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Growth, Flowering Performance and Seed Yield of Sunflower (*Helianthus annuus*) Applied with Fermented Fruit Juice and Rice Water

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Abstract The nutrients coming from Fermented Fruit Juice (FFJ) and rice water are known for improving the growth and characteristics of the plant. The objective of the study was to ascertain the impact of various FFJ concentrations in rice water on sunflower growth, flowering efficiency, and seed yield. Complete Randomized Design (CRD) was used to plan the experiment, which consisted of five treatments and six replications. The treatments were as follows: T1 – Chemical fertilizer (Control); T2 – 15 mL FFJ; T3 – 30 mL FFJ; T4 – 60 mL FFJ and T5 – 90 mL FFJ. All of the FFJ treatments were diluted in 1 liter of rice water. The data were analyzed using Analysis of Variance (ANOVA). Findings showed that there are significant differences in the sunflower's height among 5 treatments in which 30 ml of FFJ with rice water produced the tallest crop, biggest flower head (11 cm), the highest number (370.17pcs) and weight (22.67g) of sunflower seeds that led to higher Return on Investment (95.84%). While, in terms of flowering activity, sunflower applied with 60 mL of FFJ with rice water was the fastest to bear flowers.

Keywords Fermented Fruit Juice (FFJ), Rice Water, Sunflower, Flowering Performance, Sunflower Seeds

1. Introduction

Helianthus annuus commonly known as sunflower is an herbaceous annual plant in the Asteraceae family that is grown for both its seeds and the flowers. The plant has a thick, hairy, upright stem from which a sizable flower head emerges. The plant has smaller, narrower upper leaves that are attached to the stalk singly and enormous, broad lower leaves that are round and alternately arranged on the stem. The huge, beautiful bloom head of sunflowers makes them popular decorative plants [1]. Today, sunflower also has been a source of beautification and attraction in different parts of the Philippines making it be known as a photography spot. Yet, it is well-known for more than just its aesthetic qualities because its seeds can be consumed raw or fried, or they can be used to extract oil, which is frequently used in cooking [2]. They are regarded as a cost-effective oil crop, which is why 87% of vegetable oil is produced with them. Since it improves the health of the soil and increases biodiversity on the farm, it might also be planted alongside other crops as a part of a crop rotation system. Moreover, it is not thought of as a heavy feeder and can grow in complicated situations. The roasted seeds were used as a coffee replacement in some cases [2]. The dried sunflower after oil extraction is also a significant source of protein in the creation of livestock and poultry diets. The

stalk, on the other hand, might serve as an organic fertilizer supply and a possible source of paper-making fiber [3]. Recent research demonstrates the potential of sunflower.

Farmers in the Philippines don't grow sunflowers very often for the purpose of making oil. They were initially cultivated and examined at Central Luzon State University, where they hope to spread the findings of their research across the nation [3]. They are now frequently produced in the nation's agro-ecotourism destinations for leisure and aesthetic reasons. The Philippines ranked 1002nd in terms of most exported goods in 2020 and 96th among nations that export sunflower seeds [5]. According to the latest statistics, sunflowers are only now beginning to acquire popularity in the Philippines and are not yet regarded as one of the country's main agricultural crops.

For the past years, farmers in the Philippines have been practicing conventional farming techniques which involve the use of chemical or synthetic products that gives harmful effects. Natural farming, or the raising of crops or livestock using organic farming techniques, is gaining popularity due to its numerous advantages for both people and the environment. Agriculture institutions are currently pushing these, which include a chemical-free harvesting technique and eco-friendly production. Natural farming is a methodology that uses a holistic production management approach that promotes and maintains agroecosystem health, including biodiversity, biological cycles, and soil activity, according to Food and Agriculture Organization [6].

