INFLUENCE OF COW DUNG AND NPK FERTILIZERS ON MACRONUTRIENTS AND OIL CONTENT OF SUNFLOWER (*Helianthus annuus* L.)

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Abstract

A field experiment was carried out at the research farm of Charfasson Govt. College, Bhola, Bangladesh in rabi season in 2015-2016 to evaluate the effects of cow dung (CD) with and without NPK fertilizers to estimate the concentration, uptake and oil content of sunflower *cv.* BARI-2 (Keroni-2). It was laid out in a completely randomized block design (CRBD) having sixteen treatments with three replications and plot size was 3m×2m. Treatments were T_1: Control (- CD and -NPK), T_2: 2.5t CD ha^{-1}, T_3: 5t CD ha^{-1}, T_4: 7.5t CD ha^{-1}, T_5: $N_{40}P_{30}K_{50}$kg ha^{-1}, T_6: $N_{80}P_{60}K_{100}$kg ha^{-1}, T_7: $N_{120}P_{90}K_{150}$kg ha^{-1}, T_8: 2.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}, T_9: 2.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1}, T_{10}: 2.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}, T_{11}: 5t CD ha^{-1}+ $N_{40}P_{30}K_{50}$kg ha^{-1}, T_{12}: 5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1}, T_{13}: 5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}, T_{14}:7.5t CD ha^{-1}+$N_{40}P_{30}K_{50}$kg ha^{-1}, T_{15}:7.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} and T_{16}: 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. Sixty plants were grown in each plot for 90 days. Maximum values of NPKS concentration (%) in different organs of sunflower were 1.08, 0.38, 2.04, 0.18 for root; 1.33, 0.33, 1.85, 0.19 for stem; 3.45, 0.67, 4.12, 0.18 for leaf; 1.99, 0.62, 3.0, 0.22 for petiole; 0.73, 0.68, 2.25, 0.23 for inflorescence, and 4.95, 0.94, 0.75, 0.26 for seed measured in combined treatments of 5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1} in most of the cases. The uptake pattern also followed the same trend as in concentration. The lowest concentration and uptake of NPKS were recorded in control (-CD and -NPK). The highest content of oil in seed (51.8%) was extracted from the treatment 5t CD ha^{-1}+ $N_{120}P_{90}K_{150}$kg ha^{-1} and the lowest value (35.6%) was in treatment 5t CD ha^{-1}+ $N_{80}P_{60}K_{100}$kg ha^{-1} which was lower than control. The findings of this study indicated that cow dung in combination with chemical fertilizers enhanced the concentration and uptake of NPKS and oil content in seeds of sunflower. The dose 5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1} can be suggested to produce maximum oil. Study generated an information for the concern people for future research.

Key words: Sunflower; Cow dung; Chemical fertilizers; Concentration; Uptake and oil content.

INTRODUCTION

In the recent years, sunflower (*Helianthus annuus* L.) oil consumption has been increased (Al-Bayati *et al.* 2021). It is the most important oil seed crops of the world because of the adequate concentration of unsaturated fatty acids (900g kg^{-1}) in its oil (Kaushik *et al*. 2014, Shogi-Kalkhoran *et al*. 2013) and occupies second place next to soybean as a source of vegetable edible oil (Kaushik *et al*. 2014). The oil present in sunflower achenes, has high quality for human consumption and can be used to produce biodiesel (Filho *et al.* 2013). It is also considered as one of the major oil producing crops because of its high-quality oil, protein contents, consumable parts of this plant and moderate production requirements (Shogi-Kalkhoran *et al*. 2013). Sunflower has gained popularity of among the oilseed crops, because of its excellent quality oil due to its richness with high degree polyunsaturated fatty acids, anti-cholesterol properties (Esmaeilian *et al*. 2012, Rasool *et al*. 2013), short duration, wide adaptability to soil and climatic conditions, photo and thermo-insensitiveness, drought tolerance and higher yield per unit area (Kaushik *et al*. 2014, Agele and Taiwo 2013). Seed contains a good amount of oil (48-53%), protein (14-19%), crude fibre (16-27%), ash (2-3%), soluble sugar (7-9%), and hull (21-27%) (Rasool *et al*. 2013). The composition of fatty acids is a main determinant of the oil quality in sunflower (Akbari *et al.*

2011). Non-dehulled or partially dehulled sunflower meal has been substituted successfully for soybean meal in diets for ruminant animals, as well as for swine and poultry feeding (Agele and Taiwo 2013). However, the sunflower crops have been presenting low yield productivity, due to the use of traditional cultivars with low productive capacity and the lack of an appropriate mineral nutrition program (Filho *et al.* 2013).

