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RESEARCH ARTICLE

BIO-ORGANIC FERMENTATION IMPROVED THE MORPHOPHENOTYPIC AND ECONOMIC ANALYSIS OF LETTUCE (LACTUCA SATIVA VAR. RED RAPID)

Marciano D. Tangpos[1,2,3]

1. College of Agriculture, Food Science, Business and Communication.
2. Cebu Technological University Barili Campus.
3. CagayBarili Cebu, Philippines.

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Abstract

This study was conducted to determine the effectivity of different organic concoctions for organically grown lettuce in a hydroponic system in one season only from 2020-2021. The organic material includes Fish Amino Acid, Fermented fruit Juice, Fermented Plant Juice, Indigenous Microorganism II, and Fermented Golden Apple Snail. Two tablespoons per liter of each organic concoction were added and applied at biweekly intervals. All treatments were in triplicate arranged in a complete randomized design and statistically analyzed with Duncans Multiple Range Test using STAR. The effect of FAA, FFJ, FPJ, IMO II, OHN, and GAS significantly had higher plant heights and leaf numbers. However, FFJ and GAS markedly higher shot weight, shoot-root ratio, and lesser root-shoot ratio, including the FPJ. Meanwhile, FFJ and GAS consistently had higher above-ground biomass, gross income, yield efficiency, income efficiency, and equilateral efficiency. All organic concoctions showed the potential to produce higher economic yield. However, the application of FFJ and GAS outstands yield and economic indicators compared to other organic concoctions, as reflected in the study.

Introduction:-

Agricultural productivity and sustainability are challenges face by farmers due to water scarcity, soil contamination, and decreasing land area (Haefele, 2011). This could have led to food shortage soon if cannot been given so much attention. Improved techniques for crop production that can meet food and nutritional requirements for the growing populace should be initiated. Such strategies include using water in a minimal amount, a short production period, and maintaining productivity with minimal production management (Shackel, 2020; Bouman and Tuong, 2001; Roose and Barthes, 2001).

Traditional production offers significant losses due to unpronounced biotic and abiotic factors. However, a hydroponic system allows optimum output with the less critical area, inputs, labor, and time (Martinez-Mate, 2018). It offers an opportunity to provide optimal conditions for plant growth with higher yields compared to open space agriculture. Developed countries practice and adapt such farming systems with equal or more production volume than open field farming (Brown-Paul, 2014; Maucieri, 2019; Resh, 2022; Gashgari, 2018).

Corresponding Author:-Marciano D. Tangpos
Address:-College of Agriculture, Food Science, Business and Communication.

Looking at the demand side, fresh vegetables like lettuce markedly hiked their consumption rates. This crop is considered the most sought green vegetable for salad and sandwiches due to incredible sources of essential nutrients such as calcium, potassium, vitamin c, and folate (Haas and James, 2009). As eaten raw, production of this crop in a commercially inorganic is strongly discouraged, yet this should be grown organically. However, it is essential to improve the production system, which will increase its productivity while maintaining its nutritional value. On the other hand, organic concoctions appear to be a good option for this challenge. It contains a vast amount of available sources of macro and micronutrients (Kiehl et al., 1999; Spehia, et al., 2018: Siavoshi et al., 2011; Caplan et al., 2017), which benefit not only the plants but the environment as well. Different sources of organic fertilizer include; Fermented Fruit Juice (FFJ), Fermented Plant Juice (FPJ), Indigenous Micro-organism (IMO), Oriental Herbal Nutrient (OHN), and other foliar fertilizers. Research has shown that organic fertilizers have improved both the quantity and the quality of lettuce (Spehia et al., 2018), tomato (Siti et al. 2017), pepper (Pagluanan and Anical, 2010), eggplant (Raigon, 2010), cowpea (Andrade, 2010), sugarcane (Tucas and Suhayon, 2020), and maize (Min and Thwe,2017; Vincent-Caboud, et al., 2019).

Meanwhile, to strengthen the effectiveness of organic fertilizer, the study examined and investigated the growth and yield of lettuce applied with different organic concoctions under a hydroponic system in Cebu, Philippines.

Methodology:

Area Preparation and organic concoction formulation

The experiment was carried out under a greenhouse structure measuring 50 square meters. The area was divided into three blocks with 7 Styrofoam, each measuring 40 cm wide by 60 cm long. To avoid water leaks, base styrofoam was blanketed with a plastic cover and wrapped with packaging tape, after which eight holes were made at the upper portion of the styrofoam at a distance of 10 cm each. Construction of benches at 1 meter from the base ground was completed and considered the established area for the experiments. The preparation of organic concoctions was based on Frias (2019), in which each medium component per concoctions was thoroughly rinsed with water and cleaned three times before the proper procedure in the organic formulation was undertaken.

Experimental Design and Lay-out

The experiment was laid out in a randomized complete block design (RCBD) replicated three (3) times with seven (7) treatments per replication. Each organic concoction was designated as a treatment: T1= tap water, T2= Fish Amino Acid, T3= Fermented Fruit Juice, T4= Fermented Plant Juice, T5= Indigenous Microorganisms II, T6= Oriental Herbal Nutrient, and T7= Golden Apple Snail. Each replication was separated at 1 m to facilitate data gathering and management.

