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Compost enriched with effective microorganism and Bordeaux mixture on ginger bacterial wilt (*Ralstonia solanaceurum*) Epidemics in southwestern, Ethiopia

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***Abstract* — Ginger is one of the most widely cultivated spice grown in various cropping systems and locations throughout the southwestern Ethiopia. Bacterial wilt, caused by Ralstonia solanacearum, is one of the serious diseases of ginger in Ethiopia. Field experiments were conducted during 2019 and 2020 to assess effects of soil amendments on bacterial wilt development and epidemics at Tepi, southwestern Ethiopia. Three soil amendments practices: compost, effective microorganisms and Bordeaux mixture alone and in integration were evaluated. Treatments were arranged in a randomized complete block design with three replications. Compost at the rate of 7 ton/ha enriched with effective microorganisms and Bordeaux mixture treatment significantly reduced ginger bacterial wilt incidence, area under disease progress curve and disease progress rate. This treatment reduced bacterial wilt mean incidence up to 21.08 % as compared to untreated control plot. Compost at the rate of 7 ton/ha also slowed down epidemic progression of bacterial wilt and significantly reduced the disease parameters when effective microorganisms and Bordeaux mixture were integrated. The overall results indicated that integrated compost enriched with effective microorganisms and Bordeaux mixture was effective to slow down the epidemics of ginger bacterial wilt and sustain ginger production and productivity. Hence, integrated compost enriched with effective microorganisms and Bordeaux mixture along with other crop management systems are recommended to improve ginger production and productivity at southwestern Ethiopia and other similar ecologies.**

Keywords* — *Bordeaux mixture, bacterial wilt, Compost, Effective microorganism, Epidemics, Ginger

I. INTRODUCTION

Ginger (*Zingiber officinale* Rosc.), is an important commercial crop grown for its aromatic rhizomes, which are used as both spice and medicine [19]. Ginger rhizome is typically consumed as a fresh paste, dried powder, slices preserved in syrup, candy, as a beverage or as flavoring agent. India is the largest producer of ginger in the world accounting for about one-third of the total world produced. The crop is known to have been introduced to Ethiopia as early as in the 13th century [15]. It cultivated in south, southwestern and northwestern parts of the country as cash crop, and is among the important spices used in every Ethiopian kitchen for the preparation of pepper powder, stew, bread, and others. It has also some use in traditional medicine for the treatment of flu and stomach ache [7].

Bacterial wilt caused by *Ralstonia solanacearum* is one of the most devastating plant diseases in the tropics. In susceptible host plants the pathogen disrupts water transport, alter physiology and induces a severe, usually fatal wilt. Currently ginger production is seriously affected by bacterial wilt and efforts to grow ginger widely in Ethiopia have been hampered by this disease [10].

The pathogen has a very wide host range. The very extensive host range includes several hundred species of plants representing 44 families [16]. Among the common hosts are chili, eggplant, irish potato, ginger, groundnut, tomato and tobacco. In Ethiopia, the disease caused losses of 51.94% [9]. [10] Reported that the disease became the major constraint in the ginger production in Ethiopia and cause losses up to 80-100%.

Effective Microorganisms (EM) with compost was found effective in improving soil and plant health there by improved the quality and productivity of crops [12][23]. EM may have an advantage of low ecological pollution rather may conserve the environment and sustainable in managing soil borne diseases. [20] Indicated that application of EM found the most effective bio control agents, it promotes microbial activity that suppresses *R. solanacearum* by competition.

Soil amendments with compost and EM can improve crop production through promoting the growth of plants and enhance microbial activity that may suppress soil borne diseases through competition and/or antibiosis. According to [2] the application of the organic amendment and compost released biologically active substances from crop residues and soil microorganisms such as allele-chemicals [24]. [14] demonstrated that the bacterial wilt of tomato was suppressed in the poultry and farmyard manure added soils. Compost made from corn stalk, rice straw and tree bark suppressed bacterial wilt caused by *R. solanacearum* and gave lowest disease incidence compared to the control plot 16]. Crop fertilization with cow manure household compost suppressed *R. solanacearum* in most soils with a clear shift in rhizosphere bacterial community [16]. According to [2] soil amendment with silicon significantly reduced bacterial wilt incidence expressed as area under the disease progress curve for susceptible tomato genotypes by 26.8% and moderately resistant by 56.1% when compared to non-treated plants grown in hydroponic culture.

