

INTERACTIVE EFFECTS OF POULTRY LITTER COMPOST AND CHEMICAL FERTILIZERS ON MACRONUTRIENTS, OIL AND PROTEIN CONTENT IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Abstract

A field experiment was carried out at the research farm of Charfasson Govt. College, Bhola, during rabi season in 2016-2017 to evaluate the effect of poultry litter compost and NPK fertilizers on concentration, uptake, oil and protein content of sunflower *cv.* BARI-2 (Keroni-2). The experiment was laid out in a completely randomized block design (CRBD) having sixteen treatments with three replications. The unit plot size was 3 m x 2 m. Treatments were T₁: Control (- PL and -NPK), T₂: 1.5 t PL ha⁻¹, T₃: 3 t PL ha⁻¹, T₄: 4.5 t PL ha⁻¹, T₅: N₄₀P₃₀K₅₀ kg ha⁻¹, T₆: N₈₀P₆₀K₁₀₀ kg ha⁻¹, T₇: N₁₂₀P₉₀K₁₅₀ kg ha⁻¹, T₈: 1.5 t PL ha⁻¹+N₄₀P₃₀K₅₀ kg ha⁻¹, T₉: 1.5 t PL ha⁻¹+ N₈₀P₆₀K₁₀₀ kg ha⁻¹, T₁₀: 1.5 t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀ kg ha⁻¹, T₁₁: 3 t PL ha⁻¹+N₄₀P₃₀K₅₀ kg ha⁻¹, T₁₂: 3 t PL ha⁻¹+ N₈₀P₆₀K₁₀₀ kg ha⁻¹, T₁₃: 3 t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀ kg ha⁻¹, T₁₄: 4.5 t PL ha⁻¹+N₄₀P₃₀K₅₀ kg ha⁻¹, T₁₅: 4.5 t PL ha⁻¹+ N₈₀P₆₀K₁₀₀ kg ha⁻¹ and T₁₆: 4.5 t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀ kg ha⁻¹. Sixty plants were grown in each plot for 90 days. Maximum values of NPKS concentration (%) in different organs of sunflower were 0.65, 0.42, 1.80, 0.17 for stem; 1.02, 0.54, 1.54, 0.18 for root; 4.47, 0.57, 3.14, 0.20 for leaf; 2.60, 0.64, 3.20, 0.32 for petiole and 5.18, 0.86, 1.02, 0.31 for seed due to application of poultry litter and NPK fertilizers. The highest concentrations of NPKS of different organs of sunflower at maturity, were found significantly ($P < 0.05$) higher in combined treatments 5 t PL ha⁻¹ + N₁₂₀P₉₀K₁₅₀kg ha⁻¹ and 7.5 t PL ha⁻¹ + N₁₂₀P₉₀K₁₅₀kg ha⁻¹, respectively, in most of the cases. However, their uptake pattern also followed the same trend as in concentration and those were found in same treatments in most of the cases. The lowest concentration and uptake were measured almost in control treatment (-PL and -NPK). Content of oil and protein increased variably due to variation in treatments. The highest content of oil in seed (47.7%) was extracted from the treatment 5 t PL ha⁻¹ + N₈₀P₆₀K₁₀₀kg ha⁻¹ and the lowest value (37.7%) was recorded in the highest dose of NPK fertilizers and poultry litter which was lower than control treatment. Protein content also followed the same pattern as in oil. The highest content of protein (31.8%) was recorded from the treatment 5 t PL ha⁻¹ + N₁₂₀P₉₀K₁₅₀kg ha⁻¹ and the lowest values (18.8%) was observed in control treatment. The overall findings of this study indicated that poultry litter compost in combination with chemical fertilizers can be applied to achieve better concentration, uptake of NPKS in different organs and oil and protein content in seeds of sunflower under field conditions at coastal zone.