Chemical and synthetic inputs, which have been used extensively due to the development in agricultural areas from past to present, increased the number of products obtained from the unit area. Nevertheless, it caused serious pollution of soils, environment, cultivated products, and ground water resources. These problems led to serious health problems for livings (Gul *et al.* 2021). These excessive use of input causes hiking the cost production also. In this situation, to produce sunflower in different climates, it is necessary to seek for alternatives that regard the need of obtaining high productivity at a low cost, while using organic sources in a rational way, reducing the environmental bad impacts of agriculture. Currently, there are several sources of organic fertilizers used in agriculture, but cattle manure has the greatest potential for fertilization. However, there isn't much information about the quantities to be used in sunflower crop in order to obtain a compensatory income (Filho *et al.* 2013). Nowadays increase in the prices of chemical fertilizers, lack of consistency in feeding the soil and endangering human health caused to the increase of the use of manure for fertility. Manure can improve soil fertility, increase water-holding capacity, decrease soil erosion, improves amount of oxygen, and promotes beneficial organisms and productivity (Esmaeilian *et al*. 2012). Organic manure contains a large amount of macro-nutrient quantities (i.e., N, P and K) (Al-Bayati *et al*. 2021). It also contains other elements, including secondary nutrients and micro-nutrients, which are significantly responsible for increased crop yield (Sheppard and Sanipelli 2012, Al-Bayati *et al.* 2021). It was also observed that after application of 15 ton ha^{-1} and 30 ton ha^{-1} cattle manure and 10 ton ha^{-1} and 20 ton ha^{-1} polymers, soil pH, organic matter, nitrogen, available phosphorus, exchangeable potassium, calcium and magnesium were increased relative to control (Ayuba *et al*. 2005, Al-Bayati *et al.* 2021) treatment. Following these developments, the studies, which target to grow healthier and qualified products by preventing the deterioration of the physical, chemical and biological properties of the soils, have accelerated (Gul *et al.* 2021). Keeping these aspects in view, the present investigation was conducted to evaluate the concentration and uptake of NPKS in different parts and oil content in the seeds of sunflower (*Helianthus annuus* L.) as influenced by cow dung and chemical fertilizer.

MATERIAL AND METHODS

A field study was carried out at the research farm of Charfasson Govt. College, Bhola, Bangladesh during rabi season in 2015-2016. Soil samples (0-15 cm depth) were collected from the research farm. The sample was air-dried, ground and sieved through 2 mm sieve for analysis. The soil had a pH of 8.36 (1: 2.5 w/v H_2O), organic carbon 0.63%, available nitrogen 0.24% (Kjeldahl extraction, Marr and Cresser 1983), available phosphorus 0.06% (Jackson 1958), available potassium 1.23% (Pratt 1965), available S 0.15% (Bardsley and Lancaster 1965), sand 12.3%, silt 51.34%, and clay 36.36%. The textural class was silty clay loam and the maximum water retentive capacity was 37%. Seeds were collected from BADC, Barishal. The sunflower variety of seed was BARI-2 (Keroni-2) was used in the trial. The experiment was laid out in a completely randomized block design having sixteen treatments

with three replications. The unit plot size was 3.0 m×2.0 m and total plots were 48. Treatments were T_1: control (-CD and -NPK), T_2: 2.5t CD ha^{-1}, T_3: 5t CD ha^{-1}, T_4: 7.5t CD ha^{-1}, T_5: $N_{40}P_{30}K_{50}$kg ha^{-1}, T_6: $N_{80}P_{60}K_{100}$kg ha^{-1}, T_7: $N_{120}P_{90}K_{150}$kg ha^{-1}, T_8: 2.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}, T_9: 2.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1}, T_{10}: 2.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}, T_{11}: 5t CD ha^{-1}+ $N_{40}P_{30}K_{50}$kg ha^{-1}, T_{12}: 5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1}, T_{13}: 5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}, T_{14}:7.5t CD ha^{-1}+$N_{40}P_{30}K_{50}$kg ha^{-1}, T_{15}:7.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} and T_{16}: 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. The doses were selected according to the Fertilizer Recommendation Guide of Bangladesh Agricultural Research Council (BARC 2012). At the time of initial land preparation, well decomposed cow dung was applied and at final land preparation, N, P and K were applied as urea, triple super phosphate and muriate of potash. Seeds were sown on 29 December, 2015. Sixty seeds were sown in each plot. The space between row to row was 40 cm and seed to seed distance maintained 25 cm. Intercultural practices i.e., weeding, spading, fencing, pesticide etc. were applied as per when needed. Finally, plants were harvested after 90 days of sowing of seeds at the period of maturity. Different organs of sunflower plants *viz.* root, stem, leaf, petiole, inflorescence and seed were collected and dried in an oven at temperature of 65^{0}C. The dry weight of different parts and seed weights were measured and those were kept in paper bags separately. The content of NPKS was determined following the methods as quoted by Huq and Alam (2005). The uptake of nutrients by different parts of sunflower plant was worked out 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 1990. Analysis of variance was done with the help of SPSS program and the mean differences among different treatments were evaluated by LSD test at 5% level.