Apart from all efforts to manage ginger bacterial wilt in different parts of the world, ginger bacterial wilt is still highly distributed and severe in southwestern areas of Ethiopia, and farmers in these areas considered the disease as a major production constraint, which limits the production as well as quality of ginger rhizomes. Thus, the integration of compost enriched with EM and Bordeaux mixture could be alternative options for the disposal of growers in managing ginger bacterial wilt. However, there is very little or no information and research done so far on the effects of soil amendments with compost enriched EM and Bordeaux mixture to manage ginger bacterial wilt disease in Ethiopia. Therefore, this study was designed to determine the effect of compost enriched with EM and Bordeaux mixture on the epidemics of ginger bacterial wilt disease and ginger rhizome yield in southwestern, Ethiopia.

II. MATERIALS AND METHODS

A. *Experimental sites*

The experiment was conducted at Tepi Agricultural Research Centre (TARC), Ethiopia during 2019 and 2020 main cropping season. TARC is located in Yeki district, Southwestern Ethiopia Regional State. The centre is found between 35º08' longitude and 7º08' latitude at an altitude of 1200 m.a.s.l. The average minimum and maximum temperatures are 15 and 30 ºC, respectively. It receives an average annual rainfall of 1630 mm [9].

B. *Experimental materials and treatments*

Boziab (37/79) variety of ginger released by Tepi Agricultural Research center was used for all treatments and control. Compost soil amendments @ 3, 5, and 7 ton/ha alone and integration with EM and Bordeaux mixture were evaluated for their response to bacterial wilt. Compost enriched with EM and Bordeaux mixture was applied as cultural management practice one month before planting to reduce pathogen inocula and prevent disease epidemics and un-amended plot used as control. The experiment was relied entirely on natural epidemics of bacterial wilt, because the sites are hot spot areas of the disease and the previous history of the field also confirmed it.

C. *Experimental design and management*

A total of 9 treatments, including controls, were laid out in a randomized complete block design in a factorial arrangement with three replications. Planting was made on a gross plot size of 6 m^2 (2 m width and 3 m length) with six rows of ginger and four harvestable central rows. A recommended spacing of 0.15 m between plants and 0.3 m between rows were used. Spacing between plots and blocks were 0.5 and 1 m, respectively. Total area allocated for the experiment was 30.5 m x 8 m (244 m^2). The four central rows were considered for data collection. All other cultural practices for growing ginger under field conditions were done uniformly following recommended practices.

D. *Disease Assessment*

Ginger bacterial wilt incidence (number of plants wilted) were visually assessed at 15-days interval starting from 60 days after planting (DAP). Plants that showed either complete or partial wilting were all considered wilted and staked to avoid double counting in subsequent assessments. Wilt incidence for each treatment was then calculated as percentage of total number of plants emerged. Disease progress was plotted by considering the disease incidence against time. The area under diseases progress curve (AUDPC) from disease incidence was computed using the formula suggested by [6].

$$\text{AUDPC} = \sum_{i=1}^{n-1}\left(\frac{X_i + X_{i+1}}{2}\right)(t_{i+1} - t_i)$$

Where, n is total number assessment times, t_i is time of the ith assessment in days from the first assessment date, x_i is percentage of disease incidence at ith assessment. AUDPC was expressed in %-days because incidence (x) was expressed in percent and time (t) in days [6].

E. *Data Analysis*

Analysis of variance (ANOVA) was performed for disease incidence and AUDPC to see the effect of treatments and their interactions. Logistic, ln [(Y/1-Y)], [22] model was used for estimation of disease progression parameters from each treatment. The transformed disease incidence data were regressed over time (DAP) to determine the rate. The goodness of fit of the models was tested based on the magnitude of the coefficient of determination (R2) and residuals (SE) obtained using the model [6]. Regression was computed using Minitab (Release 15.0 for windows®, 2007). Least significant difference (LSD) was used for mean separation at 5% level of significance. Relationship of final disease incidence and AUDPC with yield and yield components was examined using correlation analysis. The two years were considered as the same due to homogeneity of variances as tested using Bartlett's test [8] and the F-test was non-significant for most of the parameters studied in each location. Thus, data were combined for analysis.