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Introduction

Sunflower (*Helianthus annuus* L.) is one of the most common oil crops widely grown in different parts of the world. Globally, sunflower ranks second next to soybean among field crops grown for edible oil⁽¹⁾. It has gained popularity of all the oilseed crops, because of its excellent quality oil due to its richness with high degree polyunsaturated fatty acids, anti-cholesterol properties, short duration, wide adaptability to soil and climatic conditions, photo and thermo-insensitiveness, drought tolerance and higher oil yield per unit area. Its seed contains a high percentage of oil (40-50 %) and rich in protein 26 per cent⁽²⁾. Sunflower oil is considered as premium oil because of its light color, flavor and this oil is unsaturated with high levels of linoleic acid. High percentage of polyunsaturated fatty acids in sunflower oil such as linoleic acid in classical sunflower, which can reach up to 90% of the total unsaturated fatty acids, makes it high-quality edible oil commercially⁽¹⁾.

A sustainable agricultural system must be economically sound, socially acceptable and environmentally compatible. The challenge of sustainable agricultural research and education program is to develop system that meet these three inter connected goals. Agricultural scientists are engaged to establish agricultural systems with lower production cost and conserving the natural resources⁽³⁾. The price of chemical fertilizers is hiking, lack of consistency in feeding the soil and endangering human health cause to the increase of the use of manure for soil fertility⁽⁴⁾. Excessive nitrogen fertilization of sunflower not only generates that environmental risk, it may also affect the grain quality, decreasing its oil content and reduce yield through an increase of plant lodging. On the other hand, manure can improve soil fertility, increase water holding capacity, decrease soil erosion, improves amount of oxygen, and promotes beneficial organisms and productivity^(4,5).

Poultry manure is an excellent organic manure as it contains high N, P, K and other essential nutrients. It has been reported to supply P more readily to plants than other organic sources. Poultry manure increased soil pH, organic matter content, available P, exchangeable cations and micronutrients, and decreased exchangeable Al and Fe contents and soil bulk density⁽⁶⁾. Despite of the large quantities of plant nutrients contained in synthetic fertilizers, compared to organic nutrients, the presence of growth promoting agents in organic fertilizers make them important in enhancing soil fertility and productivity⁽⁵⁾. Sunflower hybrid gave a higher yield from a combination of organic manures with N and P. The highest seed and stalk yield was recorded in sunflower with the application of poultry manure as compared to other organic manures⁽³⁾. In Bangladesh, a huge quantity of poultry litter is produced every year and increasing day by day. It accelerates the environmental pollution as well. A scanty information is available in the literature in relation to agricultural uses of poultry litter compost in Bangladesh. Considering the above facts, a field experiment was conducted using

poultry litter compost and NPK fertilizers to evaluate NPKS, oil and protein content in different organs and seeds of sunflower at southern coastal belt of Bangladesh.

