

Production and effect of vermiwash singly and in combination with vermicompost on the growth, development, and productivity of tomatoes in the greenhouse in Suriname

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Abstract. Awadhpersad VRR, Ori L, Ansari A. 2021. Production and effect of vermiwash singly and in combination with vermicompost on the growth, development, and productivity of tomatoes in the greenhouse in Suriname. *Asian J Agric* 5: 29-34. In Suriname farmers often largely rely on high inputs of synthetic fertilizers and pesticides to achieve high yield. To overcome this, sustainable agriculture seeks to introduce agricultural practices that are environmentally sound, economically viable, and socially supportive. In the present study, the effect of vermicompost and vermiwash and in combination was evaluated on the growth and yield of tomato (*Lycopersicon esculentum* Mill.) in the greenhouse. The experiment was a Randomized Block Design with four treatments and three replications. The growth parameters were measured for plant height, shoot wet and dry weight, root weight, and length, and yield in terms of the number of fruits and fruit weight. The produced vermiwash was a brownish colored liquid and had all the essential macro and micro plant nutrients, which indicates an environmentally friendly enriched nutrient liquid fertilizer for sustainable agriculture. The research results at harvest time indicated that the plant height, shoot fresh and dry weight, root weight, root density, root length, yield and fruit weight were higher for the plants treated with a combination of vermicompost and vermiwash. It was also noted that the flowering and fruiting ratio were significantly enhanced by application of vermiwash as a foliar spray. The combination of vermicompost and vermiwash (50 g + 50 mL) significantly ($p < 0.05$) resulted in the highest yielding plants, followed by vermiwash (100 mL) and vermicompost (100 g).

Keywords: Biofertilizer, earthworms, organic tomato, vermicompost, vermiwash

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to the Solanaceae family and is a popular vegetable widely grown in the tropics, including Suriname. According to the Ministry of Agriculture, Animal Husbandry and Fisheries (LVV) statistical data, the total tomato production area in 2017 was approximately 119 ha. with a total yield of 1.442 tons of tomato fruits, which makes tomato one of the most cultivated crops in Suriname. This crop is an excellent source of minerals and vitamins, including iron, phosphorus, vitamin A and C (Bhowmik et al. 2012).

In Suriname, agricultural practices largely rely on high inputs of synthetic fertilizers and pesticides to achieve high yield and protect the crops against pathogens and pests. Excessive use of fertilizers and pesticides leads to gradual degradation of soil fertility and microbiological diversity (Samadhiya et al. 2013). This decline in soil quality further leads to water and land pollution, thereby lowering the land's worth.

The massive application of pesticides and synthetic fertilizers also leads to high residue levels in crops, which is bad for human health. Nowadays, consumers are more aware of the food they consume and the chemicals that are used for crop production. Therefore, it is very important to seek alternative bio-fertilizers as a supplement for chemical fertilizers.

Presently, there is a strong interest in alternative strategies to ensure competitive yields, protection of crops, environment, and the health of humankind. Sustainable agriculture seeks to introduce agricultural practices that are environmentally sound, economically viable, and socially supportive. In this context, alternative sources such as microbial inoculants and composted products are considered to meet the nutrient requirements of crops.

Earthworms are known to decompose organic waste into nutrient-rich vermicasts through the combined action with microorganisms. The produced vermicompost is reported to be rich in nitrogen (N), phosphorus (P), potassium (K) and micronutrients, with a greater rate of microbial and enzymatic activities. Several researchers found that vermicompost has a positive effect on the growth, development, flowering, and yield of plants. It has also been noted that vermicompost increases the root apparatus and the biomass production of the plants and improves the soil fertility (Manyuchi 2016; Zafarian and Rezvani 2016).

