Effect of Effective Microorganisms and Vermiwash on Yield and Quality of Lettuce (*Lactuca sativa* L.) in Hydroponic Cultivation

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***Abstract*—** The study investigated the effect of foliar spraying of vermiwash (VW) and effective microorganisms (EM) on lettuce. Six treatments viz. EM (1:100 v/v) - T1; 1:10 (v/v) VW- T2; 1:20 (v/v) VW – T3; 1:10 (v/v) VW + EM (1:100 v/v) - T4; 1:20 (v/v) VW + EM (1:100 v/v) - T5; without foliar spraying- T6 (control) were tested. Foliar spraying of EM and VW were done, respectively at 7 and 3 days interval. At harvesting, yield in lettuce plants were significantly increased in T1, T3, T5 and T6 than the T2 and T4. Total nitrogen content of leaf tissues was significantly increased in T5. The qualities of lettuce were significantly increased in EM and VW treated plants. The results of this experiment showed that the spraying of EM and 1:20 (v/v) VW + EM were suitable to enhance the quality of lettuce than growing lettuce with inorganic fertilizers alone.

***Keywords*—**Effective microorganisms, hydroponics, lettuce, vermiwash.

I. Introduction

VERMIWASH is an organic fertilizer collected after passage of water through a column of warm activation. It contains micro and macronutrients along with several plant growth hormones, enzymes and vitamins, which enhances the growth and productivity [1]-[2]-[3]-[4]. It also provides protection against diseases in crops [5]. Foliar applications of vermiwash are more advantageous due to absence of nutrient leaching, which is often encountered when performing soil amendments.

Effective Microorganisms (EM) is a commercial product that ensures greater consistency of microbial species composition and enhanced effectiveness of agricultural applications. Various effective microorganisms and physiological active substances are contained in EM. Therefore, it must be effective to improve the quality and productivity of soil and to increase the vegetable production [6].

Lettuce is an annual, attractive, high value salad type crop of the family Asteraceae. It has high demand in both local and export markets due a good source of vitamin A, C, Calcium and Phosphorous in Sri Lanka. Lettuce is cultivated mainly in up country of Sri Lanka under open field conditions as well as under Controlled Environmental Agriculture [7]. Lettuce becomes bitter taste when it expose to high night temperatures [8]-[9]. Thus, this study was designed to study the effect foliar spraying of vermiwash and EM on growth and yield of lettuce cultivated in a Dry Zone of Sri Lanka by placing the special focus on crop quality as it is a high value leafy vegetable which is consumed as a raw product.

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II. Materials And Methods

This study was carried out during the period from August 2015 to February 2016 at the Polytunnel of Faculty of Agriculture, Rajarata University of Sri Lanka. The site is located at Puliyankumala in Anuradhapura district of Sri Lanka. The average temperature at the polytunnel during the production period was 31^0C. A barrel having the capacity of 125 L was used for extraction of vermiwash. The basal layer of the barrel comprised of broken bricks followed by a layer of coarse sand (10 cm thick) in-order to ensure proper drainage. A layer (10 cm) of pre-decomposed mixture consisting cow dung, rice straw, leaves of *Gliricidia sepium* and *Tithonia diversifolia* and egg shells was placed at the top. 100 locally collected earthworms were introduced into the soil. Water was added to the unit in-order to keep it moist. The whole unit was kept for 15 days for incubation and during that period the tap of the barrel was kept open. The extraction was started after 15 days, by adding 2 liters of water per days and the extraction was continued for another 14 number of days. The extracted Vermiwash was subjected to chemical analysis at the laboratory of CIC agribusiness, Palwehera (Table 2). The commercially available EM was also used in foliar spraying.

Two weeks old lettuce seedlings in cell plug nurseries were transplanted in a stationary culture hydroponics system using Albert's fertilizer® at the rate of 1.5 g/L. The foliar applications *viz.* EM (1:100 v/v) - T1, 1:10 (v/v) VW- T2, 1:20 VW (v/v) – T3, 1:10 (v/v) VW + EM (1:100 v/v) - T4, 1:20 (v/v) VW + EM (1:100 v/v) - T5, without foliar spraying- T6 (control) were practiced. Those treatments were placed in complete randomize design with three replicates. VW was applied in three day intervals and EM was applied in weekly intervals in treatments where the VW and EM were included.

The following growth parameters were recorded at harvest (4 weeks after transplanting); i) number of leaves per plant (ii) leaf area (cm^2) (iii) shoot fresh weight (g/plant) (iv) shoot dry weight (g/plant). Physiological parameters namely; (i) photosynthetic rate (ii) conductance to water (iii) intercellular CO_2 concentration (iv) Transpiration rate were measured using LI-6400 XT portable photosynthesis system at 3 weeks after transplanting. Fresh lettuce from all treatments was subjected to organoleptic tests. The harvested lettuce was washed and prepared by chopping (dressings were not incorporated). Codes were tagged to identify treatments. Untrained panelist consisting 20 numbers (10 females and 10 males) were used. The

panelists were aged between 20 and 25 years. Traits evaluated were color, texture, taste, and overall acceptability. Evaluation was based on a scale of, 1- Dislike very much, 2- Dislike, 3- Neither like nor dislike 4- Like 5- Like very much.

