a	22.00a	29.86ab
Beans	11.83a	22.61a	29.56ab
Conventional tillage	11.50a	22.42a	29.44ab

Effect of mulch tillage with various types of crop residues on the tomato yield

The average results on the number of tomato fruits are presented in the Table5. The number of fruits varied from 14.67 to 9.25; the number of ripe fruits were recorded at the harvest time. The yield varied from 63.45t.ha-[1] to 39.03t.ha-[1]. The analysis of variance showed that the effect of mulch tillage with various type of crop residues on the number of tomato fruits and fruits weight were non-significant (*P*-value>0.05) at 5% level of significance.

Table5.Effect of Mulch Tillage with various types of crop residues on the yield parameters

Treatment	Number of fruits	Yield ($t.ha^{-1}$)
Peas	9.25a	39.03a
Wheats	10.50a	43.61a
Soybeans	14.67a	63.45a
Maize	10.42a	45.90a
Common Beans	12.92a	54.68a
Conventional tillage (No mulch)	12.33a	47.43a

Contribution of tomato production on the school's feeding budget

The results on the contribution of harvested tomato on the school feeding budget were presented in Table 6.

Table 6.Contribution of tomato production on the school's feeding budget

Date	**Harvested yield(kg)**	**Actual market price(RWF)**	**Contribution on the budget(RWF)**
23/12/2022	71	1200	85200
02/01/2023	90	1200	108000
16/01/2023	99	1200	118800
04/02/2023	83	1200	99600
18/02/2023	60	1200	72000
Total	**403**	**1200**	**483600**

DISCUSSIONS

Effect of mulch tillage with various types of crop residues on soil quality

The analysis of variance **Appendix1** revealed that there was no significant influence on the soil PH among all treatments at 5% level of significance (P>0.05). Wheat, soybean and Maize crop residues exhibited an increase of pH by 0.1, while beans and control decreased the pH by 0.2 and 0.1 respectively and peas' crop residues did not change the soil PH. This change in PH might be related to the cation concentration, Carbon and Nitrogen cycles, types of crop residues and soil (Bin, et al. 2021). The increase in PH due to application of crop residues have been reported also by (Butterly, Jeffrey and Caixian 2013) in their study to evaluate the contribution of crop residues to changes in soil pH under field conditions where they found that the application of residues to acid and moderately acid soils increased the pH of both topsoil and subsoil, which persisted over 26 months. On the other, another study conducted by (Cao, et al. 2021) showed that straw coverage with no-till and rotary tillage significantly reduced the soil pH from 7.7 to 7.4 and 7.2.

The analysis of Variance showed that all types of crop residues did not significantly influenced both the soil organic matter and soil nitrogen at 5% level of significance ($P>0.05$). The highest soil organic matter of 61.0% and Nitrogen of $2.6g.kg^{-1}$ have been recorded from the plot treated with wheat crop residues and the lowest with 46.1% and $1.7g.kg^{-1}$ in the plots treated with bean crop residues. This might be linked to the nature of crop residues, their rate of decomposition and their Carbon-Nitrogen ratio which can result into either quick or late decomposition, mineralization and nutrients utilization by the crop. (Ali , et al. 2020) also found that the content of soil organic carbon increased by 52% and 50% with a treatment of 5% (w/w) raw garlic stalk in 2016 and 2017, respectively. In their study on the effects of full straw incorporation on soil fertility and crop yield in rice-wheat rotation for silty clay loamy cropland, (Zhao , et al. 2019) found that straw and partial fertilizers incorporation significantly increased the soil available nitrogen at soil depths of 0–20 cm by averages of 64%.

Unlike other soil properties Potassium was significantly influenced by crop residues application on the content in the soil at 5% level of significance ($P<0.05$). The highest level of Potassium was obtained from plots treated with common beans with 15.5g/kg followed by maize with 15.0g/kg and the remaining plots treated with crop residues of peas, wheat, soybeans and the control exhibited a decrease in the level of potassium with 12.4, 13.4, 12.8 and 13.0 g/kg respectively. This inconsistency has also been reported by (Lupwayi, et al. 2005) from their study on Potassium release during decomposition of crop residues under conventional and zero tillage where they found that the correlations between K release and residue quality were inconsistent and they concluded that because K is not a structural component of plant tissue, its release is probably related more to leaching than to residue decomposition.

The effect of all types of crop residues on the CEC was non-significant at 5% level of significance. Except wheat and maize crop residues which exhibited an increase by 1.3mmol+.kg^{-1} and 1mmol+.kg^{-1} the remaining treatments decreased the CEC. Contrary, in his study on the Effect of Crop Residue on Soil Chemical Properties and Rice Yield on an Ultisol at Abakaliki, Southeastern Nigeria (Ogbodo 2011) found that in the plots with crop residues, the CEC was significantly higher.