Materials and Methods

A field study was carried out at the research farm of Charfasson Govt. College, Bhola, Bangladesh during the rabi season in 2016-2017. Soil samples (0-15 cm depth) were collected from the research farm. The samples were air-dried, ground and sieved through 2 mm sieve for physical and chemical analysis and kept in polyethylene bags. The soil had found pH of 8.30 (1: 2.5 w/v H₂O), organic carbon 0.85%⁽⁷⁾, available nitrogen 0.27%⁽⁸⁾, available phosphorus 0.09%⁽⁹⁾, available potassium 1.33%⁽¹⁰⁾, available S 0.13%⁽¹¹⁾ and sand 12.2%, silt 51.34% and clay 36.46%, textural class- silty clay loam⁽¹²⁾. The maximum water retentive capacity was 39%. Seeds (v. BARI-2 Keroni-2) were collected from BADC Barisal. The experiment was laid out in a completely randomized block design (CRBD) having sixteen treatments with three replications. Each plot size was 3 m x 2 m. Treatments were T₁: Control (- PL and -NPK), T₂:1.5 t PL ha⁻¹, T₃:3 t PL ha⁻¹, T₄: 4.5 t PL ha⁻¹, T₅:N₄₀P₃₀K₅₀ kg ha⁻¹, T₆:N₈₀P₆₀K₁₀₀ kg ha⁻¹, T₇:N₁₂₀P₉₀K₁₅₀ kg ha⁻¹, T₈: 1.5 t PL ha⁻¹+N₄₀P₃₀K₅₀kg ha⁻¹, T₉:1.5 t PL ha⁻¹+ N₈₀P₆₀K₁₀₀kg ha⁻¹, T₁₀:1.5 t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀ kg ha⁻¹, T₁₁: 3 t PL ha⁻¹+N₄₀P₃₀K₅₀kg ha⁻¹, T₁₂: 3 t PL ha⁻¹+ N₈₀P₆₀K₁₀₀ kg ha⁻¹, T₁₃:3 t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀kg ha⁻¹, T₁₄: 4.5 t PL ha⁻¹+N₄₀P₃₀K₅₀ kg ha⁻¹, T₁₅:4.5 t PL ha⁻¹+ N₈₀P₆₀K₁₀₀kg ha⁻¹ and T₁₆:4.5 t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀kg ha⁻¹. Doses were selected according to BARC⁽¹³⁾. At the time of final land preparation poultry litter compost with N, P and K were applied in desired treatments. Nitrogen, phosphorus and potassium were applied as urea, triple super phosphate and muriate of potash, respectively. Sixty seeds plot⁻¹ were sown on 16th December, 2016. Distance between row to row was 40 cm and seed to seed 25 cm. Intercultural practices *i.e.* weeding, spading, fencing, pesticide spraying *etc.* were done as and when necessary. Finally, plants were harvested after 90 days of sowing of seeds at the period of maturity. Plants were harvested as root, stem, leaf, petiole, inflorescence and seed. Samples were air-dried after then oven-dried at temperature of 65°C. The dry weight of different plant parameters and seed weight were measured and kept in brown paper bags separately. The uptake of nutrients by different parts of sunflower plants were estimated by multiplying the nutrient concentration and dry matter yield of the plant parts. Estimation of oil content (%) in the seed sample was done by Soxhlet Fat Extraction method evolved by AOAC⁽¹⁴⁾. Seed protein content was calculated by multiplying the N content of seed with a factor of 6.25. Analysis of variance was done with the help of SPSS program and the mean differences among the treatments were evaluated by LSD test at 5% level.

Results and Discussion

(a) *Concentration and uptake of NPKS in root:* The concentration and uptake of nitrogen in root ranged from 0.39 to 1.02% and 9.5 to 111.6 mg plant⁻¹ root, respectively. The highest values of concentration and uptake were observed in 3 t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹ (Table 1). The same values for phosphorus ranged from 0.11 to 0.54% and uptake 2.7 to 64.6 mg plant⁻¹ in root and the highest values of concentration and uptake were recorded in T₁₃ (3t PL ha⁻¹ +N₁₂₀P₉₀K₁₅₀kg ha⁻¹) and T₁₄ (4.5 ton PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹), respectively.

Table 1. Effects of poultry litter compost and NPK fertilizers on the concentration and uptake of NPKS in root of sunflower.

Treatments	Nitrogen		Phosphorus		Potassium		Sulfur	
	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)
T ₁ :Control (-PL and-NPK)	0.39	9.5	0.11	2.7	0.36	8.8	0.07	1.7
T ₂ : 1.5 t PLha ⁻¹	0.43	20.6	0.22	10.6	0.56	26.9	0.12	5.8
T ₃ : 3 t PL ha ⁻¹	0.49	18.2	0.24	8.9	0.78	28.9	0.14	5.2
T ₄ : 4.5t PL ha ⁻¹	0.75	31.2	0.27	11.2	0.78	32.4	0.16	6.7
T ₅ : N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.44	23.8	0.34	18.4	0.82	44.4	0.06	3.2
T ₆ : N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.52	47.3	0.37	33.6	0.96	87.3	0.07	6.4
T ₇ : N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	0.59	66.4	0.41	46.1	1.06	119.3	0.08	9.0
T ₈ : 1.5t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.52	33.6	0.44	28.5	1.12	72.5	0.11	7.1
T ₉ : 1.5t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.55	45.6	0.42	34.8	1.10	91.2	0.13	10.8
T ₁₀ : 1.5t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	0.67	80.1	0.45	53.8	1.13	135.0	0.15	17.9
T ₁₁ : 3t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.41	25.3	0.48	29.6	1.17	72.1	0.12	7.4
T ₁₂ : 3t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.53	39.6	0.50	37.4	1.26	94.1	0.14	10.5
T ₁₃ : 3t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	1.02	111.6	0.54	59.1	1.50	164.1	0.16	17.5
T ₁₄ : 4.5t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.77	87.5	0.52	59.1	1.32	150.0	0.15	17.0
T ₁₅ : 4.5t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.81	87.2	0.46	49.5	1.50	161.4	0.18	19.4
T ₁₆ : 4.5t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	0.77	97.5	0.51	64.6	1.54	195.0	0.13	16.5
LSD at 5%	0.04	10.11	0.053	4.64	0.20	14.5	0.13	1.95