Sweet, ripe fruits, fruit vegetables, and root crops are used to make fermented fruit juice or FFJ. The fermented extract is applied to the plants to encourage flowering and fruit setting after being thoroughly combined with raw sugar or molasses and briefly kept. In natural farming, this liquid is a nutritional activation enzyme that boosts nutrients in the soil and in the plants growing in it. On the other hand, rice contains starch, which gives the water its opaque, white color. This starch is beneficial to plants because it encourages healthy bacteria to grow in the roots. In addition, rice water contains a trace amount of nitrogen, potassium and phosphorus and is found to be beneficial to plants [7].

The nutrients coming from Fermented Fruit Juice and rice water are known to improve the growth of the plant, that's why the idea of diluting the FFJ to rice water was conceptualized. Different concentrations were used to identify the most helpful and beneficial for the growing, flowering performance and seed yield of sunflower.

2. Materials and Methods

2.1. Experimental Area

The experimental site was located at 13 °47' North, 122 ° 27' East of Brgy. Villa Batabat Buenavista, Quezon, Philippines. The size of the area is 300 m^2 and is suitable for the preferred spacing of sunflower, the topography of the land was considered plain making it ideal for the conduct of this study. During the dry season, the land was directly hit by the sun for up to 6- 8 hours per day which is considered as one of the basic needs of sunflower. During the wet season, heavy rainfall doesn't affect the area as there are no instances of flooding or overwatering which can affect the containers and can result in the destruction and poor growth of plants.

2.2. Test Crop

Sunspot sunflower variety was used in the study which reaches a height of about 61 cm (24 inches). The stems are strong enough to sustain the large golden-yellow blooms. With the proper growing conditions, sunflowers would reach maturity on its 80 days after planting. Managing and observing the growth, flowering performance and seed yield of sunflower were done until the sunflower reaches maturity.

2.3. Treatment and Layout

The study was laid in Completely Randomized Design (CRD) composed of five (5) treatments and replicated six (6) times. A total of 60 sunflower pots were used. The sunflowers were fertilized with the same amount but with different concentrations of Fermented Fruit Juice diluted into rice water. The following were the treatments: T1 - Control (Chemical fertilizer); T2- 15 mL FFJ per 1 liter Rice Water Treatment 3- 30 mL FFJ per 1 liter Rice Water Treatment 4- 60 mL FFJ per 1 liter Rice Water Treatment 5- 90 mL FFJ per 1 liter Rice Water.

2.4. Preparation of Fermented Fruit Juice

Bananas were used in the preparation of Fermented Fruit Juice. It was chopped into small pieces and weighed (10 kg). Then, it was put inside a jar and poured with 10 kilograms of molasses. The mixture was mixed using a ladle. After the mixture had been thoroughly mixed, the container's opening was covered with a piece of cloth and secured with a rubber band. To avoid contaminants, the container was kept in a cool, dark, and clean environment and fermented for seven days. It was extracted after seven days, with the liquid separated from the solid materials using a strainer. The extracted liquid was placed in a clean bottle and labeled as Fermented Fruit Juice (FFJ).

2.5. Preparation of Rice Water

On the day of fertilizer application, the water used to rinse the rice was collected from the households near the experimental site and was put in a container. By completely rinsing the rice with water, the starch from the rice was incorporated into the water.

2.6. Pot Preparation

Loose and well-drained soil, carbonized rice hull and vermicast were mixed with the ratio of 1:1:1 ratio on a volume basis. The pot used is a 3-gallon container with a diameter of 12 inches. It was put in a sunny spot with at least 6 or more hours of sunlight.

2.7. Sowing of Sunflowers Seeds

Seeds were sown for about ½ inch deep in a seedling tray that has a potting mix that includes garden soil, carbonized rice hull and vermicast. Watering them after planting was also done.

2.8. Transplanting the Sunflower Seedlings

When the sunflower seedlings have their first set of true leaves, it was transplanted in the prepared planting medium. The spacing of each seedling in a pot was 2 feet apart in order for the sunflower to have space while growing.