Effect of mulch tillage with various types of crop residues on tomato growth parameters

The tomato plant height was non-significantly different (P value> 0.05) by different crop residues at 30, 60 and 90days after transplanting Appendix 2, Appendix 3 and Appendix 4 respectively. There was non-statistical difference in plots treated with different crop residues. Tomato plants from plots treated with soybean crop residues were high (52.67cm) while those of wheat crop residues were short (38.0cm), 30days after transplanting. At 60days after transplanting, the highest plant height were also from soybean crop residues treatment plots (156.0cm) and the shortest were from maize crop residues treatment plots (132.0cm). At 90days after transplanting, the longest tomato plant was obtained from the plots treated with soybean crop residues (132.0cm) while the shortest were tomato plants from plots treated with peas crop residues (170.7cm). This might be due to high nitrogen content of soybean crop residues and their quick decomposition nature which might encourage vegetative growth. Similar findings were made by (Mysoon, Atif and Osama 2019) in their study to assess the impact of degradable mulch on tomato growth and yield in the field. Tomato plants did not exhibit any appreciable differences in plant height throughout the growing season regardless of the type of mulch used.

The average number of leaves was non-significant different at 5% level of significance (P> 0.05) in all treatments (soybean, wheat, peas, common beans, maize and the control) at 30, 60 and 90 DAT Appendix 5, Appendix 6 and Appendix 7. There's a non-significant variation, the highest number of tomato leaves was treated with soybean crop residues (11.92, 22.92 and 30.94) whereas the smallest was treated by wheat crop residues (10.67, 21.03 and 27.78) at 30, 60 and 90 DAT. The increase in the number of leaves might be a result of quick mineralization of organic matter from soybean crop residues unlike wheat crop residues. The similar findings on the Effect of Different materials on the performance of Tomatoes in Dhankuta, Nepal by (Shiksha, et al. 2021), they found that the number of leaves were a non-significantly (P > 0.05) influenced at 30, 45 and 60 DAT by the application of Rice husk and straws.. The similar results were also found by (Ihab, et al. 2019) on "Response of Soil Properties, Growth, Yield and Fruit Quality of Cantaloupe Plants (Cucumis melo L.) to organic mulch.", they obtained that the effect of organic mulch on the number of leaves has no significant difference after 25,55 and 80 DAT in the 1st season (2016) although the wheat straw had greatest effect on number of leaves of cantaloupe plant.

Effect of mulch tillage with various types of crop residues on tomato yield parameters

The average number of fruits per tomato was non-significant different (*P*-value>0.05) with different types of crop residues Appendix 8. Tomato treated with soybean crop residues possessed the maximum number of tomato fruits whereas the minimum was possessed by tomato treated by pea crop residues. This might be due to quick decomposition of soybean crop residues and mineralization of its organic matter which availed nutrients and promoted tomato fruiting. The case was different to pea crop residues. The similar findings on Mulching Methods and their Effect on the Yield of Tomato (*Lycopersicon esculentum,* L) in the Zeta plain was found by (Branka and Velibor 2012), who concluded that, there was no significant difference in number of fruits between the plants grown on black and red foil or those grown on straw, sawdust and the control.

The fruit weight of tomato was not significantly different at 5% level of significance (P>0.05) in all treatments, Appendix 9. The highest tomato yield of $63.45 t.ha^{-1}$ was recorded within plots treated with soybean crop residues while the lowest yield of $39.3 t.ha^{-1}$ was recorded in plots treated with pea's crop residues. The fruit weight of tomatoes was non-significantly influenced (P value> 0.05) by different crop residues. Similar result was obtained by (Tswanya, Olayini and Atanda 2017) who concluded that the total fruits weight of tomato was no significantly increased by mulch material treatments.

Contribution of tomato production on the school's feeding budget

According to the ministry of education mandates, each student should consume about 160g of tomato per meal. Apart from the price hiking at the local market, growing tomato in Rutsiro where the school is located is challenging because of its mountainous topography which makes the region very cold. The soil also is clay and acidic. The study was conducted to determine the best crop residues that can be used to improve the soil fertility in school garden while increasing tomato production and enhance students' nutrition through homegrown solution. The study has contributed a total sum of RWF483600 to the school feeding budget in three months. Not only school garden contribute to students' diet but also can lead to improved academic student achievement, development, health, environmental attitudes, and knowledge of food systems (Webb, Diaz and Campbell2 2018).

