

Potential of Vermicomposting Leachate as Organic Foliar Fertilizer and Nutrient Solution in Hydroponic Culture: A Review

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Abstract. Vermicomposting technology has been gaining attention as an environmental friendly waste management approach in both industrial and agricultural sectors. Studies have been carried out on processing various type of wastes into value added products. It is a green technology that produces vermicompost which has been proven to be effective as a plant nutrient supplement. Besides that, in the vermicomposting process, leachate that is derived from it contains high amount of valuable plant nutrients which has the potential to be used as liquid fertilizer as well as in hydroponics culture as a nutrient solution. Limited number of studies have been carried out on vermicomposting leachate as liquid fertilizer and its potential in hydroponic culture is almost non-existent. This paper reviews the potential of vermicomposting leachate as foliar fertilizer and nutrient solution in hydroponics and its limitations.

Keywords: Vermicomposting leachate, Organic foliar fertilizer, Nutrient solution, Hydroponics

1. Introduction

High usage of chemical or inorganic fertilizers in agricultural sectors has raised concern towards healthy living environment. Agricultural industries have been too dependent on chemical fertilizer for better crops growth and yields. Using chemical fertilizer on crops is not a long term solution for increasing crop yields in order to meet the demands that increasing drastically throughout the world. Constant use of it on crops may cause soil pollution and poses as a health threat as well to humans who later consume these heavily fertilized crops. Regardless of the benefits of using chemical fertilizers for increasing crop growth and yield, in the long term it brings more harm than good. Consuming these inorganic fertilized crops may not pose immediate health problem but in the long run, these “toxic” substances will accumulate in vital organs of human body(bioaccumulation). We should not compromise human health just for better crop yield and meeting the increasing food demand. Therefore, with the increased awareness on this matter, organic fertilizers are getting more attention these days. One of the buzzwords these days on organic fertilizing is vermicomposting. Vermicomposting technique which acts as an alternate waste management option in this modern era has been gaining popularity due to its environmental friendly approach. This green technology produces value added product such as vermicompost with high plant nutrients content from wastes generated in agriculture sectors as well as in industry. Despite stabilizing wastes and transforming them into useful products, earthworms that are responsible for composting the wastes through vermicomposting are being cultured as well. Attention has mainly been given on vermicompost that is produced. Very little studies have been carried out on the potentials of vermicomposting leachate as plant growth promoters and increasing plant yield.

2. Vermicomposting Leachate

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Vermicomposting leachate is produced during the process of vermicomposting as the micro-organisms release water during the decomposition of organic material. The leachate is drained to prevent saturation of the vermicomposting unit as well as to reduce attraction of pests.

2.1. Potential as Foliar Fertilizer

Vermicomposting leachate when collected, can be used as liquid fertilizer as it contains high concentration of plant nutrients as well as humic and fulvic acids. Much attention has been given as vermicomposting technique stabilizes the wastes and produces value added by-products with the help of earthworms and microorganisms. Vermicomposts that is processed from different types of wastes have later been used as plant growth medium and as soil amendments for various types of crops. Leachate is generated along with vermicomposting process commonly referred to as vermicomposting leachate or worm-bed leachate[1]. Draining the leachate can prevent saturation of the vermicomposting unit as well as to avoid leaching problem that may cause pollution especially when the site is located near to groundwater source. Studies have found that this leachate that is obtained from vermicomposting contains high amount of plant nutrients that may act as liquid fertilizer to improve plant growth. Table 1 shows the characteristic of vermicomposting leachate derived from animal manure and vegetable waste.

Table 1: Characteristic of vermicomposting leachate obtained from sheep manure [1], cow dung, vegetable waste and mixture of cow dung and vegetable waste (1:2) [2]