III. RESULTS AND DISCUSSION

A. *Disease incidence*

AUDPC values calculated from disease incidence assessed at different days after planting, yield and final disease incidence significantly (P<0.05) varied between some of soil amendment bacterial wilt management practices and the control, (Table 1). AUDPC and PDI values were lower on compost 7 t/ha enriched with EM and Bordeaux mixture treated plots than on other treatments and control. Control plots had the highest (2117.05%-days) AUDPC values, while the lowest (1470%-days) AUDPC values were calculated from compost enriched with EM and Bordeaux mixture treated plots. The highest yield (16.26 t/ha) was also obtained from the plots treated with compost 7 ton/ha enriched with EM and Bordeaux mixture, whereas the lowest yield (8.43 t/ha) was calculated from the untreated control plots. The overall values indicated that compost 7 ton/ha enriched with EM and Bordeaux mixture treated plots showed consistent in increase in yield ton/ha, reduction in AUDPC and PDI values than other treatments and control. This could be attributed to besides the suppression of the spread of disease at field, compost also provide nutrients and organic matter, thereby eliminating or reducing the need for fertilizer. Compost can also improve soil structure which allows for better water transmission, thereby decreasing the potential for bacterial wilt disease development.

Table 1. Effects of compost enriched with EM and Bordeaux mixture on bacterial wilt (R. solanacearum) final disease incidence (%), yield (t/ha) and AUDPC (%-days) at Tepi, Ethiopia during the 2019/20 main cropping season.

Treatments	Yield (t/ha)	PDI (%)[1]	AUDPC (%-days)[2]
Compost 3 t/ha	12.33^{c}	55^{cd}	1675.14^{c}
Compost 5 t/ha	12.53^{c}	55.16^{cd}	1582.24^{cd}
Compost 7 t/ha	13.4^{bc}	53.06^{de}	1540.52^{d}
Sole Bordeaux mixture	9.83^{d}	60^{b}	1919.94^{b}
Sole EM	9.43^{de}	58.06^{bc}	1964.78^{b}
Compost 3 t/ha+ EM + Bordeaux mixture	13.26^{bc}	50.5^{ef}	1688.35^{c}
Compost 5 t/ha+ EM + Bordeaux mixture	14.13^{b}	46.76^{f}	1495.06^{d}
Compost 7 t/ha+ EM + Bordeaux mixture	16.26^{a}	42.53^{g}	1470^{d}
Control	8.43^{e}	66.86^{a}	2117.05^{a}
LSD (5%)	1.3	4.1	124.09
CV (%)	6.18	4.37	4.17

[1]Percent disease incidence at 120 days after planting (DAP). [2]AUDPC = standardized area under disease progress curve of ginger bacterial wilt. Means followed by same letter(s) within a column are not significantly different at 5% level of significance.

One of the beneficial properties of compost is the microbially induced suppression of soil borne plant pathogens and disease [13]. [4] reported that suppressive compost possess a higher microbial activity than conducive ones. They suggested that a high microbial activity causes a depletion in essential nutrients for the survival and multiplication of the pathogen, thus preventing infection of the host. The beneficial microbes in compost and other decomposing organic matter can activate certain disease resistance systems in plants. When a pathogen infects a plant, the plant mobilizes certain biochemical defenses, but these are often too late to avoid the disease. Plants grown in compost appear to have these systems already running and this prevents the pathogen from causing disease. This mechanism, called systemic acquired resistance, is somewhat pathogen specific, but it opens the door for enhancing disease control through common farming practices [4].

B. Disease Progress Rate

The disease progress rates calculated from mean disease incidence records showed variations among some of soil amendments treatments used and control. The lowest disease progress rates was calculated from the plot treated with compost 7 t/ha enriched with EM and Bordeaux mixture (0.030 units/day), while the highest disease progress rates was recorded from untreated control plot (0.041units/day) (Table 2). It was also observed that disease progressed relatively at faster rates on sole EM, Bordeaux mixture and untreated control plots. The results indicated that the rate at which bacterial wilt progressed was slower when compost integrated with EM and Bordeaux mixture than the untreated plots. This may be due to compost could enhance the health and vigorousity of plants that might increase plant chances to withstand pathogen attack and activate the host defense system. In agreement with this study, [14] who found that compost amended soils reduced disease severity of ear blight on brassicas compared to the bare soil. Also [11] reported that compost teas significantly reduced disease incidence and population counts of alternaria blight and significantly increased the activities of both peroxidase, β-1, 3-glucanase and chitinase that could increase plant resistance both under greenhouse and field planted tomato and onion.

Table 2. Effects of compost enriched with EM and Bordeaux mixture on disease progress rate (r) and parameter estimates of bacterial wilt (*Ralstonia solanacearum*) of ginger at Tepi, Ethiopia during the 2019/20 main cropping season.