The by-product of the vermicomposting process, which is termed vermiwash is a brownish colored substance that is formed due to the movement of water in the vermicomposting units through the burrows formed by the earthworms. This liquid is reported to be rich in NPK components, micronutrients, plant growth hormones, microbes, and enzymes. It is used as a foliar spray that

plants can easily absorb (Manyuchi et al. 2013; Kaur et al. 2015). The foliar application of vermiwash is also reported to have a pesticide effect, with plants showing less or no incidence of diseases and pests (Verma et al. 2018).

Both vermicompost and vermiwash are used as bio-fertilizers in sustainable agriculture practices. It is reported that the combined use of vermiwash and vermicompost leads to the highest yielding plants with more branches, higher number of capsules, higher plant dry weight, improve root growth parameters, improve physicochemical, biological, and microbiological properties of the soil (Makker et al. 2017). Improving the growing conditions with vermiwash and vermicompost enhance the quality of the crop, by increasing their nutrition status, which also improves the sustainability of commercial agriculture in a less tangible, but equally important way, since the main goal of agriculture is to grow food for the well-being of the population. Therefore, this research aims to provide an insight on how to produce vermiwash out of organic waste material and its effect on crop production singly and in combination with vermicompost.

MATERIALS AND METHODS

Production of vermiwash

The research was conducted in the vermicomposting station at the Anton de Kom University of Suriname at the Leysweg, Paramaribo. The experiment was set up in 9 plastic buckets. The *Eisenia foetida* earthworms were collected from the existing vermicomposting station.

The Vermiwash culture bed was prepared in plastic bucket of 20 liters and a tap was fixed at the lower side of each bucket to regulate the water supply. The basal layer consisted of pebbles (4.5 cm) and a layer of coarse sand (4.5 cm) to ensure proper drainage. On top of the basal layer a layer of loamy soil (8 cm) was placed and moistened. Approximately 50 earthworms were introduced per bucket of different age groups of juveniles, non-clitellate and clitellate earthworms. On top of the soil fresh/dry cattle dung was scattered (4.5 cm) and a combination of dry grass clippings and dry neem leaves was added.

Approximately after 60 days of vermicomposting the tap was closed. On top of the bucket, a water sprinkler was hung. About 1 liter of water (the volume of water is 1/20 of the size of the bucket) was poured into the sprinkler and allowed to gradually sprinkle on the bucket overnight. The tap was opened the next day to collect the Vermiwash.

The physicochemical analysis was conducted for the obtained vermiwash, the vermicompost of rice straw collected from the existing vermicompost unit, and the initial and final soil samples using the methods described according to the soil laboratory prescriptions of the Anton de Kom University of Suriname.

Cultivation of tomato plants

Experimental site

The research was conducted at the Anton de Kom University of Suriname at the Leysweg, Paramaribo, with latitude/longitude: 5° 48' 29.99" N/55° 12' 35.40" W and with an altitude of 3 m above sea level. The mean maximum and minimum day temperatures (C) in the greenhouse were 30.61 & 29.50 respectively. Relative humidity ranged from 70.97 - 77.81%.

Experimental layout/set-up

The experiment was set up in the greenhouse in pots from March to August 2018. The experiment was a Randomized Block Design (RBD) with 4 treatments and 3 replications. Each block consisted of four rows and seven plants per row. The treatments are given in Table 1.

For the implementation of the experiment three-week old tomato seedlings of the variety Delhi 501 were used. These were transplanted in earthen plant pots of a volume of 12 liters. Before transplanting, the earthen plant pots were irrigated, and plant holes were made. Initially, the amount of fertilizer was added, according to the treatments in the plant holes, after which the tomato plants were transplanted. Afterward, according to the treatments, the tomato plants were fertilized at an interval of two weeks, and vermiwash was used as a foliar spray. In total, during the cultivation period, the tomato plants were four times fertilized. The total amount of fertilizer added per plant is given in Table 2.

During the cultivation period of the tomato plants once a week the plant height was measured. At the end of the experiment, the root length was measured, and the biomass was determined, with wet and dry weight of the shoots and roots. For the production, the number and weight of fruits per plant were recorded. Data were pooled from all replications to calculate the average yield per plant.