CONCLUSION

This study was conducted to study the effect of mulch tillage with various types of crop residues on the Bumba Technical Secondary School garden's soil quality; tomato growth and yield and their contribution to the school's feeding budget. Among all crop residues applied as mulch, soybean crop residues were found to be the best over the peas, wheat, maize, common beans and conventional tillage in providing higher yield of tomato through improving tomato growth, number of fruits and fruit weight. Soybean crop residues also improved the soil PH and phosphorus level in the soil. The obtained yield of tomato also contributed to the school budget and student nutrition quality of food. Therefore, soybean crop residues should be used as mulch to improve the yield of tomato and quality of soils. As there was no school garden at Bumba Technical secondary school before, they should maintain it and other schools should adopt school gardens and mulch tillage with soybean crop residues in order to improve food quality for their student and reducing vegetables cost.

Acknowledgement

This work was supported and funded by the Strengthening Education for Agricultural Development (SEAD) West Project. The authors would like to thank all the staff of SEAD West project and their partners for the capacity building provided through several trainings sessions. The authors would also like to thank all the staff teachers and students of Bumba Technical Secondary School who contributed the land and participated in the implementation of this project.

References

Ali , Ahmad, Muhammad Imran Ghani, Ding Haiyan , Muhammad Iqbal , Zhihui Cheng , and Zucong Cai. "Garlic Substrate Induces Cucumber Growth Development and Decreases Fusarium Wilt through Regulation of Soil Microbial Community Structure and Diversity in Replanted Disturbed Soil." *International Journal of Molecular science* 21, no. 17 (2020): 6008.

Hoover, Amy, Sarvenaz Vandyousef, Bonnie Martin, Katie Nikah, Michele Hockett Cooper, and Anne Muller. "Barriers, Strategies, and Resources to Thriving School." (Journal of Nutrition Education and Behavior) 53 (2021).

Khursheed, Saima, Cheryl Simmons, Sartaj A Wani, Tahir Ali, Raina SK, and Najar GR. "Conservation tillage: impacts on soil physical." *MedCrave* (Adv Plants Agric Res) 9, no. 2 (2019): 342-346.

Ndahiro, André. *School garden in Rwanda .* Kigali: FAO Sub regional Office for Southern and East Africa, 2006.

Stewart, Robert E. *Tillage.* February 24, 2022. https://www.britannica.com/topic/tillage (accessed February 15, 2023).

Zhao , Xinlin, Guoyin Yuan , Huoyan Wang , Dianjun Lu , Xiaoqin Chen, and Jianmin Zhou. "Effects of Full Straw Incorporation on Soil Fertility and Crop Yield in Rice-Wheat Rotation for Silty Clay Loamy Cropland." *Agronomy* 9, no. 3 (2019): 133.

Ayinkamiye, Emerance. *District development strategy 2018-2024.* Rutsiro district, 2018.

Bin, Fu, Chen Ling , Huang Hongying, Qu Ping, and Wei Zhenggui. "Impact of crop residues on soil health: a review." *Environmntal pollutants and Bioavailability* 33, no. 1 (2021): 164-173.

Bista, Prakriti , Stephen Machado, Rajan Ghimir, Georgine Yorgey, and Donald Wysocki. "Conservation Tillage systems." *ResearchGate*, 2017: 99-124.

Branka, Nikolic, and Spalevic Velibor. "mulching methods and their effects on the yield of tomato (Lycopersicon esculentum, Mill.) in the Zeta plain." *Agriculture & Forestry* (https//www.researchgate.net/publication/236355546) 52, no. 06 (1-4) (2012): 17-33.

Butterly, Clayton, Baldock A. Jeffrey, and Tang Caixian. "The contribution of crop residues to changes in soil pH under field conditions." *Plant and soil* 366, no. 1 (2013): 185-198.

Cao, Qingjun, et al. "Eleven-year mulching and tillage practices alter the soil quality and bacterial community composition in Northeast China." *Archives of Agronomy and Soil Science* 68, no. 6 (2021).

ELD. "Land degradation." *The Economics of Land Degradation*, 2018.

Ihab, I. Sadek, A. Youssef Mohamed, Y. Soleiman Nayera, and Mohsen Alyafei Mohammed Abdul. "Response of Soil Properties, Growth, Yield and Fruit Quality of Cantaloupe Plants (Cucumis melo L.) to organic mulch." *Merit Research Journals* (Merit Research Journal of Agricultural Science and Soil Sciences) 7, no. 9 (September 2019): 106-122.

Lupwayi, N. Z. , G. W. Clayton, J. T. O ’Donovan, K. N. Harker, T. K. Turkington, and Y. K. Soon. "Potassium release during decomposition of crop." *Can. J. Soil. Sci.*, 2005.

MINAGRI. *Environmental and social management plan for indicative feeder .* Intercontinental Consultants and Technocrats Pvt. Ltd., 2018.

Mutimura, Eugene. *National comprehensive school feeding policy.* Kigali: Ministry of Education, 2019.

Mysoon, Alamro, Mahadeen Atif, and Mohawesh Osama. "Effect of degradable mulch on tomato growth and yield under field conditions." *Bulgarian Journal of Agricultural Sciences* 25, no. 6 (2019): 1122-1132.