Characteristic	Sheep manure		
pH	7.8 ± 0.1		
Electrolytic conductivity (dS m ⁻¹)	46 ± 12		
Total nitrogen (g kg ⁻¹)	9.4 ± 1.2		
Nitrates (mg N kg ⁻¹)	247 ± 30		
Ammonium (mg N kg ⁻¹)	7.4 ± 1.1		
Phosphorus (mg N kg ⁻¹)	1.6 ± 0.2		
Humic/ fulvic ratio	1.6 ± 0.1		
Germination Index for cress (%)	65 ± 7		
	Cow dung	Vegetable waste	Mixture of cow dung and vegetable waste (1:2)
pH (1:10 ratio)	6.7	7.5	7.1
Total C (g l ⁻¹)	8.2	9.4	8.9
Total N (g l ⁻¹)	0.8	0.7	0.7
Total P (g l ⁻¹)	0.6	0.4	0.5
Total K (g l ⁻¹)	0.6	0.5	0.5
Calcium (mg l ⁻¹)	71	94	85
Boron (µg l ⁻¹)	151	182	191

Vermicomposting leachate when used as a liquid fertilizer provides the advantage of homogeneity when applied to soil or to leaf as foliar fertilizer as compared to application of solid fertilizer. When used as foliar fertilizer, leaching problem due to soil properties is prevented. Soils with different texture will have different rate of leaching. For soil with high leaching intensity, efficiency of fertilizer applied to soil surface is decreased as the nutrient will be leached out easily. Most of the time, plant nutrients are lost due to this leaching problem as it is leached out before they are taken up by plants. Plant nutrients will be leached out at different rate with different clay concentration that is present in soil. The amount of nutrients in the top soil, percolation rate, in addition to the tightness and binding properties of the nutrients determine the rate of leaching of the nutrients [3]. Certain nutrients such as sodium and magnesium are more susceptible to leaching in soil with high clay concentration. On the other hand, soil water holding capacity will determine the significance of leaching losses. Therefore, usage of foliar fertilizer in such soils is recommended in order to reduce the risk of environmental contamination. Foliar fertilizing of plant nutrients rich liquid such as vermicomposting leachate has great potential in overcoming the leaching problem and at the same time providing essential nutrients to plants. For this reason, valuable plant nutrients will not be lost due to soils

texture and problems on pollution or contamination soil and groundwater can be avoided. For efficiency of foliar fertilizer, few studies have found out that up to 80% of nitrogen applied through foliar were absorbed by the leaves[3][4]. This shows the potential of plant absorbing nutrients through foliar. Collecting leachate produced during process of vermicomposting can prevent soil pollution and even ground water pollution when the set up is near to the surface of ground water source. This collected worm bed leachate when used as foliar fertilizer, leaching of plant nutrients in soils can be prevented. Fertilizers that are applied to soils are facing problem of leaching especially in area with high rainfall and eventually lead to water pollution due to run-off and may reach groundwater source. When the rate of leaching is high in soil, nutrients from fertilizer applied are lost before absorption by plant roots. As a deduction, the fertilizing process is less effective. Apart from that, nutrients that are absorbed through leaves in foliar application may overcome the problem of delaying in nutrient absorption in plant roots. The nutrient content that are present in leachate is one of the advantages of it being used as liquid fertilizer since is totally soluble. Therefore when applied as foliar fertilizer, it will not clog up the sprayers. Humic acids and fulvic acids are detected in leachate. They have chemical characteristics that stimulate plant growth and increase in nutrient uptake on plants[5]. Foliar fertilizer when applied to leaf surface, the nutrients penetrate cuticle and cellulose wall through limited or free diffusion [6]. It is proven that ions can be absorbed by leaves stomatas[7]. Another potential for vermicomposting leachate is that it can be used as a growth promoter during early stage of plant growth when the roots are not well developed.

Table 2: Studies carried out on vermicomposting leachate from different wastes.

Vermicomposting leachate	Plant used	Findings	References
Sheep manure	Radish (<i>Raphanus sativus L.</i>)	Germination (%) > 50% are obtained with 10% vermicomposting leachate, number of leaves, plant height (cm), and shoot dry weight (g) are highest in leachate of 10% dilution as well. Whereas root dry weight(g) is highest in leachate of 15% dilution	[1]
Cow dung, vegetable waste and mixture of cow dung and vegetable waste (1:2)	Strawberry (<i>Fragaria x ananassa Duch.</i>)	High leaf area and dry weight of plants were obtained for leachate from cow dung, vegetable waste and mix waste. Foliar application of leachate obtained from mixture of cow dung and vegetable waste showed supremacy in plant growth. Significantly higher fruit yield were obtained if compared to control.	[2]
Cow manure	Sorghum (<i>Sorghum bicolor (L.) Moench</i>)	Germination index of vermicomposting leachate for crest was 65 ±7 %. For maximum growth, NPK fertilization was required.	[8]
Cow manure	Maize (<i>Zea Mays L.</i>)	Vermicomposting leachate has to be diluted to 50% to 500ml to get maximum plant growth.	[9]