Seedling preparation and treatment application

Lettuce (var. red rapid) seeds were used and sown in a plug tray with 1:1 garden soil and vermicompost. Proper care and management facilitated good seedlings with higher mortality and vigor. After seven (7) days of sowing, vigorous seedlings were transplanted to each cup along with the growing media and hardened for three days before transfer.

Hardened seedlings were then transferred to Styrofoam filled with 5 liters of water each. Each Styrofoam contains eight holes which correspond to eight seedlings per box. Before treatment application, each organic concoction was diluted in a liter of water, wherein two tablespoons of organic concoction were added and applied at biweekly intervals. Maintaining the volume of water in the Styrofoam was being monitored; hence, refilling water was done at biweekly intervals associated with the designated treatments. Further, pH was maintained between 5.5 and 6.5 by adding NaOH whenever the pH of the solution went below 5.5, respectively.

Harvesting and data gathered

The crop was harvested after thirty-two (32) days from sowing by pulling the lettuce plant from the cups. The roots were cleaned with water first. Afterward, the removal of roots, and marketable and non-marketable leaves was done. The roots in every treatment and every replication were measured and weighed. Marketable and non-marketable leaves were also weighed and counted separately. Gathered data includes the horticultural characteristics, shoot, and root features, yield and yield components, and gross margin analysis.

Statistical Analysis

The data was statistically analyzed using the computer software Statistical Tool for Agricultural Research (STAR version 2.0.1). A comparison of means was made using Analysis of Variance (ANOVA), while the determination of significance was assessed through Duncan Multiple Range Tests at a 1 % alpha level.

Results And Discussions:

Plant height and leaf number of lettuce (**Lactuca sativa** var. Red rapid)

The application of different organic concoctions affected the upper ground morphology of lettuce. After 10, 20, and 32 days of transplanting, lettuce significantly increased its plant height when organically fertilized with the fermented golden apple snail. It was observed that GAS had a growth effect on lettuce, but in the later period, the result was comparable to the application of OHN, IMO II, FPJ, and FPJ, respectively. This similar effect showed that GAS hastens vegetative growth during the early period while FAA, FFJ, IMO II, and OHN stimulate its growth habit at the later stage of the lettuce. On the other hand, the Fish Amino Acid hierarchy showed significant effects on the number of leaves of the test plant in the early and maturity stage of lettuce. However, the effectivity of FAA was also comparable to FFJ, FPJ, IMO II, and GAS in terms of its leaf number. Different concoctions' differentiated but comparable effects were mainly attributed to their present nutrients. For example, FAA has a great source of nitrogen which prohibits plant growth as an aid for cell division in rice (Priyanka et al., 2019) and tomato (Abbasi et al., 2003).

Table 1:- Plant height and leaf number of lettuce (**Lactuca sativa** var. Red rapid) as influenced by the application of different organic concoctions.

Replication		Plant height (cm)			Leaf number		
		10 DAT	20 DAT	32 DAT	10 DAT	20 DAT	32 DAT
T1	Control	3.31e	05.40d	06.30b	4.80c	07.52b	09.11c
T2	FAA	5.20b	10.39bc	12.37a	5.19a	14.34a	19.34a
T3	FFJ	5.29b	10.69b	12.31a	5.13ab	14.65a	18.94ab
T4	FPJ	4.37d	09.85c	11.02ab	4.83bc	14.36a	18.85 ab
T5	IMO II	5.22b	10.74ab	12.17a	4.53cd	14.37a	19.18 ab
T6	OHN	4.85c	09.99c	11.93a	4.48d	13.86a	18.30b
T7	GAS	5.78a	11.29a	12.11a	4.67cd	14.57a	18.84ab
CV (%)		2.09	2.16	4.53	2.28	2.13	2.01

Means with the same letter designation were not significantly difference at 1 % level using DMRT test.

While FPJ and FFJ exhibit early growth and maturity of lettuce, researchers also found that these concoctions exhibit early flowers and fruits at vegetative growth, flowering, and better reproductive development of tomato plants (Siti et al., 2017). Also, applying fermented plant juice and fruit juice increases the morphology, height, and leaf number of hot pepper (Jang and Kuk, 2020). In terms of Indigenous Microorganism, the application of this fermented organic increases the heights, tillers, panicles of rice (Alam et al., 2017), and sweet corn (Villaver, 2019). Similar results of this study also explained that IMO had a symbiotic relationship with the natural environment and produced nutrients, hormones, and antibiotics that plants would directly use (Kumar and Gopal, 2015). About OHN, watermelon increases its vegetative yield due to its nutrient availability (Gasana and Kim, 2022). The fermented GAS also demonstrates an increase in morphological and yield components of tomato (Batiles and Magarro, 2010).

The effect of different organic concoctions greatly influences the importance of organically made fertilizer based on the result of the study. Hence, the study implied that the organic concoction might be used as fertilizer for healthy, productive, and sustainable lettuce farming. Application of these concoctions will have a potential initiative in producing more while maintaining ecological balance without toxic consideration.