Similarly, concentration and uptake of potassium in root varied from 0.36 to 1.54% and 8.8 to 195.0 mg plant⁻¹ root, respectively. The highest values of concentration and uptake were recorded in T₁₃ (4.5t PL ha⁻¹ + N₁₂₀P₉₀K₁₅₀kg ha⁻¹) (Table 1). Sulfur concentration and uptake ranged from 0.07 to 0.18% and 1.7 to 19.4 mg plant⁻¹ root, respectively. The highest values of concentration and uptake were observed in T₁₃ (4.5t PL ha⁻¹ + N₈₀P₆₀K₁₀₀kg ha⁻¹).

(b) *Concentration and uptake of NPKS in stem:* Nitrogen concentration and uptake in stem ranged from 0.20 to 0.65% and 33.1 to 381.6 mg plant⁻¹ stem, respectively (Table 2). The highest values were found in T₁₃ (3t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹. Phosphorus concentration and uptake of stem varied from 0.13 to 0.42% and 21.5 to 256.6 mg plant⁻¹ stem respectively (Table 2).

Table 2. Effects of poultry litter and NPK fertilizers on the concentration and uptake of NPKS in stem of sunflower.

Treatments	Nitrogen		Phosphorus		Potassium		Sulfur	
	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)
T ₁ : Control(-PL and -NPK)	0.20	33.1	0.13	21.5	0.64	106.0	0.04	6.6
T ₂ : 1.5t PL ha ⁻¹	0.23	56.2	0.16	39.2	1.20	293.4	0.07	17.1
T ₃ : 3t PL ha ⁻¹	0.33	61.8	0.17	31.9	1.42	266.1	0.08	15.0
T ₄ : 4.5t PL ha ⁻¹	0.35	61.5	0.20	35.1	1.52	266.9	0.10	17.6
T ₅ : N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.22	61.4	0.20	55.8	1.48	412.9	0.04	11.2
T ₆ : N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.19	90.2	0.26	123.4	1.57	745.3	0.08	38.0
T ₇ : N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	0.17	103.5	0.42	256.6	1.60	973.8	0.09	54.8
T ₈ : 1.5t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.26	78.6	0.23	69.6	1.57	474.8	0.12	36.3
T ₉ : 1.5t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.29	111.4	0.22	84.5	1.40	537.7	0.14	53.8
T ₁₀ : 1.5t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	0.31	197.8	0.22	140.4	1.56	995.6	0.13	83.0
T ₁₁ : 3t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.37	112.6	0.23	88.3	1.46	444.4	0.17	51.7
T ₁₂ : 3t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.40	153.7	0.21	80.7	1.69	649.3	0.15	57.6
T ₁₃ : 3t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	0.65	381.6	0.23	135.0	1.70	997.9	0.17	99.8
T ₁₄ : 4.5t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	0.45	178.6	0.24	95.3	1.80	714.4	0.15	59.5
T ₁₅ : 4.5t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	0.52	289.8	0.20	111.5	1.78	992.0	0.16	89.2
T ₁₆ : 4.5t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	0.56	344.8	0.20	123.1	1.62	997.4	0.14	86.2
LSD at 5%	0.053	34.04	0.06	25.80	0.26	30.42	0.053	6.69

