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Management of Bacterial Wilt of Tomato (*Solanum lycopersicum* L.) using Some Plant Resistance Activators

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ABSTRACT

Bacterial wilt (*Ralstonia solanacearum*) is a soil borne plant pathogen, which negatively affects tomato production globally. Plant resistance activators (PRAs): Acibenzolar-S-methyl (ASM), β-Aminobutyric acid (BABA), Salicylic acid (SA) and Acetylsalicylic acid (ASA) were investigated to determine their effectiveness in managing bacterial wilt under screenhouse conditions. PRAs at 25 µg/ml, 50 µg/ml and 75 µg/ml concentrations each, were applied as foliar spray and root drenching to tomato cultivars: Perfect Pee and Roma Round laid out in a Complete Randomized Design with three replications. Seedlings were artificially inoculated with *R. solanacearum* suspension (6×10^7cfu/ml) using the foliar method. All the PRAs reduced bacterial wilt incidence and severity to the barest minimum. The highest number of fruits, irrespective of the varieties and application method was significantly different ($p \leq 0.05$) from the control. However, the least and highest significantly different ($p \leq 0.05$) fruit yield (4.60 and 38.70 g/plant) was recorded for foliar spray-treated SA Roma Round and ASA Perfect Pee respectively at 50 µg/ml. In all, ASA foliar spray at 50µg/ml produced significantly higher tomato yield than the other plant activators and untreated controls. This suggests that the use of ASA in controlling bacterial wilt would be effective in integrated disease management program.

Keywords: *Ralstonia solanacearum*, Perfect Pee, Roma Round, Incidence, Severity

INTRODUCTION

Tomato, *Solanum lycopersicum* L., is one of the most widely grown vegetables in the world (Hirano and Arie, 2006). It is an important food, cash and industrial crop which contributes to GDP (Ajagbe *et al.,* 2014). World annual production stands at 180.64 million metric tonnes (FAOSTAT, 2020). China, the leading producer, accounts for 64.76 million metric tonnes of the total production (FAOSTAT, 2020). In Africa, Nigeria is the 2nd largest producer after Egypt and the 14th in the world with 3.69 million metric tonnes (FAOSTAT, 2020).

Tomato wilts caused by *Fusarium oxysporum* f.sp. *lycopersici* and *Ralstonia solanacearum* are the most important diseases of tomato in the Savanna and Forest zones of Nigeria (Popoola *et al*., 2012). Wilt caused by *R. solanacearum* is a major limitation in the production of solanaceous crops worldwide due to its destructive nature, wide host range and geographical distribution causing up to 75-100% tomato yield loss (Adebayo, 2011;

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Popoola *et al*., 2012; Animashaun *et al*., 2017).

The use of resistant cultivars remains the most effective, economical and environment friendly method for managing bacterial diseases (Ganiyu, 2014; Animashaun *et al*., 2017), but conventional breeding techniques used for developing resistance in tomato plant against bacterial wilt confer limited durability due to polygenic trait and result in different strains of *Ralstonia solanacearum.*

Induction of plant resistance using plant resistance activators (PRAs) is one of the methods of reducing bacterial diseases by inducing the plant's own defense mechanisms (Walters *et al*., 2013). PRAs offer the advantage of not depending on the genetic makeup of the plant and the availability of resistance genes. PRAs have the potential to be more economical, environmentally sustainable with less negative impact on human health while improving yield compared to other methods of disease control. PRAs are agents that enhance protection against pathogen attacks by inducing the plant's own defense mechanisms, a process known as induced resistance (Walte rs *et al*., 2013). PRAs strengthen plants against various pathogens, including viruses, bacteria, oomycetes and fungi attacking solanaceous plants. These specific activators have been developed as a potential Systemic Acquired Resistance (SAR) to induce resistance in plant by contact with a pathogen or their metabolites or by a diverse group of structurally unrelated organic and inorganic compounds (Kuc, 2001; Cohen *et al.,* 2002). Thus, the study evaluated acibenzolar-S-methyl, β-Aminobutyric acid, Salicylic acid and Acetyl Salicylic acid at three different concentrations (25 µg/ml, 50 µg/ml and 75 µg/ml) applied as foliar spray and root drench on the performance of two susceptible tomato accessions inoculated with *R. solanacearum* under screen house conditions.