RESULTS AND DISCUSSION

Concentration and uptake of NPKS in root

Effects of cow dung and NPK fertilizers on concentration and uptake of NPKS in root of sunflower is presented in Table 1. Treatments of both NPK fertilizers and cow dung in different combinations significantly ($P<0.05$) increased the concentrations and uptake of NPKS with increasing rates of fertilizers and cow dung.

The highest concentration (1.08%) and uptake (111.7mg plant^{-1} root) of nitrogen were recorded in the treatment, 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. The highest dose of individual treatment of NPK fertilizers and combined treatments of NPK fertilizers and cow dung e.g. $N_{120}P_{90}K_{150}$kg ha^{-1}, 5t CD ha^{-1}+ $N_{80}P_{60}K_{100}$kg ha^{-1}, 5t CD ha^{-1}+ $N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} produced significantly ($P<0.05$) higher result when compared with other treatments. Maximum phosphorus concentration (0.38%) and uptake (39.3mg plant^{-1} root) were recorded in 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. The variation in uptake of phosphorus between treatment to treatment found significant (Table 1). Variation in concentration of potassium between the treatments in some cases were observed significant ($P<0.05$) (Table 1). Maximum concentration (2.04%) and uptake (210.7mg plant^{-1}) of potassium were found in 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. The maximum value of sulfur concentration (0.18%) was achieved in 2.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} and that of uptake (14.88g plant^{-1}) in 7.5t CD ha^{-1}+ $N_{80}P_{60}K_{100}$kg ha^{-1}. Naveen (2009) reported that significantly higher N, P and K uptake in sunflower plant was noticed in combined treatments of cow dung along with NPK fertilizer over the control.

Table 1. Effects of cow dung and NPK fertilizers on the concentration and uptake of NPKS in root.

Treatments	***Nitrogen***		***Phosphorus***		***Potassium***		***Sulfur***	
	Conc. (%)	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**
T_1: Control (-CD and - NPK)	0.35	2.9	0.17	1.41	0.66	5.48	0.02	0.18
T_2: 2.5t CD ha^{-1} (50 % RDF)	0.42	8.4	0.19	3.80	1.21	24.2	0.12	2.46
T_3: 5t CD ha^{-1} (100 % RDF)	0.53	10.6	0.22	4.40	1.45	29.0	0.13	2.58
T_4: 7.5t CD ha^{-1} (150 % RDF)	0.77	36.0	0.24	11.21	1.59	74.3	0.12	5.46
T_5: $N_{40}P_{30}K_{50}$kg ha^{-1} (50% RDF)	0.52	29.5	0.24	13.61	1.15	65.2	0.05	2.61
T_6: $N_{80}P_{60}K_{100}$kg ha^{-1} (100% RDF)	0.54	32.4	0.22	13.2	1.63	97.8	0.13	7.62
T_7: $N_{120}P_{90}K_{150}$kg ha^{-1} (150% RDF)	0.55	36.7	0.33	22.0	1.45	96.7	0.13	8.54
T_8:2.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$ kg ha^{-1}	0.56	39.2	0.23	16.1	1.57	109.9	0.08	5.25
T_9: 2.5t CD ha^{-1} +$N_{80}P_{60}K_{100}$ kg ha^{-1}	0.61	38.6	0.23	14.6	1.07	67.7	0.18	10.76
T_{10}: 2.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	0.71	61.6	0.26	22.5	1.31	113.6	0.10	9.02
T_{11}: 5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}	0.56	52.2	0.23	21.5	1.43	133.4	0.05	4.29
T_{12}: 5t CD ha^{-1} +$N_{80}P_{60}K_{100}$ kg ha^{-1}	0.57	45.6	0.32	25.6	1.05	84.0	0.14	11.36
T_{13}: 5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	1.08	111.7	0.38	39.3	2.04	210.7	0.13	13.81
T_{14}: 7.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}	0.59	66.8	0.28	31.7	1.57	177.9	0.06	7.14
T_{15}: 7.5t CD ha^{-1} + $N_{80}P_{60}K_{100}$kg ha^{-1}	0.66	84.7	0.21	26.9	1.63	209.1	0.12	14.88
T_{16}: 7.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	0.69	73.6	0.35	37.3	1.49	159.0	0.12	13.23
LSD at 5%	0.074	5.0	0.053	0.79	0.073	1.81	0.053	0.80