The maximum values of concentration and uptake were recorded in the same treatment T₁₃ (3t PL ha⁻¹ + N₁₂₀P₉₀K₁₅₀kg ha⁻¹). Potassium concentration and uptake ranged from 0.64 to 1.80% and 106.0 to 997.9 mg plant⁻¹ in stem respectively (Table 2). Maximum values of concentration and uptake were found in T₁₄ (4.5t PL ha⁻¹+N₄₀P₃₀K₅₀kg ha⁻¹) and T₁₃ (3t PL ha⁻¹ +N₁₂₀P₉₀K₁₅₀kg ha⁻¹), respectively. Similarly, sulfur concentration and uptake varied from 0.04 to 0.17% and 6.6 to 99.8 mg plant⁻¹ in stem respectively. Study showed that the highest value of concentration of sulfur was found in T₁₃ (3t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹) and uptake in T₁₃ (3t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹), respectively.

(c) *Concentration and uptake of NPKS in leaf:* The concentration and uptake of nitrogen and phosphorus varied from 1.37 to 4.47 and 0.40 to 0.57%; and 86.2 to 747.4 and 18.9 to 95.3 mg plant⁻¹ leaf, respectively (Table 3).

Table 3. Effects of poultry litter compost and NPK fertilizers on the concentration and uptake of NPKS in leaf of sunflower.

Treatments	Nitrogen		Phosphorus		Potassium		Sulfur	
	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)
T ₁ : Control(-PL and -NPK)	1.37	86.2	0.40	18.9	1.44	90.6	0.07	4.4
T ₂ : 1.5t PL ha ⁻¹	2.22	174.3	0.37	29.0	1.90	149.2	0.10	7.9
T ₃ :3t PL ha ⁻¹	2.30	139.4	0.45	27.3	2.12	128.5	0.10	6.1
T ₄ : 4.5t PL ha ⁻¹	2.42	188.8	0.46	35.9	2.15	167.7	0.14	10.9
T ₅ : N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	2.31	205.6	0.41	36.5	2.23	198.5	0.07	6.2
T ₆ : N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	2.42	248.5	0.42	43.1	2.38	244.4	0.08	8.2
T ₇ :N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	2.47	295.9	0.45	53.9	2.49	298.3	0.06	7.2
T ₈ : 1.5t PL ha ⁻¹ +N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	2.48	190.2	0.33	25.3	2.57	197.1	0.12	9.2
T ₉ : 1.5t PL ha ⁻¹ +N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	2.50	280.0	0.53	59.4	2.64	295.7	0.14	15.7
T ₁₀ : 1.5t PL ha ⁻¹ +N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	2.62	292.4	0.48	53.6	2.69	300.2	0.16	17.9
T ₁₁ : 3t PL ha ⁻¹ +N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	2.72	297.6	0.29	31.7	2.81	307.4	0.13	14.2
T ₁₂ : 3t PL ha ⁻¹ +N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	2.93	354.5	0.30	36.3	2.97	359.4	0.17	20.6
T ₁₃ : 3t PL ha ⁻¹ +N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	4.47	747.4	0.57	95.3	3.07	513.3	0.20	33.4
T ₁₄ : 4.5t PL ha ⁻¹ +N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	2.97	428.6	0.47	67.8	3.06	441.6	0.15	21.6
T ₁₅ : 4.5t PL ha ⁻¹ +N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	3.02	397.4	0.44	57.9	3.14	413.2	0.17	22.4
T ₁₆ : 4.5t PL ha ⁻¹ +N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	3.10	665.6	0.42	90.2	3.07	659.1	0.19	40.8
LSD at 5%	0.18	24.57	0.053	6.5	0.12	42.44	0.053	4.15

The highest values of concentration and uptake of nitrogen and phosphorus were recorded in the same treatment (3t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹). Similarly, concentration and uptake of potassium and sulfur ranged from 1.44 to 3.14 and 0.07 to 0.20%, and 90.6 to 659.1 and 4.4 to 40.8 mg plant⁻¹ leaf, respectively (Table 4). The highest values of concentration and uptake were found in the treatments of 4.5t PL ha⁻¹+N₈₀P₆₀K₁₀₀kg ha⁻¹ and 3t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹, and 4.5t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀kg ha⁻¹, respectively.