MATERIALS AND METHODS

Experimental site, design and source of materials

The experiment was carried out in screenhouse of Nigeria Agricultural Quarantine Post-Entry Surveillance and Diagnostic Station, Moor Plantation, Ibadan. The location falls within the rainforest transition agro-ecological zone of Nigeria between latitude N7.38437 and longitude E3.83843 taking from Garmin GPS unit. The experiment was laid out in a completely randomized design (CRD) with three replicates. Two susceptible tomato cultivars (cvs. Roma Round and Perfect Pee), were sourced from Tomato Germplasm Collection, Plant Tissue Culture Laboratory, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. Four Plant Resistance Activators (PRAs); Acibenzola-S-methyl (ASM), Acetylsalicylic acid (ASA), β-aminobutyric acid (BABA) and Salicylic acid (SA) were sourced from Sigma Aldrich Co. St. Louise, USA. Each activator (ASM, ASA, SA and BABA) was prepared at three different concentrations (25 µg/ml, 50 µg/ml and 75 µg/ml) by weighing and dissolving in sterile distilled water.

Bacterial isolation on selective medium, identification and inoculum preparation

Isolation of *R. solanacearum* was conducted from infected tomato plants obtained from FUNAAB and National Horticultural Research Institute (NIHORT) tomato fields. After bacterial ooze streaming inside test tube, 1 ml of the suspension was streaked on casamino acid-peptone glucose medium (CPG) agar and incubated for 48 hrs at 28^{o}C (Denny and Hayward, 2001). Pure culture was obtained through subculturing and the

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working concentration of the suspension was adjusted to 6 x 10^7cfu/ml through serial dilution. Simple staining and KOH solubility test were carried out according to Popoola *et al.* (2015) for identification.

Pathogenicity test of *R. solanacearum* on tomato

Using the technique of Denny and Hayward (2001) with modification, one month-old tomato (cv. Roma Round) seedlings were inoculated with 20 ml of *R. solanacearum* suspension (6 x 10^7 cfu/ml) using the foliar clip method, two weeks after transplanting. Seedlings were incubated at temperature between 25-28^{o}C with relative humidity maintained between 85 and 90%. Negative control seedlings were watered with sterile distilled water. Prior to inoculation, plants were left without water 24 hrs, thereafter, seedlings were watered regularly. Tested isolate was re-isolated on CPG.

Nursery and pre-transplanting application of plant resistance activators and *R. solanacearum*

Tomato seedlings were raised in the nursery using plastic trays filled with sandy-loam steam-sterilized soil. Plant activators were applied as foliar spray using a hand-held sprayer and as soil drenching at 14 and 21 days after seed emergence (Anith *et al*., 2004; Pradhanang, *et al*., 2005). Second application of plant activators was done 5 days prior to inoculation with *R. solanacearum* (Hassan and Abo-Elyousr, 2013; Ganiyu *et al*., 2017).

Transplanting and application of plant resistance activators

PRAs treated (foliar spray and soil drenching separately) at different concentrations (25 µg/ml, 50 µg/ml and 75 µg/ml) and untreated tomato seedlings (two) per pot were transplanted at 4 weeks old into polythene bags (38 cm high and 31 cm wide) filled with 15 kg of sterilized soil. The seedlings, 4 days after transplanting, were again subjected to foliar spray and soil drenching separately with PRAs and at weekly intervals, thereafter for 4 weeks using the same concentration regime (Anith *et al*., 2004; Pradhanang, *et al*., 2005). Each treatment comprised of 24 pots per replication.

Data Collection

Data were collected on bacterial wilt incidence, which was calculated as the percentage of the number of leaves wilted to the total number of leaves. Disease severity was evaluated using the 0-5 scale of Ganiyu *et al.* (2017) where: 0 = 0% plant wilted; 1 = 1–10% plant wilted; 2 = 10.01–25% plant wilted; 3 = 25.01–50%; 4 = 50.01–75% and 5= 75.01-100% plant wilted. Data on Plant height (cm), number of leaves/plant, number of flowers/plant, number of fruits/plant, and fruit yield (g/plant) were also collected.