Table 1. Treatments and their added quantities per plant

Treatment	Quantity added per plant
Control	No additives
Vermicompost	100 g
Vermiwash	100 mL
Combination of vermicompost and vermiwash	50 g + 50 mL

Table 2. Total amount of fertilizer added per plant

Treatment	Total amount added per plant
Control	No additives
Vermicompost	400 g
Vermiwash	400 mL
Combination of vermicompost and vermiwash	200 g + 200 mL

RESULTS AND DISCUSSION

Physicochemical properties of vermiwash

The harvested vermiwash from the beginning till day 60, showed a color change in the liquid from transparent to light yellow to brown, where the maximum nutrient value of the vermiwash was found.

The physicochemical properties of the vermiwash indicated the presence of nutrients in a significant quantity, which is also confirmed by Ansari and Sukhraj (2010); Kaur et al. (2015). The results of the physicochemical properties are shown in Table 3 and agree with the work done by Ansari and Sukhraj (2010). Although it had to be noted that several researchers found different nutritional value for the vermiwash, because the nutritional value depends on the feed used for the vermicomposting process and quality of the vermicompost (Kaur et al. 2015; Zaefarian and Rezvani 2016).

Physicochemical properties of the soil

The physicochemical properties of the soil at the beginning and at the end of the experiment are shown in Table 4. The soil analysis at the beginning of the experiment showed that the pH was alkaline; this result was obtained due to the fact that for the soil analysis the sample was ground fine and so the shells in the sample, were the cause that the result was alkaline. Measurement of the sample with the soil pH meter showed that the pH was almost natural. The physicochemical properties of the soil were acceptable for the cultivation of the tomato plants.

At the end of the experiment, a mixed sample was taken from each treatment to determine the nutrient values. Comparison of the soil nutrient at the beginning and at the end of the experiment showed that there was no difference (Table 4). At the end of the experiment, the nutrient values of the treated soils for Exchangeable P, K, Ca, and Mg were slightly higher than the nutrient value of the soil at the beginning of the experiment. The overall highest value is seen for the combination treatment.

As reported by researchers, the combination of vermicompost and vermiwash has a positive effect on the biochemical characteristics of the soil, there are marked improvements in soil micronutrients, physical and chemical properties (Ansari and Sukhraj 2010; Tharmaraj et al. 2011).

It is also reported that vermicompost has enzymes that break down the organic matter in the soil to release the nutrients, so it rejuvenates the depleted soil fertility, increases the water holding capacity, maintains the soil quality, and enriches the nutrient composition (Adhikary 2012; Prabina et al. 2018).

Vegetative growth

Plant height

The results obtained showed that all the plants are grown on vermicompost and vermiwash singly and in combination had a significant shoot growth (Table 5). The

tallest plants were observed for the plants fertilized with a combination of vermicompost and vermiwash (112.62 \pm 4.33 cm), which also had the maximum (98.69 cm) increase in height. The control plants showed minimum shoot growth because the nutrients were not available in sufficient quantity. The results of the LSD test showed that there was a significant difference between the treated and the control plants ($p < 0.05$) and between the vermicompost and combination plants ($p = 0.005$). There was no significant difference between the vermicompost and vermiwash plants ($p = 0.175$) and the vermiwash and combination plants ($p = 0.148$).

Vermicompost and vermiwash are reported to be rich in nitrogen (N), phosphorus (P), potassium (K), and micronutrients, with a greater rate of microbial and enzymatic activities (Manyuchi et al. 2013; Zaefarian and Rezvani 2016). They also contain hormones like auxins, cytokinesis, gibberellins, and humic acids, which are responsible for plant growth. It is also reported that vermicompost and vermiwash are enriched in certain metabolites and vitamins that belong to the B group and provitamin D which help to enhance plant growth (Jaikisun et al. 2014; Lujan-Hdalgo and Celina 2016).