Root and shoot characteristics of lettuce

Plants are composed of below and above systems, the shoot and the root, which absorb carbon from the air, water, and minerals from the soil (Kuzyakoy et al., 2001). Root-derived phytohormones modulate shoot growth, and nutrient uptake activity in the root is up-regulated by shoot-derived signals indicating that the root and shoot deliver messages to each other to induce systematic response for growth and development (Liu et al., 2009). For instance, different organic concoctions have significantly contributed to the shoot and root characteristics of lettuce. Application of FFJ increased its shoot weight (11.73 g) with comparable weights using GAS (108.83 g). However, regarding its root weight, FA markedly showed a higher root weight (14. 73 g) which also had a comparable effect using FFJ, OHN, and GAS, with root weights varying from 13.97 to 14.13 grams, respectively.

It is noted that leafy vegetable needs nitrogen (root) and carbon (shoot) as the primary substrate for their growth (Yuan et al., 2020). Hence, applying nitrogenous-based fertilizer is a component for a higher yield. A good understanding of the factors controlling biomass allocation is a prerequisite for correctly predicting the long-term effects of different organic concoctions (Johnson et al., 2007). The root shoots' ratio must be understood to differentiate its magnitude of application in either or both concoctions.

Table 2:- Root and Shoot Characteristics of lettuce (**Lactuca sativa** var. Red rapid) as influenced by the application of different organic concoctions.

Replication		Weight plant^{-1}(g)		SRS	RSR
		Shoot	Root		
T1	Control	33.00d	7.92d	4.17c	0.2433a
T2	FAA	101.27b	14.73a	6.88ab	0.1433bc
T3	FFJ	111.73a	13.97abc	8.01a	0.1233c
T4	FPJ	98.23b	12.27c	8.01a	0.1233c
T5	IMO II	79.97c	12.83bc	6.27b	0.1600bc
T6	OHN	97.67b	14.13ab	6.92ab	0.1467bc
T7	GAS	108.83a	14.13ab	7.71a	0.1267bc
CV (%)		2.6	4.8	6.19	7.89

Means with the same letter designation were not significantly difference at 1 % level using DMRT test.

The root-to-shoot ratio measures the number of plant tissues with supportive functions (roots) compared to the amount of plant tissue with growth functions (shoots). If a plant with a higher proportion of roots than other parts, it will be able to compete more successfully for soil nutrients. Plants concentrate more on increasing root biomass with fewer nutrients than above-ground biomass. Hence, an increase in SRS indicated an abundant nutrient in the medium that plants can consume. Our study noted that FFJ, FPJ, and GAS significantly showed higher SRS comparable to other organic concoctions except for water-based only. Likewise, the ability to increase root biomass is concentrated in the water-based application. The FFJ and FPJ consistently had lower RSR indicating the availability of nutrients for plant growth and development with comparable effects on other organic concoctions being used. However, based on the results, it is implied that different organic concoction contains nutrients necessary to increase the above-ground biomass of plants (yield).

Economic analysis of organic concoction fertilization on lettuce

Economic considerations should be considered to gain attention to the farm industries. A basis of economic attributes would be an efficient tool for indicating the total adaptability of organic concoctions. Statistically, FFJ (558.67 g) and GAS (544.17 g) significantly had higher economic biomass, gross income, yield efficiency, income efficiency, and equilateral efficiency than other concoctions tested.

Table 3:- Economic analysis of lettuce (Lactuca sativa var. Red rapid) as influence by application of different organic concoctions.

Replication		Economic Yield (g)	Gross Income	Yield Efficiency	Income efficiency	Equilateral Efficiency
T1	Control	165.00d	41.25d	(0.33d)	(33.13)	(2.69)
T2	FAA	506.33b	126.58b	3.07b	306.87	2.74
T3	FFJ	558.67a	139.67a	3.38a	338.59	3.06
T4	FPJ	491.17b	122.79b	2.97b	297.68	2.65
T5	IMO II	399.83c	99.96c	2.42c	242.32	2.09
T6	OHN	488.33b	122.08b	2.95b	295.96	2.63
T7	GAS	544.17a	136.04a	3.298a	329.8	2.97
CV (%)		2.6	2.6	2.4		

Means with the same letter designation were not significantly difference at 1 % level using DMRT test.

Similarly, other organic concoctions such as FAA, FPJ, IMO II, and OHN should have significant results on economic parameters, but then the latter FFJ and GAS outstand the most. However, an adverse effect was obtained using water-based only. The result showed that even without the use of inorganic fertilizer, farm industries could produce more yields with this organic concoction, specifically on FFJ and GAS. The result indicated that FFJ and GAS tested to be economically viable for lettuce production under the hydroponic scheme for economic reasons.

Conclussion and Recommendation:

Both organic concoctions showed potential to be used as fertilizer in the absence of inorganic fertilizer. FAA and FFJ show higher heights and leaves; FFJ and GAS also showed a significant increase in above-ground biomass and consistently had higher economic indicators, which has to be given attention by the farm industries in hydroponic schemes worldwide. However, retesting these organic concoctions should also be considered with other crops to widen the scope of its effects.

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