RDF=Recommended doses of fertilizer, CD= Cow dung, Conc.= Concentration

Concentration and uptake of NPKS in stem

NPKS concentration and uptake in stem of sunflower plants were significantly ($P<0.05$) increased over the control (Table 2). Values of concentration and uptake of NPKS increased with the increased rates of NPK fertilizers and cow dung. The change in concentration of NPKS between treatments was statistically identical in most of the treatments. The range of concentration and uptake of nitrogen varied from 0.29 to 1.33% and 29.0 to 532.0 mg plant^{-1} in stem, respectively (Table 2).

Table 2. Effects of NPK fertilizers and cow dung on the concentration and uptake of NPKS in stem.

Treatments	***Nitrogen***		***Phosphorus***		***Potassium***		***Sulfur***	
	Conc. (%)	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**
T_1: Control (-CD and -NPK)	0.29	29.0	0.16	16.0	0.55	55.0	0.04	4.0
T_2: 2.5t CD ha^{-1} (50 % RDF)	0.32	36.3	0.20	22.7	0.90	102.0	0.10	11.3
T_3: 5t CD ha^{-1} (100 % RDF)	0.34	52.1	0.21	32.2	0.95	145.6	0.12	18.4
T_4: 7.5t CD ha^{-1} (150 % RDF)	0.53	102.4	0.24	46.4	1.25	241.6	0.14	27.1
T_5: $N_{40}P_{30}K_{50}$kg ha^{-1} (50% RDF)	0.30	68.0	0.24	54.4	1.40	317.4	0.06	13.6
T_6: $N_{80}P_{60}K_{100}$kg ha^{-1} (100% RDF)	0.31	64.1	0.25	51.7	1.50	310.1	0.05	10.3
T_7: $N_{120}P_{90}K_{150}$kg ha^{-1} (150% RDF)	0.36	134.4	0.25	93.3	1.60	597.3	0.09	33.6
T_8: 2.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$ kg ha^{-1}	0.31	165.3	0.27	144.0	1.64	874.6	0.12	64.0
T_9: 2.5t CD ha^{-1} +$N_{80}P_{60}K_{100}$ kg ha^{-1}	0.32	121.6	0.26	98.8	1.57	596.6	0.14	53.2
T_{10}: 2.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	0.41	133.9	0.30	98.0	1.67	545.6	0.17	55.5
T_{11}: :5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}	0.37	162.8	0.26	114.4	1.42	624.8	0.17	74.8
T_{12}: 5t CD ha^{-1} +$N_{80}P_{60}K_{100}$ kg ha^{-1}	0.45	169.5	0.24	90.4	1.78	670.5	0.14	52.7
T_{13}: 5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	1.33	532.0	0.33	132.0	1.85	740.0	0.15	60.0
T_{14}- 7.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}	0.49	228.7	0.21	98.0	1.70	793.4	0.16	74.7
T_{15}: 7.5t CD ha^{-1} +$N_{80}P_{60}K_{100}$kg ha^{-1}	0.52	218.4	0.20	84.0	1.80	756.0	0.19	79.8
T_{16}: 7.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	0.45	273.0	0.31	188.1	1.64	995.0	0.12	72.8
LSD at 5%	.074	3.1	0.074	3.39	0.27	22.86	0.053	4.74

RDF=Recommended doses of fertilizer, CD= Cow dung Conc. = Concentration

The highest values of both concentration and uptake of nitrogen were recorded in 5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}. The highest values of phosphorus concentration and uptake were 0.33% and 188.1 mg plant^{-1} in stem, respectively. These values of concentration and uptake of phosphorus were observed in the treatments, 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}, respectively (Table 2). Maximum concentration (1.85%) and uptake (995.0 mg plant^{-1} stem) of potassium were recorded in 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t CD ha^{-1}+ $N_{120}P_{90}$ K_{150}kg ha^{-1} treatments, respectively (Table 2). Maximum concentration (0.19%) and uptake (79.8 mg plant^{-1} stem) of sulfur were recorded in the same treatment (7.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1}). Mohsin *et al.* (2019) reported similar findings that the maximum concentration of nitrogen in root, stem and leaf of mungbean were 1.59, 2.51 and 3.82% in the treatments, P @ 5kg and K @ 12kg ha^{-1}, P @ 10kg and K @ 12kg ha^{-1}, and P @ 10kg and K @ 18kg ha^{-1}.

