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Enhancing Sunflower Production Through the Use of Sustainable Nutrient Management in the Coastal Region of Bangladesh

U.K. Sarker[1], M. S. Hossin[2*], M. R. Uddin[3], D. Hossain[4], M. K. Islam[4] and M. K. Hossain[4]

[1]Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali-8602.
[2]Associate Professor, Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali-8602.
[3]Assistant Professor, Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali-8602.
[4]Professor, Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali-8602.
*Correspondence: hossin.shahin@gmail.com, Tel: +8801716813628.

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Abstract: A field experiment was done to observe how sunflowers responded to varying irrigation intervals, as well as different quantities of processing poultry manure and inorganic fertilizers. The results demonstrated that the combined use of varying irrigation intervals, as well as variable quantities of poultry manure and NPK fertilizers, had a substantial impact on all growth and seed production features. The best sunflower yield and yield contributing characteristics were 91.67 cm plant height, 3.48 cm stem girth, 18.00 number of leaves per plant, 16.00 cm head diameter, 808.33 seeds per head, 54.00 g 1000-seed weight, and 1.70 tha^{-1} seed yield with a 10 day irrigation interval and 4 tha^{-1} processed poultry manure and NPK fertilizer combination of ten day irrigation interval and second place went to a 3 tha^{-1} processing poultry manure with NPK fertilizer, which yielded 801.00 g of seed per head and 1.60 ton seed output per hectare. In terms of sunflower growth and yield, all of the other treatments were found to be inferior. In comparison to other irrigation intervals and processing poultry manure treatments, a 10 day irrigation interval and 4 tha^{-1} processing poultry manure with adjusted amount of NPK fertilizers from 5 tha^{-1} poultry manure (recommended dose) exhibited more promising outcomes.

Keywords: Sunflower; irrigation; poultry manure; NPK fertilizer; coastal region.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a photo-insensitive crop that originated in eastern North America and belongs to the Asteraceae family. It was introduced into the Russian Federation, where it became a food crop and was farmed in the late 1800s after substantial advancements by Russian farmers. It is one of the most extensively produced oil crops in many parts of the world (Shoghi *et al.* 2013). Sunflower production has increased dramatically over the previous decade, surpassing only soybean production as the world's second most important oilseed crop. Sunflower oil accounts for around 15% of all major vegetable oil output worldwide. Sunflower oil is regarded as premium due to its light color and flavor, as well as the fact that it is unsaturated and high in linoleic acid. Sunflower oil is in high demand because it is cholesterol-free and hence beneficial to one's health. Sunflower seeds produce 500 to 600 grams of oil per kilogram, which is much more than any other oil seed. Sunflower oil has 55-60% linoleic acid content and 25-30% oleic acid content on average. Sunflower oil has a higher unsaturation level than mustard oil, making it better for cooking. Sunflower oil cake has a high protein content of 40-44% and a high carbohydrate content of 25-30% (Weiss 1983).

Sunflower is a major oilseed crop in the globe, second only to soybean in terms of production (FAO 2003). It is a temperature-neutral crop that may be grown across Bangladesh during both the Rabi and Kharif seasons. Sunflower has the ability to close the gap between edible oil production and consumption by containing almost 40% to 50% oil and a protein content of roughly 23% (Rosa and Rosemar 2009). Sunflower cultivation is suited in Bangladesh's coastal region due to its wide adaptability, and it is a useful substitute when other crops are difficult to produce due to climate change, rising soil salinity in coastal areas, and a lack of irrigation facilities, among other factors. Sunflowers may be grown in any district in Bangladesh, with an average yield of 1.2 t ha^{-1}, which is promising but not enough (BBS 2016). Sunflower production is low due to a lack of high-yielding varieties, cultivation on marginal soils with insufficient nutrients, and

the continued and unbalanced use of artificial fertilizer, all of which degrade soil health. Experiments demonstrated that the crop was extremely responsive to various fertilizers, and that careful fertilization may significantly enhance output (Kazi *et al.* 2002).