Treatments	Disease progress rate (r) at Tepi			
	Disease progress rate (unit day^{-1}) [1]	SE of rate [2]	SE of intercept [3]	R^2 (%) [4]
Compost 3 t/ha	0.039	0.085	0.021	99.2
Compost 5 t/ha	0.036	0.180	0.101	95.6
Compost 7 t/ha	0.037	0.150	0.068	97.2
Sole Bordeaux mixture	0.039	0.077	0.018	99.3
Sole EM	0.036	0.140	0.058	97.5
Compost 3 t/ha+ EM + Bordeaux mixture	0.035	0.075	0.016	99.2
Compost 5 t/ha+ EM + Bordeaux mixture	0.034	0.032	0.003	99.8
Compost 7 t/ha+ EM + Bordeaux mixture	0.030	0.020	0.001	99.9
Control	0.041	0.173	0.090	97.0

[1]Disease progress rate obtained from regression line of disease incidence with time of assessment (days). [2]Standard error of rate. [3]Standard error of parameter estimates. [4]Coefficient of determination of the Logistic model.

A similar result was also noted by [18] against *Phytophthora capsici* in pepper plants by compost water extracts and the test again activates expression of pathogenesis-related genes and peroxide generation in the leaves and lignin accumulation in the stems. In addition, composted paper mill residuals suppressed bacterial spot of bean at field and under grehouse condition, which likely due to induced systemic resistance [21]. [18] Showed the same result on the suppression of *Colletotrichum coccodes* in pepper leaves and *C. orbiculare* in cucumber leaves.

C. Disease Progress Curve

The disease progress curves of bacterial wilt (severity versus DAP) were sketched in Figure 1. The curves revealed that disease severity progressed increasingly starting from the onset to the final severity records in all treatments during the study periods. The five disease progress curves for each treatments also indicated that the disease progress was not similar for each soil amendment treatments used. The disease severity in untreated control plots followed relatively high progressive curves and displayed the highest levels of bacterial wilt severity. The sole Bordeaux mixture and EM treated plots followed similar curves as untreated plots but lied intermediate between controls and compost 5 ton/ha enriched with EM and Bordeaux mixture treated plots with intermediate levels of bacterial wilt severity. Whereas disease progress curves of plots treated with compost at 7 ton/ha enriched with EM and Bordeaux mixture treatments progressed slowly and display the lowest levels of bacterial wilt severity at different days after planting.

The disease progress curves in Figure 1 depicted only for five treatment categories (sole EM, sole Bordeaux mixture, compost 5 ton/ha enriched with EM and Bordeaux mixture, compost 7 ton/ha enriched with EM and Bordeaux mixture and control) based on their bacterial wilt severity levels, for the sake of clarity and ease of graphic presentation. Accordingly, sole EM, Bordeaux mixture and compost 5 ton/ha with EM and Bordeaux mixture is treatments lied in between control and compost 7 ton/ha enriched with EM and Bordeaux mixture, whereas treatments like compost 3 ton/ha, 5 ton/ha, 7 ton/ha were intermediate between sole EM and compost 5 ton/ha with EM treatments.

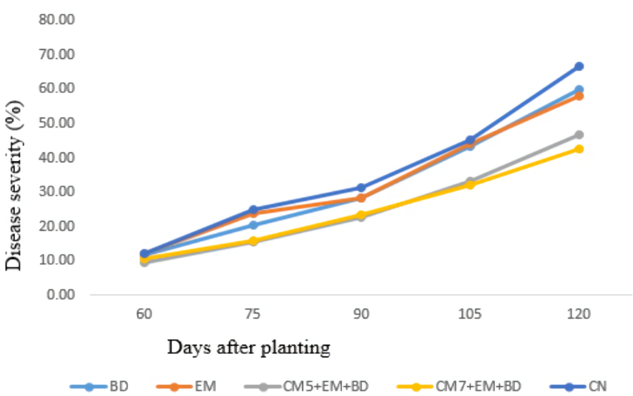

Fig. 1. Ginger bacterial wilt (Ralstonia solanacearum) disease progress curves as affected by compost enriched with EM and Bordeaux mixture (BD), effective microorganisms (EM), compost 5 ton/ha enriched with EM and Bordeaux mixture (CM5+EM+BD) and compost 7 ton/ha enriched with EM and Bordeaux mixture (CM7+EM+BD) and control (CN) at Tepi in 2019 and 2020 main cropping seasons.