Concentration and uptake of NPKS in leaf

Results showed that concentration and uptake of all these nutrients in leaf increased significantly over the control. With the increase rates of both of fertilizers and cow dung, content and uptake of NPKS also increased (Table 3). The highest concentration of nitrogen in leaf (3.45%) and uptake (739.6 mg plant^{-1}) were recorded in 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t CD ha^{-1}+$N_{40}P_{30}K_{50}$kg ha^{-1} treatments, respectively (Table 3). The concentration phosphorus (0.67%) and uptake (129.5mg plant^{-1}) in leaf of phosphorus were found highest in 5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1} (Table 3).

Table 3. Effects of NPK fertilizers and cow dung on the concentration and uptake of NPKS in leaf.

Treatments	Nitrogen		Phosphorus		Potassium		Sulfur	
	Conc. (%)	Uptake (mg plant^{-1})	Conc. (%)	Uptake (mg plant^{-1})	Conc. (%)	Uptake (mg plant^{-1})	Conc. (%)	Uptake (mg plant^{-1})
T1: Control (-CD and -NPK)	2.37	158.1	0.22	14.7	1.80	120.1	0.07	4.7
T2: 2.5t CD ha-1 (50 % RDF)	2.75	220.0	0.23	18.4	1.85	148.0	0.10	8.0
T3: 5t CD ha-1 (100 % RDF)	2.83	245.4	0.27	23.4	2.05	177.7	0.13	11.3
T4: 7.5t CD ha-1 (150 % RDF)	3.19	297.6	0.45	42.0	2.77	258.4	0.15	14.0
T5: N40P30K50kg ha-1 (50% RDF)	2.50	283.3	0.31	35.1	2.83	320.6	0.06	6.8
T6: N80P60K100kg ha-1 (100% RDF)	2.60	303.4	0.32	37.3	2.71	316.3	0.04	4.7
T7:N120P90K150kg ha-1 (150% RDF)	2.83	452.8	0.35	56.0	2.94	470.0	0.09	14.4
T8: 2.5t CD ha-1 +N40P30K50 kg ha-1	2.85	513.0	0.35	63.0	2.76	496.8	0.12	21.6
T9: 2.5t CD ha-1 +N80P60K100 kg ha-1	2.86	438.4	0.39	59.8	3.23	495.2	0.14	21.5
T10: 2.5t CD ha-1 +N120P90K150kg ha-1	2.87	382.6	0.40	53.3	2.99	398.6	0.17	22.7
T11: 5t CD ha-1 +N40P30K50kg ha-1	3.16	547.6	0.42	72.8	3.02	523.4	0.18	31.2
T12-: 5t CD ha-1 +N80P60K100 kg ha-1	3.21	599.3	0.44	82.1	3.31	618.0	0.13	24.3
T13: 5t CD ha-1 +N120P90K150kg ha-1	3.25	628.2	0.67	129.5	4.12	796.4	0.15	29.0
T14: 7.5t CD ha-1 +N40P30K50kg ha-1	2.92	739.6	0.50	126.7	3.51	889.1	0.14	35.5
T15: 7.5t CD ha-1 +N80P60K100kg ha-1	3.24	540.1	0.44	73.3	3.66	610.1	0.16	26.7
T16: 7.5t CD ha-1 +N120P90K150kg ha-1	3.45	713.1	0.45	93.0	3.14	649.0	0.17	35.1
LSD at 5%	0.29	11.53	0.05	5.25	0.32	9.8	0.09	3.65

RDF=Recommended doses of fertilizer, CD= Cow dung, Conc.=Concentration

The highest concentration (4.12%) and uptake (889.1 mg plant^{-1}) of leaf potassium were recorded in the treatments 5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t CD ha^{-1} + $N_{40}P_{30}K_{50}$kg ha^{-1}, respectively. The suphur concentration (0.18%) and uptake (35.5 mg plant^{-1}) in leaf were recorded maximum in the treatments 5t CD ha^{-1}+ $N_{40}P_{30}K_{50}$kg ha^{-1} and 7.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}, respectively. Marr and

Cresser (1983) 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 (1983).

Concentration and uptake of NPKS in petiole and inflorescence

Application of NPK fertilizers and cow dung on sunflower showed that the concentration and uptake of NPKS in petiole and inflorescence were increased significantly ($P<0.05$) (Tables 4 and 5). Both the concentration and uptake of these nutrients increased significantly ($P<0.05$) when NPK fertilizers applied alone and in combination with cow dung over the control. In the treatments study also showed that in the treatments sole NPKS or combined with cow dung, the variations showed identical results in most of the cases. When the treatments compared among themselves then the variations showed identical results in most of the cases.