(d) *Concentration and uptake of NPKS in petiole:* The concentration and uptake of nitrogen and phosphorus in petiole varied from 0.38 to 2.60% and 0.05 to 0.64%, and 7.2 to 226.2 and 1.0 to 50.5 mg plant⁻¹ petiole, respectively (Table 5).

Table 4. Effects of poultry litter compost and NPK fertilizers on the concentration and uptake of NPKS in petiole of sunflower

Treatments	Nitrogen		Phosphorus		Potassium		Sulfur	
	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)
T ₁ : Control(-P Land-NPK)	0.38	7.2	0.05	1.0	0.61	11.6	0.03	0.6
T ₂ : 1.5t PL ha ⁻¹	0.43	12.5	0.09	2.6	0.85	24.7	0.08	2.3
T ₃ : 3t PL ha ⁻¹	0.57	13.7	0.16	3.8	0.89	21.4	0.16	3.8
T ₄ : 4.5t PL ha ⁻¹	0.58	16.2	0.17	4.8	1.12	31.4	0.19	5.3
T ₅ : N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	1.20	40.8	0.26	8.8	1.66	56.4	0.07	2.4
T ₆ :N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	1.31	61.6	0.26	12.2	1.64	77.1	0.09	4.2
T ₇ :N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	1.47	88.2	0.34	20.4	1.75	105.0	0.11	6.6
T ₈ :1.5t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	1.72	58.5	0.28	9.5	1.79	60.9	0.14	4.8
T ₉ :1.5t PL ha ⁻¹ +N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	1.77	79.7	0.30	13.5	1.98	89.1	0.17	7.7
T ₁₀ : 1.5t PL ha ⁻¹ +N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	1.75	80.5	0.49	22.5	2.40	110.4	0.32	8.7
T ₁₁ : 3t PL ha ⁻¹ +N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	1.71	68.4	0.44	17.6	1.90	76.0	0.12	4.8
T ₁₂ : 3t PL ha ⁻¹ +N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	1.92	99.8	0.48	25.0	2.00	104.0	0.14	7.3
T ₁₃ : 3t PL ha ⁻¹ +N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	2.31	150.2	0.62	40.3	3.00	195.0	0.18	11.7
T ₁₄ : 4.5t PL ha ⁻¹ +N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	2.20	170.8	0.41	20.1	2.95	144.6	0.16	7.8
T ₁₅ : 4.5t PL ha ⁻¹ +N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	2.50	137.5	0.64	35.2	2.91	160.1	0.18	9.9
T ₁₆ : 4.5t PL ha ⁻¹ +N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	2.60	226.2	0.58	50.5	3.20	278.4	0.20	17.4
LSD at 5%	0.117	7.66	0.105	3.28	0.166	118.85	0.053	2.12

The maximum values of concentration and uptake of nitrogen and phosphorus were found in the treatments of T₁₆ (4.5t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹), T₁₅ (4.5t PL ha⁻¹ + N₈₀P₆₀K₁₀₀kg ha⁻¹), and T₁₆ (4.5t PL ha⁻¹ + N₁₂₀P₉₀K₁₅₀kg ha⁻¹) respectively. The concentration and uptake of potassium and sulfur ranged from 0.61 to 3.20 and 0.03 to 0.32%, and 11.6 to 278.4 and 0.6 to 17.4 mg plant⁻¹ petiole, respectively (Table 4). The highest values of concentration and uptake were observed in the treatments of T₁₆ (4.5t PL ha⁻¹ +N₁₂₀P₉₀K₁₅₀kg ha⁻¹), and T₁₀ (1.5t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹), andT₁₆ (4.5t PL ha⁻¹+ N₁₂₀P₉₀K₁₅₀kg ha⁻¹) respectively.