Parametric data were analyzed by ANOVA for significance under α=0.05 and mean separation was done by Least Significant Difference. Data were analyzed by using standard Statistical Analytical System (SAS) version 9.1. The Results of organoleptic test was analyzed by using Friedman test in MINITAB.

III. Results And Discussion

A. Plant Growth Parameters

The shoot fresh weight and shoot dry weight were significantly (*p<0.05*) increased in the lettuce plants in control. The plants receiving single and combined treatments of Vermiwash (1:20 v/v) and EM (1:100 v/v) *i.e.* T1, T3, and T5, were not statistically significant with the control. The variation of leaf area also showed a similar trend of response as in the shoot growth. In a study conducted in field grown soybean treated with vermiwash and neem based pesticides showed that the productivity enhancement [10]. In this study, the shoot growth and leaf area were not enhanced in stationary culture hydroponics lettuce production system with foliar spraying of vermiwash and EM, compared to the control. It may due to poor extension of root system towards nutrient solution in stationary culture hydroponics system at its early stage of growth with foliar spraying of EM and vermiwash. Since the vermiwash contains small amount of nitrogen it would be insufficient to growth of the shoot portion in the lettuce (Table 2).

TABLE 1
GROWTH PARAMETERS IN LETTUCE AS AFFECTED BY THE TREATMENTS

Treatment	No. of leaves	Leaf area (cm^2)	Weight of shoots (g/plant)	
			Fresh weight	Dry weight
EM (1:100 v/v)	6.41 ab	1561.7 ab	24.69 a	2.57 a
1:10 (v/v) VW	5.91 ab	1049.9 b	15.37 ab	1.64 b
1:20 (v/v) VW	6.75 ab	1743.6 a	24.25 a	2.40 a
1:10 (v/v) VW + EM (1:100 v/v)	5.36 b	1125.4 b	15.69 b	1.56 b
1:20 (v/v) VW + EM (1:100 v/v)	6.33 ab	1743.6 a	24.14 a	2.46 a
Control	7.25 a	1823.9 a	30.43 a	2.74 a
CV%	12.79	21.21	20.24	17.12

EM, Effective microorganisms; VW, Vermiwash
In a column, values followed by a common letter are not significantly different at 5% probability

TABLE II
THE NUTRIENT COMPOSITION OF VERMIWASH USED IN THE EXPERIMENT

Nutrient element	Amount
pH	8.9
EC (µs/cm)	5680
Total N	0.01%
P	38 ppm
K	3400 ppm
Ca	ND
Mg	84 ppm
Cu	0.8 ppm
Fe	10.1 ppm
Mn	1.5 ppm
Zn	0.65 ppm

B. Plant Physiological Parameters

The photosynthetic rate was increased in the plants receiving single and combined treatment of EM (1:100 v/v) and 1:20 (v/v) VW in comparison to the control, but this increase was not statistically significant. The pattern of photosynthetic rate was observed for the six individual treatments followed in the order of 1:20 (v/v) VW +EM (1:100 v/v) > EM (1:100 v/v) > 1:20 (v/v) VW > 1:10 (v/v) VW + EM (1:100 v/v) > 1:10 (v/v) VW > control. Conductance to water was increased with application of single EM and combined treatment of EM and 1:20 (v/v) VW in comparison to the control and this increase was statistically significant (*p<0.05*). Although the rate of transpiration was statistically not significant, it was increased with the plants receiving single and combined treatments of EM and 1:20 (v/v) VW in comparison to the control. The chlorophyll content of the plants was higher under the single EM (1:100 v/v) treatment when compared to those in the VW and combined treatments with VW and EM. Thus, single EM (1:100 v/v) and combined treatment of EM (1:100 v/v) and VW (*i.e.* 1:20 (v/v) dilution) were increased the physiological parameters tested in lettuce considerably when compared to the control (Table 3).