Concentration and uptake of NPKS in petiole

In petiole, nitrogen concentration and uptake varied from 0.37-1.99% and 5.6-188.0 mg $plant^{-1}$, phosphorus from 0.16 to 0.62% and 2.4 to 62.0 mg $plant^{-1}$, potassium from 0.65 to 3.0% and 10.0 to 300.0 mg $plant^{-1}$ and sulfur from 0.05 to 0.22% and 0.80 to 22.0mg $plant^{-1}$, respectively. The highest concentration of NPKS and uptake of NPKS were found in the treatment 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. But nitrogen concentration found highest in 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} treatment.

Table 4. Effects of cow dung and NPK fertilizers on the concentration and uptake of NPKS in petiole.

Treatments	***Nitrogen***		***Phosphorus***		***Potassium***		***Sulfur***	
	Conc. (%)	**Uptake (mg $plant^{-1}$)**	**Conc. (%)**	**Uptake (mg $plant^{-1}$)**	**Conc. (%)**	**Uptake (mg $plant^{-1}$)**	**Conc. (%)**	**Uptake (mg $plant^{-1}$)**
T_1: Control (- CD and -NPK)	0.37	5.6	0.16	2.4	0.65	10.0	0.05	0.8
T_2: 2.5t CD ha^{-1} (50 % RDF)	0.41	8.9	0.26	5.6	0.91	19.7	0.14	3.0
T_3: 5t CD ha^{-1} (100 % RDF)	0.55	14.7	0.29	7.4	1.20	32.0	0.17	4.5
T_4: 7.5t CD ha^{-1} (150 % RDF)	0.59	17.7	0.32	9.6	1.45	43.5	0.19	5.7
T_5: $N_{40}P_{30}K_{50}$kg ha^{-1} (50% RDF)	1.24	39.3	0.35	11.1	1.49	47.2	0.06	1.9
T_6: $N_{80}P_{60}K_{100}$kg ha^{-1} (100% RDF)	1.42	82.8	0.34	19.8	1.91	111.4	0.05	2.9
T_7: $N_{120}P_{90}K_{150}$kg ha^{-1}(150% RDF)	1.51	85.6	0.39	22.1	2.00	113.4	0.07	4.0
T_8: 2.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$ kg ha^{-1}	1.60	85.3	0.43	22.9	1.80	95.94	0.18	9.6
T_9: 2.5t CD ha^{-1} +$N_{80}P_{60}K_{100}$ kg ha^{-1}	1.62	97.2	0.40	24.0	1.98	118.8	0.15	9.0
T_{10}: 2.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	1.73	118.2	0.43	29.4	2.18	148.9	0.17	11.6
T_{11}: 5t CD ha^{-1} +$N_{40}P_{30}K_{50}$kg ha^{-1}	1.53	99.5	0.41	26.7	2.28	148.2	0.20	13.0
T_{12}: 5t CD ha^{-1} + $N_{80}P_{60}K_{100}$ kg ha^{-1}	1.91	143.3	0.42	31.5	2.29	171.8	0.21	15.8
T_{13}: 5t CD ha^{-1}+ $N_{120}P_{90}K_{150}$kg ha^{-1}	1.99	159.2	0.45	36.0	2.61	208.8	0.20	16.0
T_{14}: 7.5t CD ha^{-1} + $N_{40}P_{30}K_{50}$kg/ha^{-1}	1.65	154.0	0.50	46.7	2.20	205.3	0.12	11.2
T_{15}: 7.5t CD ha^{-1} + $N_{80}P_{60}K_{100}$kg ha^{-1}	1.78	172.0	0.58	56.1	2.51	242.7	0.17	16.4
T_{16}: 7.5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1}	1.88	188.0	0.62	62.0	3.00	300.0	0.22	22.0
LSD at 5%	0.234	4.58	0.053	3.69	0.053	6.68	.053	1.76

RDF=Recommended doses of fertilizer, CD= Cow dung, Conc. = Concentration

Concentration and uptake of NPKS in inflorescence

The highest nitrogen concentration (0.73%) and uptake (141.1 mg $plant^{-1}$) in inflorescence were recorded in the treatment, 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. The highest phosphorus concentration

(0.68%) and uptake (150.8mg plant^{-1}) in inflorescence were found in 7.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} and 7.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}, respectively (Table 5). The highest potassium concentration (2.25%) and uptake (434.9 mg plant^{-1}) of inflorescence of sunflower were achieved in treatment where maximum dose of cow dung and NPK fertilizers applied in the treatment 7.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1} (Table 5). The highest sulfur concentration (0.23%) and uptake (44.5mg plant^{-1}) of inflorescence of sunflower were measured from the treatment of highest levels of cow dung and NPK fertilizers, i.e., in the treatment 7.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1} (Table 5). Ferreira *et al*. (2022) suggested that the N-based fertilization with animal manures increased the rate of nutrient uptake by maize, oat and radish plants.