(e) *Concentration and uptake of NPKS in seed:* Values for nitrogen and phosphorus concentration and uptake of sunflower seed ranged from 2.89 to 5.18 and 0.26 to 0.86% and 213.9 to 2294.7 and 19.2 to 381.0 mg plant⁻¹ seed, respectively. The highest values of the nutrients were recorded in the same treatment (3t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹). Concentration and uptake of potassium and sulfur ranged from 0.44 to 1.02 and 0.15 to 0.31%, and 32.6 to 447.4 and 11.1 to 128.5 mg plant⁻¹ seed, respectively (Table 5).

Table 5. Effects of poultry litter compost and NPK fertilizers on the concentration and uptake of NPKS, oil and protein content in seeds of sunflower

Treatments	Nitrogen		Phosphorus		Potassium		Sulfur		Oil content (%)	Protein content (%)
	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)	Conc. (%)	Uptake (mg/plant)		
T ₁ : Control (-PL and -NPK)	2.89	213.9	0.26	19.2	0.44	32.6	0.15	11.1	42.6	18.0
T ₂ : 1.5t PL ha ⁻¹	3.89	462.9	0.36	42.8	0.61	72.6	0.16	19.0	43.1	23.8
T ₃ : 3t PL ha ⁻¹	4.10	516.6	0.34	42.8	0.66	83.2	0.17	21.4	44.0	25.4
T ₄ : 4.5t PL ha ⁻¹	4.41	564.5	0.38	48.6	0.71	90.9	0.17	21.8	44.2	27.1
T ₅ : N ₈₀ P ₃₀ K ₅₀ kg ha ⁻¹	3.18	572.4	0.54	97.2	0.72	129.6	0.13	23.4	38.5	20.3
T ₆ : N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	3.19	685.9	0.56	120.4	0.77	165.6	0.15	32.3	43.3	20.4
T ₇ : N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	3.20	1110.9	0.59	204.7	0.76	263.7	0.18	62.5	40.7	20.4
T ₈ : 1.5t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	4.39	1137.0	0.56	145.0	0.77	299.4	0.20	51.8	42.2	27.5
T ₉ : 1.5t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	4.84	1655.3	0.57	194.9	0.81	277.0	0.22	75.2	43.2	30.0
T ₁₀ : 1.5t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	5.14	1747.6	0.68	231.2	0.84	285.6	0.14	44.2	46.0	31.5
T ₁₁ : 3t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	4.63	1861.3	0.56	225.1	0.87	349.7	0.22	88.4	41.8	28.7
T ₁₂ : 3t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	5.11	1849.8	0.75	271.5	0.90	325.8	0.31	112.2	47.7	31.5
T ₁₃ : 3t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	5.18	2294.7	0.86	381.0	1.01	447.4	0.29	128.5	46.2	31.8
T ₁₄ : 4.5t PL ha ⁻¹ + N ₄₀ P ₃₀ K ₅₀ kg ha ⁻¹	5.01	2224.4	0.76	337.4	0.88	390.7	0.22	97.7	44.0	30.8
T ₁₅ : 4.5t PL ha ⁻¹ + N ₈₀ P ₆₀ K ₁₀₀ kg ha ⁻¹	5.06	1831.7	0.79	282.4	0.94	340.3	0.21	76.0	43.7	31.3
T ₁₆ : 4.5t PL ha ⁻¹ + N ₁₂₀ P ₉₀ K ₁₅₀ kg ha ⁻¹	4.83	1729.1	0.79	268.5	1.02	365.2	0.20	71.6	37.7	30.4
LSD at 5%	0.18	74.28	0.139	41.17	0.04	32.91	0.04	14.4	1.6	0.08

The highest value of concentration and uptake of potassium and sulfur were recorded in the treatments of T₁₆ (4.5t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹), T₁₂ (3t PL ha⁻¹ +N₈₀P₆₀K₁₀₀kg ha⁻¹, and T₁₃ (3t PL ha⁻¹ +N₁₂₀P₉₀K₁₅₀kg ha⁻¹), respectively. These findings are in agreement to the results of Sharma *et al.*⁽¹⁵⁾ recorded that conjunctive nutrient treatments proved quite superior to other set of treatments in improving the uptake of N, P, K and S and micronutrients in sunflower plant and their build up in the soil.