Table 3. Physicochemical properties of vermiwash harvested at day 60

Parameters	Vermiwash
pH H ₂ O	7.30
EC (mS)	8.93
Tot. N (ppm)	216.00
Tot. P (ppm)	70.00
Tot. K (ppm)	1327.63
Tot. Ca (ppm)	258.17
Tot. Mg (ppm)	210.54
Tot. Na (ppm)	245.16

Table 4. Physicochemical properties of the soil at the beginning and at the end of the experiment

Parameters	Begin	End of the experiment			
		C	V	W	VW
pH H ₂ O	8.10	8.30	8.00	7.90	7.90
EC (mS)	2.40	2.13	3.02	2.63	3.08
CEC (meq/100 g)	8.48	10.40	8.89	9.30	9.45
Org. C (%)	4.29	4.21	3.66	4.46	3.87
Tot. N (%)	0.24	0.18	0.22	0.19	0.21
Tot. P (%)	0.01	0.02	0.03	0.04	0.04
Tot. K (%)	0.05	0.07	0.07	0.09	0.09
Tot. Ca (%)	6.21	7.55	7.38	8.82	9.00
Tot. Mg (%)	0.18	0.18	0.17	0.19	0.21
Tot. Na (%)	0.36	0.31	0.38	0.41	0.42

Note: Treatment codes; C: Control; V: Vermicompost; W: Vermiwash; VW: Vermicompost + Vermiwash

Table 5. Plant height (Mean \pm SEM) and % increase

Week	Treatments			
	C	V	W	VW
1	11.40 \pm 1.87	12.71 \pm 1.76	12.79 \pm 1.70	13.93 \pm 1.33
2	13.42 \pm 2.11	20.88 \pm 2.45	17.48 \pm 2.21	22.93 \pm 1.62
3	19.69 \pm 2.73	29.40 \pm 6.76	29.26 \pm 5.19	36.21 \pm 3.62
4	26.17 \pm 3.88	47.48 \pm 9.70	46.10 \pm 7.93	54.67 \pm 4.32
5	30.57 \pm 6.27	57.59 \pm 9.72	58.17 \pm 8.05	66.67 \pm 6.42
6	41.36 \pm 7.89	69.69 \pm 5.25	78.62 \pm 6.63	82.90 \pm 3.52
7	53.81 \pm 8.03	80.80 \pm 8.19	89.29 \pm 7.58	92.52 \pm 4.07
8	67.38 \pm 6.87	89.14 \pm 9.54	98.95 \pm 7.74	100.00 \pm 7.31
9	79.62 \pm 6.79	94.43 \pm 11.90	106.33 \pm 8.64	108.90 \pm 5.51
10	85.38 \pm 7.37	100.90 \pm 11.69	108.81 \pm 11.16	112.62 \pm 4.33
Increase (cm)	73.98	88.19	96.02	98.69
Increase (%)	87	87	88	88
Ranking	a	b	bc	c

Note: The different letters of the ranking are significantly different at $P \leq 0.05$ according to LSD multiple range test. Treatment code: C: Control; V: Vermicompost; W: Vermiwash; VW: Vermicompost + Vermiwash

Shoot fresh and dry weight

The LSD test for shoot fresh and dry weight showed that there was a significant difference between the treatments ($p = 0.000$). The highest average shoot fresh and dry weight between the treatments were recorded for the plants fertilized with vermiwash (W) (resp. 1107 \pm 0.45 g, 320 \pm 0.40 g) and the lowest for the control plants (C) (resp. 160 \pm 4.04 g, 83 \pm 0.21 g). The moisture content was the highest for the plants fertilized with vermicompost (810 g) and the lowest for the control plants (77 g) (Table 6), which means that the plants fertilized with vermicompost had more moisture in their tissue. This result is in line with the fact that vermicompost has a moisture content of about 32 - 66% and is humus like sweet-smelling compost material (Adhikary 2012).