Table 5. Effects of NPK fertilizers and cow dung on the concentration and uptake of NPKS in inflorescence.

Treatments	*Nitrogen*		*Phosphorus*		*Potassium*		*Sulfur*	
	Conc. (%)	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**	**Conc. (%)**	**Uptake (mg plant^{-1})**
T_1: Control(-CD and -NPK)	0.28	16.8	0.15	9.0	0.71	42.6	0.03	1.8
T_2: 2.5t CD ha^{-1} (50 % RDF)	0.35	35.0	0.22	17.0	1.25	125.0	0.05	5.0
T_3: 5t CD ha^{-1} (100 % RDF)	0.37	39.5	0.20	20.3	1.42	151.5	0.08	8.5
T_4: 7.5t CD ha^{-1} (150 % RDF)	0.40	58.7	0.26	35.2	1.54	225.9	0.12	17.6
T_5: $N_{40}P_{30}K_{50}$kg ha^{-1} (50% RDF)	0.45	63.0	0.30	42.0	1.62	226.8	0.05	7.0
T_6: $N_{80}P_{60}K_{100}$kg ha^{-1} (100% RDF)	0.50	60.0	0.36	43.2	1.67	200.4	0.04	4.8
T_7:$N_{120}P_{90}K_{150}$kg ha^{-1} (150% RDF)	0.52	79.7	0.45	69.0	1.75	268.3	0.05	7.7
T_8:2.5t CD ha^{-1} +$N_{40}P_{30}K_{50}$ kg ha^{-1}	0.43	63.1	0.42	61.6	1.64	240.6	0.14	20.5
T_9: 2.5t CD ha^{-1} + $N_{80}P_{60}K_{100}$ kg ha^{-1}	0.48	70.4	0.47	68.9	1.69	247.9	0.14	20.5
T_{10}: 2.5t CD ha^{-1} +$N_{120}P_{90}K_{150}$kg ha^{-1}	0.58	88.9	0.51	78.2	1.77	271.3	0.17	26.6
T_{11}: 5t CD ha^{-1} + $N_{40}P_{30}K_{50}$kg ha^{-1}	0.54	90.0	0.50	83.4	1.73	288.4	0.12	20.0
T_{12}: 5t CD ha^{-1} + $N_{80}P_{60}K_{100}$ kg ha^{-1}	0.59	100.3	0.48	81.6	1.81	307.7	0.18	30.6
T_{13}: 5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1}	0.63	109.2	0.55	95.3	1.95	337.9	0.21	36.4
T_{14}: 7.5t CD ha^{-1} + $N_{40}P_{30}K_{50}$kg ha^{-1}	0.56	100.8	0.61	109.8	1.88	338.4	0.20	36.0
T_{15}: 7.5t CD ha^{-1} + $N_{80}P_{60}K_{100}$kg ha^{-1}	0.67	125.1	0.68	121.4	2.12	395.8	0.19	35.5
T_{16}: 7.5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1}	0.73	141.1	0.65	150.8	2.25	434.9	0.23	44.5
LSD at 5%	0.04	6.87	0.053	6.07	0.34	11.46	0.053	4.25

RDF=Recommended doses of fertilizer, CD= Cow dung, Conc. = Concentration

Concentration and uptake of NPKS and oil content in seed

Concentration and uptake of NPKS in seeds of sunflower increased significantly (P<0.05) over the control (Table 6). The application of different combinations of cow dung and NPK fertilizers increased, the nutrient concentrations of NPKS increased with the increasing doses of cow dung and NPK fertilizers. However, the variations among the treatments were statistically not significant in most of the cases of nutrients concentrations. Similar trend was also observed in case of uptake of these nutrients.