2.9. Application of treatments

For Treatment 1 (control-chemical fertilizer), complete fertilizer (14-14-14) was used. One-half tbsp. or 7.39 g of CF was diluted in 1 liter of water, drenched into the soil and applied every 15 days [8]. The treatments 2, 3, 4 and 5 which are 15, 30, 60 and 90 mL concentrations of Fermented Fruit Juice (FFJ) were diluted to one liter of rice water. One liter of each was applied on the sunflower once a week after the flower was transplanted to the pots. The application was done early in the morning. The application started at 15 mL of FFJ per 1 liter of rice water.

2.10. Management Practices

Weeding was done to manage the weeds as they will compete with sunflowers for moisture and nutrition. Staking was also done to provide the sunflower with support while it grows. For pest control, a net was provided along the area to protect the plants from the animals. In seed harvesting, they were collected once they reached maturity. After collecting and counting the seeds, they were stored in a dry, dark, cool place in a sealed jar or plastic so that they can be used at the next planting time.

2.11. Data Gathered

For the sunflowers' growth performance, the data were gathered weekly recording the sunflower's height and was measured using a tape measure. For its flowering performance, the number of days to bear flowers was recorded. For seed yield, the seeds were collected and counted when the sunflower reached its maturity. For its economic analysis, Return on Investment (ROI) was computed based on the seed yield.

2.12. Statistical Data Analysis

The data were analyzed using ANOVA. Further tests used the Least Significant Difference to determine the significant differences in the growth, flowering performance and seed yield of sunflowers using the treatments applied.

3. Results

Growth parameters

Growing sunflowers in rotation is important to the cropping system's long-term viability. Sunflower has long been known for its role in nutrient cycling. It acts as a "scavenger" after shallow-rooted crops because its deep root system can recover some of the nitrogen applied to the previous crop that was leached below its root zone [9]. The growth of sunflowers depends on the nutritional content of the medium where they grow and the fertilizer applied to them. Fermented Fruit Juice with rice water was applied after transplanting up to 56 days after transplanting as seen in Table 1.

Seven Days After Transplanting (DAT), the mean height of sunflower applied with chemical fertilizer and those applied with 15 mL and 30 mL of FFJ with rice water were not significantly different from each other. On the other hand, crops applied with 60 mL of FFJ with rice water were significantly different from those applied with 90 mL of FFJ with rice water. Fourteen DATs show that the sunflower increased its height. Wherein, crops applied with 90 mL of FFJ with rice water were the tallest and significantly different from the height of sunflowers applied with 15 mL, 30 mL and 60 mL FFJ with rice water. Twenty DAT, no significant difference was observed in the height of sunflowers applied with 15 mL and 60 mL of FFJ with rice water. Again, the height of those applied with 90 mL of FFJ with rice water was significantly different from other treatments. Twenty-eight DAT, sunflowers continuously increased their height and sunflowers under the control set-up were leading. It could be noted that chemical fertilizer is considered to be fast-release. While, those applied with FPJ and rice water are lagging. This might be because the sunflowers are still adjusting to the liquid fertilizer applied to them. This was the time that those applied with 15 mL, 30 mL and 60 mL were not significantly different from one another but statistically different from those applied with 90 mL of FFJ with rice water. Thirty-five DATs show again that the height of sunflowers in the control set-up and those applied with 15 mL, 30 mL and 60 mL were not significantly different from each other but significantly different to crops applied with 90 mL of FFJ. The same goes to plant height forty-two DAT. However, it was revealed that the leading height for this week was applied with 15 mL of FFJ with rice water. Forty-nine DAT, again, plant height of those applied with 15 mL, 30 mL and 60 mL were not significantly different

from each other but significantly different with those applied with 90 mL FFJ with rice water. In the final measurement of its height, 56 DAT, results showed that those under the control set-up and those applied with 15 mL, 30 mL and 60 mL FFJ with rice water were still not significantly different from each other but still significantly different from the height of sunflowers applied with 90 mL FFJ with rice water. Sunflowers applied with 30 mL of FFJ with rice water were the tallest with a mean height of 121.00 cm. This could be the optimum amount of FFJ that the sunflower needed.