According to a study on plant biomass of strawberries, addition of vermicompost increased the plant dry weight (Joshi and Vig 2010). As for the addition of vermiwash, it has been reported that it exhibited growth-promoting effects on the exo-morphological characters such as plant height, length and diameter of the internode, number of leaves, leaf surface area and wet and dry weight of the shoot (Samadhiya et al. 2013; Kaur et al. 2015). A study about the effect of vermiwash on the growth parameters of brinjal plants found that the results from the vermiwash were a little bit higher compared to the vermicompost which is also seen in this research (Jaybhaye et al. 2015).

Another study reported that the combination of vermiwash and vermicompost resulted in the highest plant dry weight (Makker et al. 2017).

Root fresh and dry weight and root length

The highest root fresh and dry weight was measured for the combination treatment and the lowest for the control plants, with respectively the maximum moisture content of 123.33 and the minimum of 3.33. The results of the LSD test for the root dry weight showed that there was a significant difference between all the treatments ($p < 0.05$) (Table 7).

The plants treated with the combination of vermicompost and vermiwash had the longest roots (97.67 \pm 5.51 cm), followed by the plants treated with vermiwash (91.33 \pm 8.08 cm), vermicompost (78.33 \pm 14.01 cm), and the control plants (38.67 \pm 1.53 cm). The LSD test also showed that there was a significant difference between the treated and control plants ($p = 0.000$) and between the plants treated with vermicompost and a combination of vermicompost and vermiwash ($p = 0.101$) (Table 8.).

According to Tomati et al. in 1988, earthworm casts promote root initiation, root biomass and root percentage. It is also reported that vermicompost has a positive effect on plant development and promotes root length (Jaikisun et al. 2014). Studies also suggested that the use of vermicompost and vermiwash separately increase the wet and dry weight of roots and root length, and the combination of vermicompost and vermiwash have much better results (Samadhiya et al. 2013; Sundarasu and Jeyasankar 2014; Kaur et al. 2015; Makker et al. 2017). The effect of vermiwash and vermicompost on the enhanced root growth parameters can be attributed to the presence of humic and fulvic acids. These compounds have been shown to increase plant height, dry and fresh weight of plants and roots as well as enhance nutrient uptake by increasing the root cell membrane permeability (Wright and Lenssen 2013; Makker et al. 2017).

Table 6. Shoot fresh – and dry weight (Mean \pm SEM) in grams and moisture content (%)

Treatment	Shoot fresh weight (Mean \pm SEM)	Shoot dry weight (Mean \pm SEM)	Moisture content (%)
C	160 \pm 4.04 a	83 \pm 0.21 a	77
V	1030 \pm 0.80 b	220 \pm 0.26 b	810
W	1107 \pm 0.45 c	320 \pm 0.40 c	787
VW	1070 \pm 0.70 d	286 \pm 0.25 d	784

Note: Values followed by different letters are significantly different at $P \leq 0.05$ according to LSD multiple range test. Treatment code: C: Control; V: Vermicompost; W: Vermiwash; VW: Vermicompost + Vermiwash

Table 7. Root fresh – and dry weight (Mean \pm SEM) in grams and % moisture content

Treatment	Root fresh weight (Mean \pm SEM)	Root dry weight (Mean \pm SEM)	Moisture content (%)
C	8.00 \pm 1.73 a	4.67 \pm 1.53 a	3.33
V	110 \pm 17.32 b	46.67 \pm 7.63 b	63.33
W	84.33 \pm 3.79 b	19.33 \pm 1.15 c	65
VW	213.33 \pm 77.67 c	90.00 \pm 10.00 d	123.33

Note: Values followed by different letters are significantly different at $P \leq 0.05$ according to LSD multiple range test. Treatment code: C: Control; V: Vermicompost; W: Vermiwash; VW: Vermicompost + Vermiwash

Table 8. Average root length (Mean \pm SEM)

Treatment	Root length (Mean \pm SEM)
C	38.67 \pm 1.53 a
V	78.33 \pm 14.01 b
W	91.33 \pm 8.08 bc
VW	97.67 \pm 5.51 c