Gani⁽⁶⁾ conducted experiment in Manikgonj also reported that the highest content and uptake of N, P, K and S were found with integrated treatment of RDF N 100% from PL + 100% RDF in jute plant. The author, further, reported that the highest content of N (2.56%), P (0.56%), K (2.57%) and S (0.073%) in jute plant were found in integrated treatment of RDF N 100% from PL + 100% RDF from experiment conducted at Kishoreganj. Tejeswara Rao *et al.*⁽¹⁶⁾ also reported that the highest phosphorus uptake of sunflower was recorded with poultry manure either with or without the spray of *Panchagavya*. Similarly, Esmaeilian *et al.*⁽⁴⁾ also revealed that combination of poultry manure and chemical fertilizer led to the highest P content and sheep manure application resulted to the highest K content. Marr and Cresser⁽⁸⁾ concluded that the typical concentrations of elements in dried healthy foliage are N 0.8-3.0%, K 0.5-2.5%, Ca 1.5-2.8%, Mg 0.15-0.45%, P 0.08-0.35%, Fe 40-150 mg kg⁻¹, Mn 30-100 mg kg⁻¹, B 10-50 mg kg⁻¹, Cu 5-12 mg kg⁻¹, Zn 30-200 mg kg⁻¹ and Mo 0.1-1.5 mg kg⁻¹. The result of the concentration of N, P and K of the present experiment are in agreement with Marr and Cresser above.

(g) *Oil and protein content in seed:* Per cent oil content in sunflower seeds varied significantly (P< 0.05) over the control due to application of PL and NPK fertilizers alone and various combinations. The highest yield of oil content (47.7%) and the lowest oil content (37.7%) were found in 3t PL ha⁻¹+N₈₀P₆₀K₁₀₀kg ha⁻¹ and 4.5t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹ treatments respectively. Among the treatments, the significant variation was found in some cases. The treatments, where the highest amount poultry litter and NPK fertilizers were added showed the lowest per cent of oil content (Table 5). These observations are in well agreement with the findings of Karim *et al.*⁽¹⁷⁾ who reported that treatment of poultry litter significantly influenced oil content of BINA Soybean-2. Similarly, Munir *et al.*⁽³⁾ also reported that all the seed quality traits of sunflower were found significantly different due to application of various combinations of poultry manure and inorganic fertilizers. Buriro *et al.*⁽¹⁸⁾ who reported that oil content of sunflower was significantly (p < 0.05) affected by conjunctive use of different organic manures and inorganic NPK fertilizers. Similar information was put forwarded by Abbas *et al.*⁽¹⁹⁾ in sunflower.

Per cent protein content showed very similar trend as in case of per cent oil in sunflower seed's due to application of various combinations of poultry litter and NPK fertilizers (Table 5). Among the various combinations of poultry litter and NPK

fertilizers, the best yield of protein (31.8%) was obtained with the application of 3 t PL ha⁻¹+N₁₂₀P₉₀K₁₅₀kg ha⁻¹. Control treatment showed the lowest yield of protein (18.0%). Results further showed that variations among the treatments were found to be not significant in most of the cases (Table 5). Per cent protein content increased with the increase of poultry litter and NPK fertilizers. These observations are in agreement with the findings of Hammad *et al.*⁽²⁰⁾ who revealed that the combination of GM+PL+SS each @ of 10 t ha⁻¹ showed maximum economic yield (3.65 t ha⁻¹) in wheat. Tejeswara Rao *et al.*⁽¹⁶⁾ reported that among the organic sources tried, the highest net returns and benefit-cost ratio of sunflower were realized with poultry manure in combination with *Panchagavya*.

It may be concluded that poultry litter compost in combination with chemical fertilizer could be applied to achieve better concentration and uptake of NPKS in different organs and oil and protein content in seeds of sunflower grown under field of coastal zone of Bangladesh.

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