2.2. Potential in Hydroponics

Study had been carried out on utilizing compost leachates for plant growth in hydroponic culture. [10] Hoagland's hydroponic solutions were used in the study and in comparison with spent mushroom compost leachate and runoff compost leachate. Diluted vermicomposting leachate was used as nutrient solution in hydroponic culture for *Plectranthus ambionicus*. Higher content of chlorophyll and carotenoids were observed compared with control. Hence indicated the potential use of diluted vermicomposting leachate as nutrient solution.

Results from this study indicated that deficiency in Nitrogen (N) and Phosphorus (P) on tomato and marigold plants were observed in both compost leachates treatment. Spent mushroom compost leachate and

runoff compost leachate that later amended with N and P showed improved N and P content in shoot and root tissue[10]. Concentration of N and P present in both non-amended leachates are relatively low if compared with concentration of N and P in vermicomposting leachate derived from sheep manure, cow dung, vegetable waste and mixture of cow dung and vegetable waste (1:2) as shown in Table 1. Hence, addition of N and P to leachates may or may not be necessary depends on the mother materials used in deriving the leachates[11].

Table 3: Composition of two Hoagland's solutions and two compost leachates. [10]

	Hoagland Full Strength	Hoagland Half Strength	Spent Mushroom Compost Leachate	Runoff Compost Leachate
NH ₄ -N (mg L ⁻¹)	14	7	34 ± 5.4	3.5 ± 0.4
NO ₃ -N (mg L ⁻¹)	196	98	0.1± 0.02	<0.02
P (mg L ⁻¹)	31	15.5	9.5 ± 0.9	0.6± 0.1
K (mg L ⁻¹)	235	117.5	400± 13	353± 15
Ca (mg L ⁻¹)	160	80	321± 33	63± 7
Mg (mg L ⁻¹)	48	24	61± 1	81± 2
Na (mg L ⁻¹)	1	193	85± 5	158± 10
SO ₄ -S (mg L ⁻¹)	64	32	235± 19	150± 10

2.3. Limitations

Although vermicomposting leachate contains high plant nutrients and plant growth stimulators, when applied to plant, extra care is needed to prevent plant damage as it was found to inhibit seed germination and growth to some degree. Therefore, dilution of leachate before using on plant is advised [12]. Vermicomposting leachate if used as foliar fertilizer, Dilution is strongly recommended when using vermicomposting leachate as foliar sprays high nutrient content as it may cause burning on leaf surface. For using it as hydroponic solution, dilution may or may not be needed. Nutrient amendment may be needed for vermicomposting leachate that derived from low plant nutrient content mother material. Timing of application is advised to be in morning or late evening when evaporation is low so that leachate sprayed on leaves surface, will not evaporate too soon leaving the salts unabsorbed. The longer the nutrient solution remains as a thin film on leaf surface, the more effective the nutrient uptake is [3]. For better nutrient absorption of the foliar fertilizer, it is suggested that the leachate is to be sprayed when the stomatas are open. To increase its efficiency as a foliar fertilizer, the time of application is crucial. On windy or sunny days where evaporation rate is high, the leachate sprayed may be evaporated before absorption occurs. Nutrient salts that are left on leaves surface will cause burning of leaves or scorching. Dilution of vermicomposting leachate is advised as to prevent leaf burning as severe leaf burning may cause reduction in yield[13].repeat sentence sort of. Using leachate as foliar fertilizer may require a number of applications for a better effects especially if there is severe nutrients deficiency.. On the other hand, the nutrients available in single applications are low due to dilution. Foliar application is effective and economical when it comes to some immobilized nutrients in soils such as iron[14]. Leaf area of plants has to be taken into consideration for foliar application efficiency as the nutrients absorption occurs in leaves. Therefore the larger the leaf area the more the amount of spray needed thus providing higher nutrient absorption.

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