Ogbodo, E.N. . "Effect of Crop Residue on Soil Chemical Properties and Rice." *World Journal of Agricultural Sciences* 7, no. 1 (2011): 13-18.

Shiksha, Sharma, Bhattari Keshav, Sedhai Amrita, Basnet Bikas, and Khanal Khapil. *The Effect of Different Mulching Materials on the Performance of Tomatoes in Dhankuta, Nepal.* Analytical, Chitwan, Nepal: Institute of Agriculture and Animal Sciences Mahndra Ratna Multiple campus, Ilam, Tribhuvan University, 2021.

Times Reporter. *Advertorial.* August 10, 2016. https://www.newtimes.co.rw/section/advertorial/840 (accessed December 07, 2021).

Tswanya, M, J Olayini, and T Atanda. *Effect of mulch material and mulching rate on fruit yield and nutritional quality of tomato (Lycopersicon lycopersicm mill) in Ogbomoso and Mokwa, Nigeria.* Abuja: Curr Trends Biomedical eng & Biosci, 2017.

USDA. "Erosion and Sedimentation on." *United State Department of Agriculture*, 2000.

Uwamariya, Valentine. *Rwanda School Feeding Operational guidelines summary.* Kigali: Ministry of Education, 2019.

Webb, Susan , John Diaz, and Catherine Campbell2. "Understanding the Barriers for School Garden Success: Expert Consensus to." *EDIS*, 2018.

APPENDICES

Appendix1.ANOVA Tables for soil parameters

ANOVA

PHwater

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.232	5	.046	.423	.824
Within Groups	1.313	12	.109		
Total	1.545	17			

ANOVA

Organic matter

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	453.769	5	90.754	.419	.827
Within Groups	2598.740	12	216.562		
Total	3052.509	17			

ANOVA

Soil Nitrogen

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.472	5	.494	2.499	.090
Within Groups	2.373	12	.198		
Total	4.845	17			

ANOVA

Phosphorus

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	211.783	5	42.357	.292	.908
Within Groups	1742.033	12	145.169		
Total	1953.816	17			

ANOVA

Potassium

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.598	5	4.920	5.466	.008
Within Groups	10.800	12	.900		

Total	35.398	17			

ANOVA

Cation exchange

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3275.778	5	655.156	.390	.847
Within Groups	20184.000	12	1682.000		
Total	23459.778	17			

Appendix 2.ANOVA table for Tomato Height at 30 days after Transplanting

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	76.33	38.17	0.94	
Block*Units* stratum					
treatment	5	434.67	86.93	2.15	0.142
Residual	10	405.00	40.50		
Total	17	916.00			

Appendix 3. ANOVA table for tomato plant height at 60days after Transplanting

Variate: DAY60

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	299.1	149.6	0.81	
block. *Units* stratum					
treatment	5	1196.3	239.3	1.29	0.340
Residual	10	1848.9	184.9		
Total	17	3344.3			

Appendix 4. ANOVA table for Tomato Height at 90 days after Transplanting

Variate: DAY90

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	890.8	445.4	1.24	

block. *Units* stratum					
treatment	5	1452.3	290.5	0.81	0.571
Residual	10	3603.2	360.3		
Total	17	5946.3			

Appendix 5.ANOVA table for number of tomato leaves at 30 days after Transplanting

Variate: Day 30

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	4.0147	2.0073	4.60	
block.*Units* stratum					
treatment	5	2.9985	0.5997	1.37	0.312
Residual	10	4.3650	0.4365		
Total	17	11.3781			

Appendix 6.ANOVA table for number of tomato leaves at 60 days after Transplanting

Variate: Day 60

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	12.198	6.099	3.98	
block. *Units* stratum					
treatment	5	6.461	1.292	0.84	0.549
Residual	10	15.340	1.534		
Total	17	33.998			

Appendix 7.ANOVA table for number of tomato leaves at 90 days after Transplanting

Variate: DAY90

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1.760	0.880	0.49	
block. *Units* stratum					
treatment	5	18.743	3.749	2.07	0.153
Residual	10	18.115	1.811		
Total	17	38.618			

Appendix 8.ANOVA table for number of tomato fruits

Variate: AV_N0_OF_FRUIT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

block stratum	2	32.22	16.11	1.33	
Block. *Units* stratum					
Treatment	5	59.31	11.86	0.98	0.475
Residual	10	120.95	12.10		
Total	17	212.48			

Appendix 9.ANOVA table for tomato yield

Variate: AV_YIELD

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	2	1038.5	519.3	1.34	
block.*Units* stratum					
treatment	5	1144.8	229.0	0.59	0.707
Residual	10	3870.1	387.0		
Total	17	6053.4			