Note: Values followed by different letters are significantly different at $P \leq 0.05$ according to LSD multiple range test. Treatment code: C: Control; V: Vermicompost; W: Vermiwash; VW: Vermicompost + Vermiwash

Table 9. Average number of fruits – and fruit weight per plant (Mean \pm SEM)

Treatment	Number of fruits per plant (Mean \pm SEM)	Fruit weight per plant (Mean \pm SEM)
C	-	-
V	25.43 \pm 3.61 a	1295.34 \pm 183.67 a
W	32.86 \pm 2.86 b	1673.51 \pm 145.52 b
VW	38.81 \pm 0.41 c	1919.88 \pm 20.40 c

Note: Values followed by different letters are significantly different at $P \leq 0.05$ according to LSD multiple range test. Treatment code: C: Control; V: Vermicompost; W: Vermiwash; VW: Vermicompost + Vermiwash

During this research, vermiwash was used as a foliar spray and not applied to the roots. In comparison to the control plants, vermiwash plants had a bigger and longer root system, which is caused by the available nutrients, hormones, and enzymes present in the vermiwash. This could also be the reason why the roots of the vermicompost treatment were bigger than the roots of the vermiwash treatment. The enhanced results of the combined effect of vermicompost and vermiwash are shown in the combination treatment of vermicompost and vermiwash, where the root structure was the biggest and the roots the longest.

Production of tomato plants

The yield results indicated that the treatments significantly differed from each other ($p < 0.05$). The highest

average yield (16.52 ± 1.01) and fruit weight (646.71 ± 68.09 g) per plant were recorded for the plants treated with the combination of vermicompost and vermiwash and the lowest average yield (9.38 ± 0.44) and fruit weight (380.52 ± 31.88 g) per plant for the plants treated with vermicompost only (Table 9). There has also been observed that the plants treated with the combination of vermicompost and vermiwash induced early flowering.

The results of the research at harvest time indicated that the plant height, shoot fresh and dry weight root weight, root density, root length, yield and fruit weight were higher for the plants treated with a combination of vermicompost and vermiwash. It was also noted that the flowering and fruiting ratio were significantly enhanced by application of vermiwash as a foliar spray, which was in line with the research done by Makker et al. in 2017. The results also showed that when vermicompost and vermiwash were used separately, they had a positive effect on plant growth, development, and yield. Studies revealed that the application of vermicompost and vermiwash separately and in combination enhance the plant growth parameters (plant height, stem thickness, and number of leaves) and yield parameters (number of flowers, fruits per plant and fruit weight) (Jaybhaye et al. 2015; Kaur et al. 2015; Maheswari et al. 2016; Makker et al. 2017).

It is also stated that foliar application of vermiwash shortens the life cycle of flowering and fruiting plants and that the fruits obtained from the combination of vermiwash and vermicompost showed even and uniform ripening (Makker et al. 2017). It is suggested that uniform maturing and fruit ripening is achieved with foliar spray of vermiwash (Makker et al. 2017).

Research investigators also stated that the flowering and fruiting ratio significantly increased for the plants treated with a combination of vermicompost and vermiwash (Sundrarasu and Jeyasankar 2014; Maheswari et al. 2016).

In summary, from this research, it can be concluded that the produced vermiwash was a brownish-colored liquid. It had all the essential macro and micro plant nutrients like N, P, K, Ca, Mg and Na which indicated the achievement of an environmentally friendly enriched nutrient liquid fertilizer. Vermicompost, vermiwash, and the combination of vermicompost and vermiwash as a biofertilizer had a positive effect on the plant growth parameters and yield parameters. The combination of vermicompost and vermiwash resulted in early reproduction and the highest yielding plants. Furthermore, the analysis of the soil samples before and after harvesting indicated a slight difference of elements in the soil. The combination of vermicompost and vermiwash notably enriched the soil with plant-available P and K elements.

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