2.6 Statistical analysis

Data were subjected to analysis of variance by SAS statistical package (2008) version 9.2 and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

Isolation of *R. solanacearum* on CPG medium, identification and pathogenicity test on tomato

White cream color bacterial pathogen was observed on Casamino Peptone Glucose (CPG) agar. The isolate was further subjected to KOH and simple staining tests. For KOH test, observation of slime thread was noted when the loop was raised from the slide. After streaming test, when the isolate was viewed under the microscope, a rod shape structure of the pathogen was observed. Based on the observation, the isolate was identified as *R. solanacearum.* The result of

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pathogenicity tested conducted on Roma Round cultivar showed that the bacterial isolate was indeed pathogenic on tomato plants. The development of wilt symptom was rapid leading to complete wilting of the plant occurred. There was no symptom development on tomato plant inoculated with sterile distilled water. The same bacterium was re-isolated from the diseased plant.

Effect of foliar and soil drench application of plant resistant activators on plant height (cm), number of leaves/plant and number of flowers/plants

Table 1 shows that plant height (cm) recorded for Perfect Pee tomatoes ranged from 121.70-151.00 cm while Roma round recorded plant heights ranged from 124.30 – 156.70 cm, when plant resistant activators were applied using foliar spray. Control plots had 70.30 cm and 79.30 cm plant height for Perfect Pee and Roma Round cultivars, respectively. Again, with the application of plant resistant activators using soil drenching method, plant heights ranged from 121.70 – 139.00 cm and 127.00-137.70 cm for Perfect Pee and Roma Round tomato, respectively. Plant height for control plots recorded 55.30 and 63.20 cm for Perfect Pee and Roma Round, respectively. Roma Round that received 50 µg/ml foliar application of Acetyl salicylic acid (ASA) had the highest plant height (156.70 cm), followed by 151.00 cm in Perfect Pee when foliar application of Salicylic acid at 25 µg/ml was received by it, which were not significantly different ($p \geq 0.05$) from each other. Generally, tomato plants that received foliar application had varying degree of significance in plant height and were mostly higher in values than those received soil drenching application of plant resistance activators.

Number of leaves for tomato that received foliar application of plant resistant activators ranged from 22.80-46.30 while those that received soil drench application ranged from 18.70-43.00. For foliar spray, the highest value of number of leaves (46.30) was recorded in Roma Round when β-Aminobutyric acid (BABA) was used at 25µg/ml concentration while the least value (22.80) was observed in the untreated control plant of Perfect Pee. Number of leaves (45.30) recorded for foliar application of ASA at 50 µg/ml concentration in Perfect Pee was not significantly different ($p \geq 0.05$) from 46.30 numbers of leaves recorded for Roma Round that received BABA at 25 µg/ml concentration. Perfect Pee that was soil-drenched with 50 µg/ml ASA had the highest number of leaves (43.00) while Roma Round also had the highest number of leaves (43.00) when BABA was soil-drenched at 25 µg/ml concentration.

The highest number of flowers (20.30) was recorded in Perfect Pee that received foliar applications of Salicylic acid (SA) at 25 µg/ml concentration while the least number of flowers (7.90) was observed in untreated control Roma Round. The highest number of flowers (20.30) recorded in Perfect Pee was not significantly different ($p \geq 0.05$) from 14.70 number of flowers recorded in both Perfect Pee and Roma Round when ASA was applied foliarly at 50 µg/ml concentration. Roma Round had the highest number of flowers of 18.30 when BABA was soil-drenched at 75µg/ml concentration, which was significantly different ($p \leq 0.05$) from the least number of flowers (6.20) observed in untreated control Roma Round.