TABLE III
PHYSIOLOGICAL PARAMETERS IN LETTUCE AS AFFECTED BY THE TREATMENTS

Treatment	Photosynthetic rate ($\mu molm^{-2}s^{-1}$)	Conductance to water ($molH_2Om^{-2}s^{-1}$)	C_i ($molCO_2m^{-2}s^{-1}$)	Transpiration rate ($molH_2Om^{-2}s^{-1}$)	Chlorophyll content (SPAD units)
EM (1:100 v/v)	4.86 a	0.31 a	248.24 a	6.85 a	22.20 a
1:10 (v/v) VW	3.83 a	0.19 ab	224.04 a	4.65 a	16.43 ab
1:20 (v/v) VW	4.60 a	0.22 ab	239.76 a	5.51 a	20.96 ab
1:10 (v/v) + EM (1:100 v/v)	4.28 a	0.24 ab	248.26 a	6.06 a	14.84 b
1:20 (v/v) VW + EM (1:100 v/v)	5.59 a	0.30ab	240.96 a	6.84 a	19.4 ab
Control	3.99 a	0.14 b	252.25 a	4.48 a	19.66 ab
CV%	23.60	38.03	8.17	30.92	18.30

EM, Effective microorganisms; VW, Vermiwash; Ci, Inter-cellar CO_2 concentration
In a column, values followed by a common letter are not significantly different at 5% probability

C. Analysis of Leaf Tissues for Nutrients

The total nitrogen content of leaf tissues was significantly increased in the lettuce plants treated with 1:20 (v/v) VW and EM (1:100 v/v).

TABLE IV
CONTENT OF NUTRIENTS IN LEAF TISSUES OF LETTUCE AS AFFECTED BY THE TREATMENTS

Treatment	Total Nitrogen (mg/g DM)
EM (1:100 v/v)	39.52 bc
1:10 (v/v) VW	41.02 b
1:20 (v/v) VW	39.38 bc
1:10 (v/v) VW + EM (1:100 v/v)	38.78 bc
1:20 (v/v) VW + EM (1:100 v/v)	44.89 a
Control	37.33 c
CV%	3.84

EM, Effective microorganisms; VW, Vermiwash
In a column, values followed by a common letter are not significantly different at 5% probability

D. Sensory Quality Attributes

There were significant ($P<0.05$) differences among treatments on organoleptic test for preference on colour, texture, taste and overall acceptability of lettuce in plants which received EM and VW in comparison to control. The highest preference was received for plants which received EM (1:100 v/v) as foliar spraying (Fig.1).

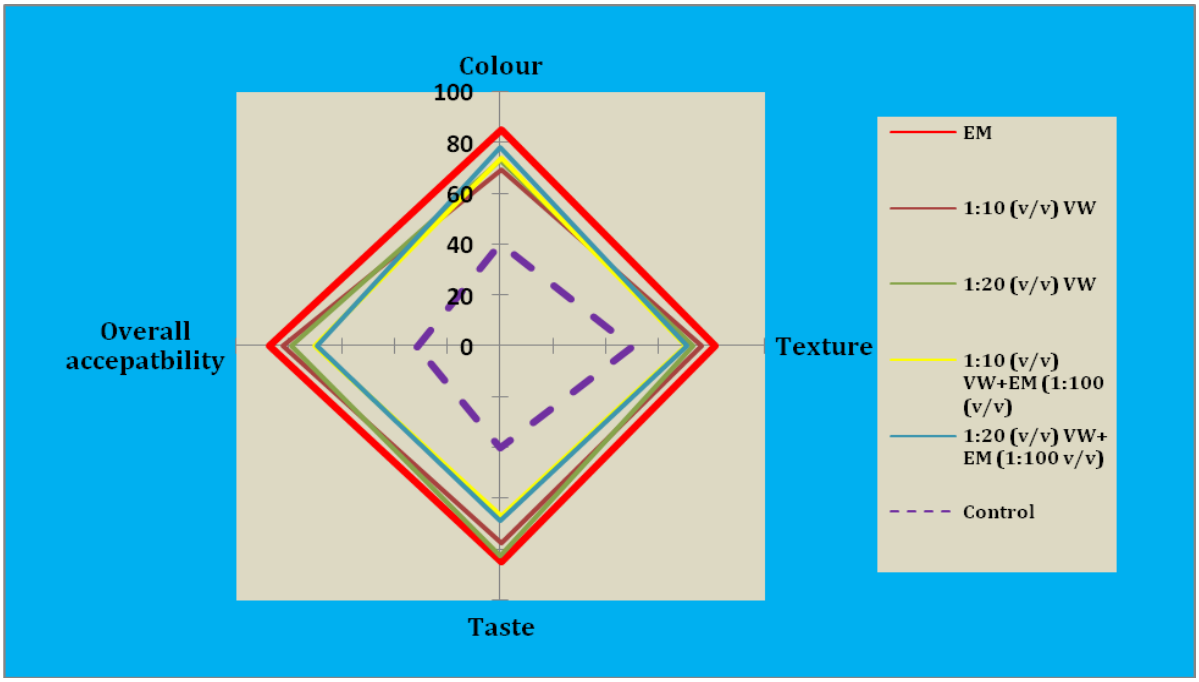

Fig. 1 Sensory attributes as affected by treatments in lettuce

In general effective microorganisms and vermiwash seem to have direct impact on physiological parameters, total nitrogen content and organoleptic quality of lettuce. Previous studies have also demonstrated a positive response with the use of effective microorganisms in crop production and indicate the potential of this technology to increase the yield and quality of crops [6].

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