Flowering parameters

Fermented Fruit Juice with rice water does significantly affect the sunflower's number of days to flower after transplanting (Table 2). Fermented Fruit Juice (FFJ) can be used to accelerate plant fruiting and increase the production of green leafy vegetables [10].

As shown in Table 2, no significant differences were observed in the number of days to flower after transplanting. Sunflowers applied with 90 mL FFJ was the slowest to flower (48.83 days). While sunflowers applied with 60 mL of FFJ with rice water were the fastest to flower (43.33). Table 3 shows the flower sizes applied with different amounts of FFJ with rice water. It shows that the flower size of the control treatment and those applied with 60 mL and 90 mL were not significantly different from each other. On the other hand, there were significant differences in the flower size applied with 15 mL and 30 mL of FFJ with rice water. Wherein, those applied with 15 mL had the smallest flower size (6.17 cm) and those applied with 30 mL had the biggest flower size (11.00 cm) (Figure 1).

Table 1. Plant Height of Sunflower Applied with Different Concentrations of FFJ with Rice Water

Treatment	7 DAT (cm)	14 DAT (cm)	21 DAT (cm)	28 DAT (cm)	35 DAT (cm)	42 DAT (cm)	49 DAT (cm)	56 DAT (cm)
Control (Chemical Fertilizer)	13.50b	30.17ab	50.00a	66.83a	94.67a	99.83ab	103.00b	103.17ab
15 mL FFJ with rice water	13.50b	27.00bc	35.00b	55.17b	80.17b	97.83b	114.83ab	118.17a
30 mL FFJ with rice water	12.17b	23.67c	39.83b	58.83ab	85.50ab	110.17a	117.83a	121.00a
60 mL FFJ with rice water	17.17a	31.67a	47.00a	63.83ab	77.17b	90.67b	104.17b	112.33ab
90 mL FFJ with rice water	9.00c	15.67d	22.83c	33.50c	56.17c	76.00c	86.83c	92.67b
CV (%)	19.16	12.26	14.07	15.98	12.76	9.61	10.09	15.27

*In a column the same letters indicate that the values are not significantly different by LSD Test (P>0.05).

*DAT- Days after transplanting

Table 2. Flowering Activity of Sunflower applied with FFJ and Rice Water

Treatment	Number of Days to Flower after Transplanting
Control (with chemical fertilizer)	44.50
15 mL FFJ with rice water	48.67
30 mL FFJ with rice water	47.67
60 mL FFJ with rice water	43.33
90 mL FFJ with rice water	48.83
CV (%)	19.28

Table 3. Flower size applied with FFJ and Rice Water

Treatment	Diameter of sunflower (cm)
Control (with chemical fertilizer)	7.67 b
15 mL FFJ with rice water	6.17 c
30 mL FFJ with rice water	11.00 a
60 mL FFJ with rice water	8.00 b
90 mL FFJ with rice water	8.00 b
CV (%)	15.13

*In a column the same letters indicate that the values are not significantly different by LSD (P>0.05)

Figure 1. Size of Sunflower Inflorescence applied with Different Concentrations of Fermented Fruit Juice and Rice Water

Table 4. Seed Yield of Sunflower applied with FFJ and Rice Water

Treatment	Number of Sunflower Seeds/inflorescence (pcs)	Weight of Sunflower seeds / inflorescence (g)
Control (with chemical fertilizer)	173.66 c	6.83 c
15 mL FFJ with rice water	212.83 b	10.83 b
30 mL FFJ with rice water	370.17 a	22.67 a
60 mL FFJ with rice water	255.50 b	11.83 b
90 mL FFJ with rice water	213.83 b	12.83 b
CV (%)	19.38	16.33

*In a column the same letters indicate that the values are not significantly different by LSD (P>0.05).