Sunflower-specific integrated nutrient management strategies can help with long-term growth, yield, and quality, as well as plant health and environmental risk reduction. In an intensive farming system, using poultry manures with the right amount of fertilizer boosts nutrient turnover in the soil plant system. The use of poultry manures reduces the amount of inorganic fertilizer used, lowering cultivation costs and enhancing soil health. Poultry dung was gathered from a nearby poultry farm and processed by adding various ingredients to it. In the Patuakhali Science and Technology University's Soil Science laboratory in Dumki, Patuakhali, assembled poultry manure was studied. 1.85% nitrogen, 0.24% phosphorus, and 0.60% potassium are found in it.

Unfortunately, there is a scarcity of data on the impacts of chicken manure on sunflower in Bangladesh, especially in the presence of nitrogen, phosphate, and potassium. With these facts in mind, the current study was designed to determine the interaction effect of irrigation intervals and poultry manure processing, as well as nitrogen, phosphorus, and potassium, on sunflower yield and yield contributing characters.

MATERIALS AND METHODS

During the months of December 2019 and April 2020, a field experiment was conducted at the Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali-8602 to investigate the interaction effect of irrigation intervals, poultry manure, nitrogen, phosphorus, and potassium on sunflower yield and yield attributes. Before sowing sunflower seeds, soil samples were taken from the experimental field, air-dried, crushed, and sieved at 2 mm. The experimental field's texture was silty clay loam with a pH of 7.0, organic carbon content of 0.75%, nitrogen content of 0.09%, phosphorus 9.24 mg/kg, and potassium content of 0.19 meq/100 g soil. In Split Plot Design, the experiment was laid out with three replications. A unit plot measuring 1.5 m x 2 m was randomly assigned twenty treatment combinations. Irrigation intervals were the primary plots, whereas poultry manure, nitrogen, phosphorus, and potassium were the subplots. Nitrogen, phosphorus, and potassium were adjusted from the recommended amount of 5 tha^{-1} poultry manure (FRG, 2018) for sunflower. Three blocks were created in the experimental area. A total of 20 unit plots were included in each block. As a result, there were 60 total unit plots. The distance between blocks was 1.0 m, and the gap between plots was 0.5 m. Plant spacing was 20 cm between plants, while row spacing was 30 cm between rows. The treatments were I_1= 10 days interval, I_2=20 days interval, I_3= 30 days interval and I_4= 40 days interval, T_1 =Control, T_2= 5tha^{-1} processing poultry manure (Recommended dose), T_3= 4 tha^{-1} processing poultry manure + $N_{18.5}P_{2.4}K_{6.0,}$ T_4= 3 tha^{-1} processing poultry manure +$N_{37}P_{4.8}K_{12,}$ T_5= 2 tha^{-1} processing poultry manure +$N_{55.5}P_{7.2}K_{18}$. When necessary, gap filling was also performed. Before sowing seeds in the experimental plot, the full amount of processing poultry manure was administered, along with TSP, MP, and half of urea. The remaining urea was divided into two equal parts and applied in two separate applications. After 20 days after sowing, half of the urea was treated as a top dressing, and the remaining urea was applied at 35 days. In this experiment, no pesticide was utilized. For a steady crop growth, irrigation intervals were properly provided. When necessary, weeding was done with a spading tool. At 140 days following seeding, the crops were harvested. Statistix10 software was used to analyze the recorded crop data and the differences between the treatment means were compared by least significant difference (LSD).

RESULTS AND DISCUSSIONS

Plant height

Sunflower plants have a solid stand and produce a lot of flowers. The treatment combination (I_1T_3) with a 10-day watering interval and 4 tha^{-1} processing poultry manure together with NPK fertilizers generated considerably taller plants (91.67 cm/plant), according to data reported in Table 1. This therapy combination had a statistically identical effect as I_1T_4 and was superior to the remainder of the study's treatments. The I_1T_4 treatment combination scored second in terms of plant height. I_4T_1 treatment combination produced the shortest plant height (46.33cm). This result was corroborated by Buriro *et al.* (2015), who discovered that using 6 tha^{-1} processing poultry manure in combination with 75% recommended dose of NPK fertilizers increased sunflower plant height.