D. Association of Yield and Disease Parameters

Calculating correlation between and among final disease incidence, AUDPC, disease progress rate, yield and yield related components was important since change of either of the parameters influenced the response of the other during the experiments. For studying relationship between disease and yield parameters, simple correlation analysis was used. Different levels of associations were observed among disease incidence, AUDPC, disease progress rate and yield and yield related components and presented in Tables 3.

rAUDPC and final disease incidence were positively and highly significantly ($P \leq 0.01$) correlated ($r = 0.892^{**}$). This is in agreement with Biniam *et al.* (2014) the epidemiological parameters PDI and AUDPC were highly correlated. In most cases, the negative correlation of rhizome yield with bacterial wilt development was found to be stronger with AUDPC than with final disease incidence. Yield and AUDPC were negatively and highly significantly ($P \leq 0.01$) correlated ($r = -0.951^{**}$). Such finding could indicate the presence of strong negative effects of bacterial wilt on rhizome yield of ginger. Yield and final disease incidence ($r = -0.957^{**}$). More or less similar phenomenon was noted for the correlation between disease parameters and yield related components of ginger. This complies with the findings of [9] who found that bacterial wilt incidence, AUDPC and infection rates are strongly and negatively correlated with ginger rhizome yields.

Table 3. Coefficients of correlation (r) between yield and disease parameters on ginger at Tepi, Ethiopia during the 2019 and 2020 main cropping season

Parameter	RL (cm)[1]	NFPR[1]	Yield ($t\ ha^{-1}$)	PDI f (%)[1]	AUDPC[1]	Dpr (units day^{-1})
RL (cm)	1					
NFPR	0.975^{**}	1				
Yield ($t\ ha^{-1}$)	0.849^{**}	0.885^{**}	1			
PDI f (%)	-0.860^{**}	-0.873^{**}	-0.957^{**}	1		
AUDPC[1]	-0.736^{**}	-0.796^{**}	-0.951^{**}	0.892^{**}	1	
Dpr (units day^{-1})	-0.922^{**}	-0.835^{**}	-0.824^{**}	0.911^{**}	0.713^{**}	1

[1] RL= rhizome length, NFPR= no. of finger per rhizome, PDI f= final disease incidence index, AUDPC = Area under disease progress curve of bacterial wilt incidence of ginger. **Level of statistical significance at $P \leq 0.01$. ^{ns} non-significant at $P > 0.05$.

IV. CONCLUSION

Based on the results obtained from this study, it can be concluded that bacterial wilt incidence, AUDPC, disease progress rates and curves were strongly influenced by soil amendments with compost enriched EM and Bordeaux mixture. Soil amendments with compost at the rate of 7 ton/ha enriched with EM and Bordeaux mixture before planting highly reduced ginger bacterial wilt incidence. It is therefore, promising to amend the soil for several weeks before planting with compost at the rate of 7 ton/ha enriched with EM and Bordeaux mixture integrated with other crop management strategies to manage bacterial wilt of ginger in the face of the current and future climate dynamics in southwestern Ethiopia. Further studies on integrated management of bacterial wilt should be continued. Also, more efforts should be done with compost quality and its effects on soil Physico-chemical properties.

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REFERENCES

[1] APNAN, H. 1995. EM application manual for APNAN countries. ASIA-Pacific National Agriculture Network.

[2] Ayana, G., Fininsa, C., Ahmed, S. & Wydra, K. 2011. Effects of soil amendment on bacterial wilt caused by Ralstonia solanacerum and tomato yields in Ethiopia. Journal of plant protection research.

[3] Bailey, K.L., & Lazarovits, G. 2003. Suppressing soil-borne diseases with residue management and organic amendments. Soil and tillage research, 72(2), pp.169-180.

[4] Baker, R. & Paulitz, T.C. 1996. Theoretical basis for microbial interactions leading to biological control of soilborne plant pathogens. Principles and Practice of Managing Soilborne Plant Pathogens. R. Hall, ed. American Phytopathological Society, St. Paul, MN, pp.50-79.

[5] Binyam, T., Temam, H., & Tekalign, T. 2014. Efficacy of Reduced Dose of Fungicide Sprays in the Management of Late Blight (Phytophthora infestans) Disease on Selected Potato (Solanum tuberosum L.) Varieties Haramaya, Eastern Ethiopia. Journal of Biology, Agriculture and Healthcare.

[6] Campbell, C. L., & V. L. Madden. 1990. Introduction to Plant Disease Epidemiology. Wiley, New York, USA. 532 PP.