Table 5. Return on Investment of Sunflower Seeds Production

Cost of Materials	Treatment				
	Control (Chemical fertilizer (g)	15 mL FFJ with rice water	30 mL FFJ with rice water	60 mL FFJ with rice water	90 mL FFJ with rice water
Seeds	1.67	1.67	1.67	1.67	1.67
Complete Fertilizer (14-14-14)	1.39				
Vermicast	46.67	46.67	46.67	46.67	46.67
CRH	6.67	6.67	6.67	6.67	6.67
Banana	-	1.67	3.33	6.67	10
Molasses	-	5.0	7.5	10	12.5
Manila Paper	-	0.5	0.5	0.5	0.5
Rubber Band	-	1	1	1	1
Neem Oil	7.17	7.17	7.17	7.17	7.17
Labor	20	20	20	20	20
Total Expenses (per inflorescence)	83.57	88.68	94.51	100.35	106.18
Average Harvest (per inflorescence)	173.66 pcs	212.83 pcs	370.17 pcs	255.50 pcs	213.83 pcs
Gross Income (Php 50/100 pcs)	86.83	106.42	185.09	127.75	106.92
Net Income	3.26	17.74	90.58	27.4	0.74
ROI (%)	3.75	20.00	95.84	27.30	0.70

Yield Parameters

Results revealed in Table 4 show a statistical variation of data in terms of seed activity. The collected data were the number and weight of sunflower seeds.

Both the number and weight of sunflower seeds / inflorescence had significant differences among the treatments. Sunflower seeds' weight and number under the control set-up and those applied with 15 mL of FFJ with rice water were significantly different from each other. However, the number of seeds obtained from sunflower applied with 15 mL FFJ was not significantly different from those applied with 60 mL and 90 mL FFJ with rice water. While, those applied with 30 mL of FFJ with rice water got the highest number and weight of sunflower seeds / inflorescence and were significantly different from the rest of the treatments.

Profitability in Sunflower Production

Table 5 shows that sunflowers with 90 mL application had the lowest ROI / inflorescence (0.70%). On the other hand, sunflowers applied with 30 mL of FFJ and rice water had the highest ROI of 95.84%, since it has the highest total harvest among the 5 treatments. Similar to the study conducted by researchers from the Department of Agriculture's (DA) Regional Field Office in the Cagayan Valley led by Executive Director Lucrecio Alavar, Jr., in field trials on two biopesticides which is the fermented fruit juice (FFJ) and lactic acid-based pesticide (LAP) it was discovered that the crops grown with biopesticides yielded 7-15 percent higher returns on investment (ROI) than crops grown without application [11].

4. Discussion

Similar to the study conducted by the DA Researchers about the use of two biopesticides, the Lactic Acid Bacteria and the Fermented Fruit Juice in their field trials on rice they recommended using 20-30 ml of FFJ per liter of water [11]. Contrary to Tagotong and Corpuz's study [12], which revealed that the plant height of pechay plants responded considerably to the application of 120 mL per liter of fermented plant/fruit juice, the results are different. The qualities of the soil, which are crucial for growth and development, will also rise with an increase in the amount of fermented fruit juice mixed with natural water. As support to the study, it was stated by Bakht et al. [13], that nutrients supplied through the application of organic fertilizer apparently enhanced the growth of sunflower. The result also might be due to the components of Fermented Fruit Juice which includes ripe bananas and molasses. In numerous ways, bananas, which are a great source of nutrients including potassium, manganese, calcium, and good pro-biotic bacteria, promote height gain [14]. While, molasses aids in the fermentation process and makes room for bacteria that might be advantageous to sunflowers. Yet, using the water from washed rice is just as beneficial as using NPK fertilizer in boosting plant growth, and in certain situations, it may even be more so, according to the results of a study on the use of rice water for plants. This is at least accurate in terms of increased plant biomass and leaf production since both treatments outperformed the plain water control group. According to this study's findings, washed rice water will function more effectively than plain water alone [15]. Also, the finding that the plant contained higher levels of N and K supports the theory that using water from washed rice can encourage more plant development [16].