Stem girth

Table 1 shows information about the girth of sunflower stems. The interaction effect of irrigation and processing poultry manure, as well as inorganic fertilizer, had a substantial impact on stem girth. The stem girth grew significantly in all treatment combinations as compared to the control group. Increased irrigation, as well as processing poultry manure and inorganic fertilizer, resulted in a considerable reduction in stem girth. The interaction effect of 10 days irrigation interval and poultry manure combined with inorganic fertilizer produced the highest stem girth (3.48 cm) in the I_1T_3 treatment combination and the lowest (1.82 cm) in the I_4T_5 treatment combination. In comparison to goat/sheep dung and buffalo manure, these findings supported the researcher's hypothesis that poultry manure was more successful in stimulating sunflower plant development features (Buriro *et al.* 2015).

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Table 1. Interaction effect of irrigation and processing poultry manure along with inorganic fertilizer on plant height, stem girth, number of leaves per plant, head diameter and number of seeds per head of sunflower.

Irrigation interval	Treatment	Plant height (cm)	Stem girth (cm)	Number of leaves/plant	Head diameter (cm)	Number of seeds/head
I_1	T_1	60.00hij	2.26hi	10.00hi	8.67jk	515.33i
	T_2	78.00e	2.46g	13.33def	12.33def	778.33cd
	T_3	91.67a	3.48a	18.00a	16.00a	808.33a
	T_4	89.67ab	3.25cde	14.67bcd	14.00b	801.00a
	T_5	84.67cd	2.35h	14.33cde	13.33bcd	787.33b
I_2	T_1	53.67kl	2.161jk	8.33jk	7.34lm	507.67ij
	T_2	71.00f	2.33h	11.33gh	10.33hi	769.33efg
	T_3	86.67cd	3.37b	16.00b	15.67a	801.33a
	T_4	80.00de	3.21def	14.67bcd	13.00bcd	787.33b
	T_5	73.00f	2.27hi	13.00ef	11.33def	776.67de
I_3	T_1	52.00i	2.078k	7.67k	7.34lm	500.67j
	T_2	70.00f	2.26hi	9.67ij	8.33kl	760.33h
	T_3	65.00g	3.32bc	15.33bc	13.67bc	785.67bc
	T_4	63.33ghi	3.15ef	13.67de	12.33def	774.33def
	T_5	63.67gh	2.07k	12.00fg	11.00gh	768.67fg
I_4	T_1	46.33m	1.91i	7.33k	6.67jk	509.67i
	T_2	58.67ij	2.19i	9.67ij	8.67jk	763.67gh
	T_3	61.67ghij	3.26cd	14.33cde	12.67cde	792.67b
	T_4	63.00ghi	3.14f	14.00cde	11.67efg	770.67defg
	T_5	57.33jk	1.82i	11.00ghi	9.67ij	766.67fgh
CV (%)		4.21	5.24	4.34	6.24	5.34

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by LSD.
Here, T_1= Control, T_2= 5tha^{-1} processing poultry manure (recommended dose), T_3= 4 tha^{-1} processing poultry manure + $N_{18.5}P_{2.4}K_{6.0}$, T_4= 3 tha^{-1} processing poultry manure +$N_{37}P_{4.8}K_{12}$, T_5= 2 tha^{-1} processing poultry manure +$N_{55.5}P_{7.2}K_{18}$. (Figures shown as subscript represent amount of nitrogen, phosphorus and potassium applied in kg/ha).