[7] Girma, H., & Digafie, T. 2004. Annual Report on the Current Status of Spice s Research, Jimma, Agricultural Research Centre, Teppi Agricultural Research Sub Centre, pp. 35-48.

[8] Gomez, K.A., & Gomez, A.A. 1984. Statistical Procedures for Agricultural Research, 2nd Edition. John Wiley and Sons Inc, New York, US. 680pp.

[9] Guji, M.J., Yetayew, H.T., & Kidanu, E.D. 2019. Yield loss of ginger (Zingiber officinale) due to bacterial wilt (Ralstonia solanacearum) in different wilt management systems in Ethiopia. Agriculture & Food Security, 8(1), pp.1-11.

[10] Habetewold, K., Bekelle, K., Kasahun, S., & Tariku, H. 2015. Prevalence of Bacterial Wilt of Ginger (Zingiber Officinale) Caused by Ralstonia Solansearum (Smith) in Ethiopia. International Journal of Research Studies in Agricultural Sciences, 6:14-22.

[11] Haggag, W.M., & Saber, M.S.M. 2007. Suppression of early blight on tomato and purple blight on onion by foliar sprays of aerated and non-aerated compost teas. Journal of Food, Agriculture and Environment, 5(2): 302-309.

[12] Higa, T., & Parr, J.F. 1994. Beneficial and effective microorganisms for a sustainable agriculture and environment (Vol. 1). Atami: International Nature Farming Research Center.

[13] Hoitink, H.A.J., Stone, A.G., & Han, D.Y. 1997. Suppression of plant diseases by composts. HortScience, 32(2), pp.184-187.

[14] Islam, T.M., & Toyota, K. 2004. Suppression of bacterial wilt of tomato by Ralstonia solanacearum by incorporation of composts in soil and possible mechanisms. Microbes and environments, 19(1), pp.53-60.

[15] Jansen, P.C.M. 1981. Spices, Condiments and Medicinal plants in Ethiopia: Their Taxonomy and Agricultural significance. Centre for Agriculture publishing and documentation, Wageningen, The Netherlands. Serratia. Journal of General Microbiology, 98:39-66.

[16] Masyitah, O. 2004. Development of disease surppressive compost, and potting mixture for control of bacterial wilt of tomato. Unpublished M. Sc. Thesis, University Protra Malaysia.

[17] Neher, D.A., Weicht, T.R., & Dunseith, P. 2014. Compost for management of weed seeds, pathogen, and early blight on Brassicas in organic farmer fields. Agroecology and Sustainable Food Systems, 1-27.

[18] Sang, M.K., Kim, J.G., & Kim, K.D. 2010. Biocontrol activity and induction of systemic resistance in pepper by compost water extracts against Phytophthora capsici. Phytopathology, 100(8): 774-783.

[19] Sharma, B.R., Dutta, S., Roy, S., Debnath, A., & Roy, M.D. 2010. The effect of soil physico- chemical properties on rhizome rot and wilt disease complex incidence of ginger under hill agro climatic region of West Bengal. Journal of Plant Pathology, 26:198-202.

[20] Singh, D., Yadav, D.K., Chaudhary, G., Rana, V.S., & Sharma, R.K. 2016. Potential of Bacillus amyloliquefaciens for biocontrol of bacterial wilt of tomato incited by Ralstonia solanacearum. Journal of Plant Pathol Microbiol, 7(327), pp.1-6.

[21] Stone, A.G., Vallad, G.E., Cooperband, L.R., Rotenberg, D., Darby, H.M., James, R.V., Stevenson, W.R., & Goodman, R.M. 2003. The effect of organic amendments on soilborne and foliar diseases in field grown snap bean and cucumber. Plant Disease, 87: 1037-1042.

[22] Van der Plank, J.E. 1963. Plant diseases: Epidemics and Control. Academic Press, London, UK.var. Varada. 349 pp.

[23] Ewa Laskowska, Łukasz Jarosz, Zbigniew Grądzki. 2017. The effect of feed supplementation with effective microorganisms (EM) on pro- and anti-inflammatory cytokine concentrations in pigs. Research in Veterinary Science. Volume 115 (244-249). https://doi.org/10.1016/j.rvsc.2017.03.008

[24] Kripa Dhakal, Ramasamy Ravi, Dilip Nandwani. 2021. Comparative Study of Sensory Attributes of Leafy Green Vegetables Grown Under Organic and Conventional Management. *International Journal of Food, Agriculture, and Natural Resources.* Vol 2 (3):29-45. https://doi.org/10.46676/ij-fanres.v2i3.52