Sixty ml of FFJ is needed to attain optimum flowering. Thus, it could be inferred that it is the optimum amount needed for faster flowering. In a related study by Bakht et al. [13], the use of organic fertilizer resulted in a substantial 2-day phenological day reduction in the time it took for early-sown sunflowers to flower as well as an increase in plant height for both early- and late-sown sunflowers. The current study's findings were consistent with those of Buriro et al. [17], who discovered that chili plants fertilized with organic fertilizer exhibited early flowering.

The amount of potassium in the soil and consequently the plants growing in it are increased by the nutritional activation enzymes in this liquid, according to Rohini [18]. Potassium makes fruit juicier and sweeter and enhances the quality of flowers by assisting plants in their internal water and sugar transport systems [18]. Moreover, this potassium is referred to as the "quality" nutrient since it influences qualities including the size, shape, color, and vigor of the seed or grain as well as cotton's fiber quality.

Moreover, the presence of minerals like potassium, nitrogen, and phosphorus as well as carbohydrates in rice water encourages the fermentation and expansion of a variety of already-existing bacteria in the soil. Moreover, these rice water constituents support N2-fixing bacteria, which promotes photosynthesis and improves plant growth. The primary factor promoting Lactobacilli growth in rice water starch is what helps plants thrive. The growth of the helpful fungi known as mycorrhizae is then aided by these beneficial bacteria. The plant roots are fed by mycorrhizae, which strengthen and improve their health [19]. Also, it could be inferred that rice water provides the vital NPK minerals required by all plants and would be beneficial for any garden by promoting growth and boosting biomass yield [14]. Additionally, only the application of organic fertilizer significantly affected the yield of both early- and late-sown sunflower seeds, according to a recent study by Oshundiya et al. [20]. The availability of nutrients in the soil during the physiological growth and development stages of the plants may be responsible for the reaction to applied fertilizer.

Meanwhile, sunflowers applied with chemical fertilizer were revealed to have the lowest seed yield. This might be because of the continuous rainfall during the experiment which washed out the fertilizer applied. As stated by Aguera and de la Haba [21], throughout sunflower's life

cycle, the meteorological conditions and enforced cultural traditions have a big impact on sunflower yield. Plant growth and development are influenced by cultural practices such as sowing date and fertilizer application, as well as some climatic conditions (temperature and rainfall).

The profitability obtained is very feasible and comparable with the use of inorganic fertilizer used by Kathun et al. [22] in their sunflower production. Moreover, the result is also similar to the study conducted by researchers from the Department of Agriculture's (DA) Regional Field Office in the Cagayan Valley led by Executive Director Lucrecio Alavar, Jr., in field trials on two biopesticides which is the fermented fruit juice (FFJ) and lactic acid-based pesticide (LAP) it was discovered that the crops grown with biopesticides yielded 7-15 percent higher returns on investment (ROI) than crops grown without application [11].

5. Conclusions

For the sunflower's growth parameter, the application of 30 ml of FFJ with rice water resulted in the tallest height (121.00 cm), biggest flower head (11 cm), highest seed yield and number of seeds, thus higher ROI (140.48%). While, the application of 60 ml of FFJ with rice water to sunflower resulted in the fastest number of days to flower (43.33 days). Thus, to attain maximum height, a greater number of seeds, better seed weight and higher ROI, the use of 30 ml FFJ diluted in 1 liter of rice water is recommended to be applied weekly. It is recommended to plant sunflower at the right planting season to attain maximum seed yield.

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