Number of leaves per plant

A plant's leaf is a crucial component. The photosynthate is determined by the leaf, and it plays a critical role in crop productivity. The interaction impact of irrigation and processing poultry manure, as well as inorganic fertilizer, produced the highest number of leaves (18.00/plant) in I_1T_3. I_1T_4, I_2T_3, I_2T_4, and I_3T_3 treatment combinations were statistically identical and placed second. I_4T_1 treatment combination had the smallest number of leaves (7.33/plant). Because of the increased competition for scarce nutrient components, the number of leaves in the I_4T_1 treatment combination decreased. The application of various quantities of nutrients resulted in a significant difference in the number of leaves per sunflower plant, according to the findings. Buriro *et al.* (2015) found that when 6 tha^{-1} processing poultry manure and 75% of the necessary amount of NPK fertilizers was applied, the largest number of leaves per plant in sunflower was produced.

Head diameter

Different irrigation intervals, as well as processing poultry manure and inorganic fertilizers, had a substantial effect on head diameter. When compared to a control treatment combination, all of the therapies significantly increased head diameter (Table 1). I_1T_3 treatment combination resulted in the largest head diameter (16.00 cm). This could be owing to the soil's hospitable climate, which is improved by proper irrigation and the processing of poultry waste with inorganic fertilizer. In the I_4T_1 treatment combination, the minimum head diameter (6.67 cm) was measured. Buriro *et al.* (2015) did a sunflower experiment and found similar results. In comparison to goat/sheep dung and buffalo manure, Sing *et al.* (2003) discovered that poultry manure was more effective at stimulating sunflower head diameter. At the flowering and seed maturity stages, Chimenti *et al.* (2002) found that sunflower is very sensitive to water deficiency stress.

Number of seeds per head

On the quantity of seeds per head of sunflower, there was a substantial interaction effect of irrigation, organic manure, and inorganic fertilizer (Table 1). The treatment combination of I_1T_3 with a 10 days irrigation interval and 4 tha^{-1} processing poultry manure with inorganic fertilizer produced the maximum number of seeds (808.33/head). This could be attributed to increased nutrient availability in the soil as a result of judicious irrigation water application and processing of poultry manure. This combination had a statistically equivalent effect to I_1T_4 and I_2T_3, but it performed best than other treatments combinations. In terms of quantity of seeds per head, treatment combinations I_1T_5, I_2T_4, I_3T_3 and I_4T_3 were statistically equal and ranked second. I_3T_1 treatment combination yielded the smallest quantity of seeds (500.67/head). Buriro *et al.* (2015) discovered that combining processing poultry manure with inorganic fertilizer increased the quantity of seeds per head of sunflower.

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Table 2. Interaction effect of irrigation and processing poultry manure along with inorganic fertilizer on seed weight per head, 1000-seed weight, seed yield per plot and seed yield per hectare of sunflower.

Irrigation interval	Treatment	Seed weight/ head (g)	1000-seed weight (g)	Seed yield (g/plot)	Seed yield (t/ha)
I_1	T_1	33.00hi	38.00k	140.00g	0.70g
	T_2	46.67c	44.00gh	280.00bc	1.40bc
	T_3	52.00a	54.00a	340.00a	1.70a
	T_4	50.00ab	53.00ab	320.00a	1.60a
	T_5	48bc	51.00cd	286.67b	1.43b
I_2	T_1	28.33jk	35.00l	126.67ef	0.63gh
	T_1	35.67gh	41.33ij	266.67bcd	1.33ef
	T_3	45.33cd	52.33abc	246.67def	1.23def
	T_4	42.00e	51.67bc	240.00def	1.20def
	T_5	39.00f	49.67de	220.00f	1.10f
I_3	T_1	25.67k	32.00m	106.60h	0.53h
	T_2	32.67i	39.67jk	241.00def	1.20def
	T_3	43.33de	51.00cd	226.67ef	1.13ef
	T_4	38.00fg	47.67f	233.33ef	1.17ef
	T_5	34.33hi	43.00hi	233.33ef	1.16ef
I_4	T_1	22.00l	30.00n	106.67h	0.63h
	T_2	28.67j	38.67k	253.33cde	1.27cde
	T_3	40.67ef	48.00ef	226.67ef	1.13ef
	T_4	34.00hi	45.67g	220.00f	1.10f
	T_5	29.67j	40.67j	140.00g	0.70g

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by LSD.
Here, T_1= Control, T_2= 5tha^{-1} processing poultry manure (recommended dose), T_3= 4 tha^{-1} processing poultry manure + $N_{18.5}P_{2.4}K_{6.0}$, T_4= 3 tha^{-1} processing poultry manure +$N_{37}P_{4.8}K_{12}$, T_5= 2 tha^{-1} processing poultry manure +$N_{55.5}P_{7.2}K_{18}$. (Figures shown as subscript represent amount of nitrogen, phosphorus and potassium applied in kg/ha).