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Table 1: Effect of foliar spray and soil drench application of plant resistant activators at different concentrations on plant height (cm), number of leaves/plant and number of flowers/plant of two tomato cultivars

Cultivar	Plant resistant activator	Concentration (µg/ml)	Plant height (cm)		Number of leaves/plants		Number of flowers/plants	
			Foliar spray	Soil drenching	Foliar spray	Soil drenching	Foliar spray	Soil drenching
Perfect pee	ASM	25	133.30abc	139.00a	37.70abc	34.30ab	10.70b	12.70a-d
		50	132.00abc	123.70a	38.70abc	38.30ab	10.00b	11.30a-d
		75	121.70abc	121.70a	33.00abc	35.00ab	9.30b	8.00bcd
	BABA	25	122.30abc	122.30a	37.70abc	33.70ab	10.00b	8.00bcd
		50	133.00abc	129.00a	39.00abc	35.70ab	10.30b	13.00a-d
		75	131.70abc	124.30a	43.00abc	33.70ab	11.00ab	9.70a-d
	SA	25	151.00a	128.70a	42.70abc	41.00ab	20.30a	11.30a-d
		50	136.30ab	123.00a	35.00abc	35.70ab	12.00ab	12.70a-d
		75	131.30abc	135.00a	37.70abc	37.00ab	10.00b	14.70a-d
	ASA	25	129.70abc	137.00a	37.00abc	35.00ab	11.30ab	10.70a-d
		50	136.30ab	133.00a	45.30ab	43.00a	14.70ab	15.30a-d
		75	128.00abc	138.30a	39.00abc	40.30ab	10.70b	16.70ab
	Control	0	70.30c	55.30b	22.80c	18.70b	8.40b	6.70cd
Roma round	ASM	25	145.00ab	130.30a	37.00abc	33.00ab	10.30b	13.30a-d
		50	137.00ab	128.30a	37.00abc	35.70ab	12.00ab	16.30a-c
		75	135.70ab	127.00a	35.00abc	33.70ab	11.30ab	11.70a-d
	BABA	25	143.70ab	135.70a	46.30a	43.00a	11.30ab	13.30a-d
		50	133.00abc	134.30a	35.70abc	37.00ab	11.30ab	13.70a-d

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	75	128.30abc	137.70a	35.00abc	36.30ab	12.70ab	18.30a
SA	25	125.70abc	131.00a	35.00abc	36.30ab	9.30b	10.00a-d
	50	124.30abc	134.30a	33.70abc	31.70ab	14.30ab	13.30a-d
	75	134.30ab	131.70a	38.30ab	37.00ab	12.00ab	12.00a-d
ASA	25	144.30ab	131.70a	35.70abc	39.00ab	13.70ab	12.00a-d
	50	156.70a	134.30a	38.30ab	35.00ab	14.70ab	13.00a-d
	75	133.70abc	135.70a	33.70abc	41.00ab	11.30ab	10.70a-d
Control	0	79.30bc	63.20b	24.90bc	22.70ab	7.90b	6.20d

Means followed by the same alphabets in a column are not significantly different according to DMRT at 5% probability level. ASM= Acibenzolar-S-methyl; BABA= β-Aminobutyric acid; SA=Salicylic acid; ASA=Acetyl Salicylic acid.

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Effect of foliar and soil drenches application of plant resistant activators on bacterial wilt incidence (%), severity and fruit yield (g/plant) of tomato

There was no disease symptom on both Perfect Pee and Roma Round for either foliar spray or soil drench application of plant resistant activators (Table 2). Both Perfect Pee and Roma Round in untreated control pots (foliar and soil drench) had 100% disease incidence, which were significantly higher than and different ($p \leq 0.05$) from 0.00% disease incidence in both application methods, irrespective of concentrations. Similar trend was observed in Perfect Pee bacterial wilt severity, where 3.10 and 5.00 disease severity for both foliar spray and soil drench, respectively. These values were significantly higher than and different ($p \leq 0.05$) from 0.00 disease severity for both foliar spray and soil drench, respectively. Likewise, Roma Round in untreated control pots had 4.70 and 5.00 severity and these values were significantly higher than and different from 0.00 disease severity obtained for both foliar spray and soil drench, respectively.