Seed weight per head

The treatment of various levels of nutrients had a substantial impact on the marketable seed weight per head (Table 2). I_1T_3 treatment combination getting 10 days irrigation interval and 4tha^{-1} processing poultry manure together with NPK fertilizer had the highest seed weight (52.00 g/head), which was statistically superior to the rest of the sunflower treatment combinations. The I_4T_1 treatment combination had the smallest seed weight (22.00 g/head). The application of a higher level of 10 days irrigation interval, as well as lower and upper levels of processing poultry manure beyond 4 tha^{-1}, resulted in a reduction in seed weight per head. This finding revealed that I_1T_3 provided easily available plant nutrients for strong growth, resulting in an increase in sunflower seed weight per head. Buriro *et al.* (2015) discovered a similar result with sunflower.

1000-seed weight

The impact of various levels of irrigation intervals and processing poultry manure, as well as inorganic fertilizer, on sunflower 1000-seed weight was considerable (Table 2). I_1T_3 treatment combination yielded the highest 1000-seed weight (54.00 g). This combination had a statistically similar effect to the I_1T_4 and I_2T_3 treatments. Irrigation interval, processing poultry manure and inorganic fertilizer application at various amounts were found to result in a significant variation in sunflower 1000-seed weight. I_4T_1 treatment combination produced the smallest 1000-seed weight (30.00 g). The 1000-seed weight was greatly lowered by reducing the amount of irrigation water used (Alahdadi *et al.* 2011 and Kassab *et al.* 2012).

Seed yield per plot

Seed yield per plot was significantly influenced by different irrigation intervals using a combination of processed poultry manure and inorganic fertilizers (Table 2). The seed yield per plot was dramatically reduced when the irrigation interval was gradually increased. This could be owing to the beneficial effects of proper irrigation intervals and chicken manure processing combined with inorganic fertilizer, resulting in better seed production per plot. I_4T_1 treatment combination produced the lowest seed production (106.60g/plot). The seed yield/plant was dramatically reduced by reducing the amount of irrigation water used (Alahdadi *et al.* 2011 and Kassab *et al.* 2012).

Seed yield per hectare

The application of varying intervals of irrigations has a substantial impact on seed output per hectare (Table 2). I_1T_3 treatment combination produced the highest seed production (1.70 tha^{-1}), which was equivalent to I_1T_4 treatment combination but superior to the other sunflower treatment combinations. Through the optimal use of irrigation and processing poultry manure with a combination of nitrogen, phosphorus, and potassium fertilizer, this treatment combination produced the maximum seed output, resulting in an increase in sunflower yield. Treatment combinations for I_1T_5 were similar to those for I_1T_3 and I_1T_4. In the treatment combination of

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I_3T_1, the lowest seed yield (0.53 tha^{-1}) was recorded. The application of a higher irrigation interval than 10 days resulted in a decrease in seed production per hectare. When irrigation was employed to provide enough water during the flowering and yield creation periods, the highest seed production of sunflower was recorded (Demir *et al.* 2006 and Kazemeini *et al.* 2009).

CONCLUSION

The use of a 10-day irrigation interval and 4 tha^{-1} processing poultry manure, as well as NPK fertilizers, makes the soils in the coastal zone conducive to improving sunflower yield and yield parameters by releasing macro and micro nutrients in appropriate proportions. As a result, enhancing sunflower yields would be best accomplished by irrigation interval and processing poultry manure in combination with NPK fertilizers.

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