For foliar spray, the highest number of fruits (30.30) was recorded for Perfect Pee when foliar application of ASA at 75µg/ml, which was not significantly different ($p \geq 0.05$) from 22.00 numbers of fruits, obtained at 50µg/ml of the same plant resistant activator (ASA) (Table 3). The least number of fruits (3.90) for foliar spray was recorded in untreated control pots that contained Roma Round, which was not significantly different ($p \geq 0.05$) from 4.70 number of fruits in untreated control pots of Perfect Pee. ASA at 50µg/ml soil drench application top the list with 23.70 numbers of fruits in Roma Round, which was significantly higher ($p \leq 0.05$) than the least number of fruits of 3.30 and 3.60 in untreated control pots of Roma Round and Perfect Pee, respectively. The highest fruit yield (38.70 g/plant) was recorded for ASA foliar spray-treated Perfect Pee, which was significantly different ($p \leq 0.05$) from the least fruit yield observed from 4.60 g/plant in Roma Round when SA was foliarly applied at 50µg/ml. For soil drenching, the highest fruit yield (37.80 g/plant) was recorded in pots with Perfect Pee when SA was applied at 25µg/ml, which was not significantly different ($p \geq 0.05$) from 37.20 g/plant but significantly different from 8.10 g/plant when Acibenzolar-S-methyl (ASM) was soil-drenched on Roma Round at 50µg/ml concentration.

DISCUSSION

The experiment was carried out in the screen house to determine the best performing plant resistance activators (PRAs) namely; Acibenzolar-S-methyl (ASM), β-Aminobutyric acid (BABA), Salicylic acid (SA) and Acetyl Salicylic acid (ASA); best concentration level and the effective techniques (foliar and soil drench) of application on two tomato cultivars (Perfect Pee and Roma Round) based on low bacterial wilt incidence, severity and high yield. PRAs were individually prepared at 25 µg/ml, 50 µg/ml and 75 µg/ml and were applied as foliar spray and soil drenching to evaluate their effects on bacterial wilt of tomato caused by *Ralstonia solanacearum.*

Bacterial suspension (6 x 10^7 cfu/ml) inoculated combined with PRAs application had varying degree of successes on the growth and fruit yield of the cultivars used in this study. The result showed that all the tested concentrations of the PRAs induced resistance in tomato against *R. solanacearum.* This finding agrees with the report of Hassan and Abo-Elyousr (2013) who stated that treating plants with PRAs induced resistance against *R. solanacearum*. Plant resistance activators (PRAs) induce systemic acquired resistance (SAR) in plants and have been

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shown to induce host resistance in tomato to bacterial wilt without environmental and health hazard (Qiu *et al.,* 1998). However, the induced resistance was attributed to varieties of metabolic and biochemical defense responses (Radwan, 2012; Takeshita *et al*., 2013; Abo-Elyousr *et al*., 2022) which enhance plants growth (El-Gamal *et al*. 2003; Hassan and Abo-Elyousr, 2013) as observed in this study with PRAs- treated tomato plants performed better than the untreated *R. solanacearum* inoculated control.

Table 2: Effect of foliar spray and soil drench application of plant resistant activators at different concentrations on bacterial wilt incidence (%) and severity of two tomato cultivars

Cultivar	Plant resistant activator	Concentration (µg/ml)	Bacterial wilt incidence (%)		Bacterial wilt severity (%)	
			Foliar spray	Soil drenching	Foliar spray	Soil drenching
Perfect Pee	ASM	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b
	BABA	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b
	SA	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b
	ASA	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b
	Control	0	100a	100a	3.10a	5.00a
Roma Round	ASM	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b
	BABA	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b
	SA	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b

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	ASA	25	0.00b	0.00b	0.00b	0.00b
		50	0.00b	0.00b	0.00b	0.00b
		75	0.00b	0.00b	0.00b	0.00b
	Control	0	100.00a	100.00a	4.70a	5.00a

Means followed by the same alphabets in a column are not significantly different according to DMRT at 5% probability level. ASM= Acibenzolar-S-methyl; BABA= β-Aminobutyric acid; SA=Salicylic acid; ASA=Acetyl Salicylic acid.

Table 3: Effect of foliar spray and soil drenches application of plant resistant activators at different concentrations on number of fruits/plant and fruit yield (g/plant) of two tomato cultivars

Cultivar	**Plant resistant activator**	**Concentration (µg/ml)**	**Number of fruits/plant**		**Fruit yield (g/plant)**	
			Foliar spray	Soil drenching	Foliar spray	Soil drenching
Perfect Pee	ASM	25	16.70bcd	7.70e-g	30.10ab	13.40d-g
		50	9.00def	14.70b-f	17.20d-h	37.20a
		75	9.30def	14.70b-f	22.70b-g	29.80a-e
	BABA	25	9.00def	12.70c-f	22.90b-g	31.70abc
		50	8.70def	6.00fg	23.40a-g	18.20fg
		75	12.30c-f	11.00c-g	25.90a-f	30.20a-d
	SA	25	11.70c-f	17.70a-d	27.20a-d	37.80a
		50	6.70ef	10.70c-g	17.30d-h	26.70a-f
		75	14.70b-e	6.00fg	34.40abc	11.40fg
	ASA	25	9.00def	16.70a-e	20.10c-h	32.90ab
		50	22.00ab	15.70a-e	38.70a	26.70a-f
		75	30.30a	15.70a-e	22.40b-g	23.30a-g
	Control	0	4.70f	3.60g	16.60d-h	15.30fg
Roma Round	ASM	25	11.00c-f	9.00d-g	9.80f-h	8.10fg
		50	10.70c-f	18.70abc	12.00d-h	16.80b-g
		75	9.00def	7.70e-g	13.60d-h	10.70fg
	BABA	25	21.00b	11.70c-g	22.20b-g	26.50b-g
		50	8.00ef	9.70c-g	9.60gh	12.80e-g
		75	18.70bc	18.70abc	26.5a-e	28.50b-g
	SA	25	13.30cde	12.00c-g	10.50e-h	14.40d-g

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	50	6.70ef	11.00c-g	4.60h	15.70c-g
	75	7.00ef	22.70ab	16.60d-h	24.80a-g
ASA	25	9.70c-f	8.00e-g	11.90d-h	10.90fg
	50	18.70bc	23.70a	25.20a-g	30.00a-f
	75	7.70ef	15.00a-e	14.50f-h	15.40c-g
Control	0	3.90f	3.30g	19.40d-h	12.80g

Means followed by the same alphabets in a column are not significantly different according to DMRT at 5% probability level. ASM= Acibenzolar-S-methyl; BABA= β-Aminobutyric acid; SA=Salicylic acid; ASA=Acetyl Salicylic acid.

Plant height, number of leaves and fruit yield were consistently higher when PRAs were applied using either foliar or soil drenching than plants in untreated control condition. The finding also corroborated with the study of Anith *et al*. (2004) and Cohen *et al*. (2015) which reported that some levels of host resistance to a pathogen could be enhanced by plant resistance activators. The result showed that all tested concentrations of either ASM; BABA; SA and ASA produced resistance against *Ralstonia solanacearum* pathogen but foliar application of ASA at 50 µg/ml concentration outstandingly produced highly significant result in growth and yield parameters. Almoneafy *et al*. (2013) reported that bio-control efficacy of *Bacillus subtilis* (strain 4812) and *Bacillus methylotrophicus* (strain H8) individually or in combination with two plant resistance activators acetylsalicylic acid (ASA) and DL-Beta-aminobutric acid (BABA) against tomato wilt caused by *Ralstonia solanacearum* was significantly inhibited in the screen house and in-vitro test when applied on seed and as soil drench. El-Gamal *et al*. (2003) found out that bean seed dressed with ASA followed by foliar spray with the same components at different concentrations caused yield improvement. This effect might be attributed to the fact that ASA diffuses more easily through growth medium than other PRAs which are less soluble and toxic to the growth of *Rhizoctonia solani* (Nehal, 2004). El-Mougy (2002) also reported that acetylsalicylic acid had antimicrobial effect on some fungal and bacterial plant pathogens and completely inhibited their growth at certain concentrations under in-vitro conditions.

CONCLUSION

Foliar application of ASA at 50 µg/ml proved to be the most effective in curbing the effects of *R. solanacearum* on tomato plants which translated to yield increase, compared with other plant resistant activators. Acetylsalicylic acid (ASA) did not exhibit any toxic effects on the plants and is deemed safe for the environment and will be a useful tool in Integrated Pest Management (IPM). Further research in open field is recommended.

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