Results of nitrogen concentration and uptake of seed varied from 3.72 (2.5t CD ha^{-1}+$N_{40}P_{30}K_{50}$kg ha^{-1}) to 4.95% (5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}) and 312.0 to 3115.0 mg plant^{-1}, respectively. The highest uptake was recorded in the treatment 7.5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1}. Concentration and uptake of phosphorus in seed ranged from 0.27 to 0.94% and 21.1 to 601.7 mg plant^{-1}, respectively. Highest concentration and uptake of phosphorus were recorded in the treatments 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t CD ha^{-1} + $N_{80}P_{60}K_{100}$kg ha^{-1}, respectively (Table 6). Potassium concentration and uptake varied from 0.16 to 0.75% and 12.5 to 429.8 mg plant^{-1} in seed, respectively. The highest values of concentration and uptake of potassium in seeds were evaluated from the same treatment, 5t CD ha^{-1}+

$N_{120}P_{90}K_{150}$kg ha^{-1}. Sulfur concentration and uptake showed a variation from 0.04 to 0.26% and 3.12 to 100.9mg plant^{-1}, respectively. Treatment 7.5t CD ha^{-1}+$N_{80}P_{60}$ K_{100}kg ha^{-1} showed the highest values of concentration and uptake of sulfur in seeds of sunflower (Table 6). Similar results were also recorded by Esmaeilian *et al.* (2012) who observed that combination of cattle manure and NPK fertilizer produced the highest N, P and K content in different organs of sunflower. Naveed *et al.* (2021) suggested that the combined application of gypsum and composted cow dung produced better production of seeds in sunflower in salt-affected soils.

Table 6. Effects of NPK fertilizers and cow dung on the concentration and uptake of NPKS and oil content in seed.

Treatments	Nitrogen		Phosphorus		Potassium		Sulfur		Oil content
	Conc. (%)	Uptake (mg plant^{-1})	Conc. (%)	Uptake (mg plant^{-1})	Conc. (%)	Uptake (mg plant^{-1})	Conc. (%)	Uptake (mg plant^{-1})	(%)
T_1: Control(-CD and -NPK)	4.00	312.0	0.27	21.1	0.16	12.5	0.04	3.12	40.9
T_2: 2.5t CD ha^{-1} (50 % RDF)	4.25	565.3	0.31	41.2	0.34	45.2	0.05	6.65	38.1
T_3: 5t CD ha^{-1} (100 % RDF)	4.26	651.8	0.53	81.1	0.46	70.4	0.08	12.1	42.8
T_4:7.5t CD ha^{-1} (150 % RDF)	4.75	893.0	0.65	122.2	0.40	75.2	0.10	17.9	42.5
T_5: $N_{40}P_{30}K_{50}$kg ha^{-1}. (50% RDF)	3.75	900.0	0.77	184.8	0.46	110.4	0.13	30.2	45.3
T_6: $N_{80}P_{60}K_{100}$kg ha^{-1}. (100% RDF)	3.78	1409.9	0.67	249.9	0.52	194.0	0.15	56.0	44.6
T_7:$N_{120}P_{90}K_{150}$kg ha^{-1} (150% RDF)	3.80	1292.0	0.63	214.2	0.58	197.2	0.14	47.9	46.7
T_8: 2.5t CD ha^{-1} + $N_{40}P_{30}K_{50}$ kg ha^{-1}	3.72	1514.0	0.73	297.1	0.62	252.3	0.11	46.0	49.3
T_9: 2.5t CD ha^{-1} + $N_{80}P_{60}K_{100}$ kg ha^{-1}	4.41	1839.0	0.76	316.9	0.66	275.2	0.12	51.7	42.6
T_{10}: 2.5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1}	4.58	1635.1	0.77	274.9	0.64	228.5	0.08	28.2	39.4
T_{11}: 5t CD ha^{-1} + $N_{40}P_{30}K_{50}$kg ha^{-1}	4.42	1816.6	0.79	324.7	0.66	271.3	0.15	59.6	43.7
T_{12}: 5t CD ha^{-1} + $N_{80}P_{60}K_{100}$ kg ha^{-1}	3.81	2007.9	0.83	437.4	0.67	353.1	0.14	73.8	35.6
T_{13}: 5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1}	4.95	2836.4	0.94	538.6	0.75	429.8	0.14	77.9	51.8
T_{14}: 7.5t CD ha^{-1} + $N_{40}P_{30}K_{50}$kg ha^{-1}	4.24	2569.4	0.89	539.3	0.60	363.6	0.16	93.9	38.4
T_{15}: 7.5t CD ha^{-1} + $N_{80}P_{60}K_{100}$kg ha^{-1}	4.66	3115.0	0.93	601.7	0.66	427.0	0.26	100.9	51.2
T_{16}: 7.5t CD ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1}	3.78	2014.2	0.83	448.2	0.69	372.6	0.12	65.3	43.3
LSD at 5%	0.48	37.8	0.05	26.27	0.092	27.12	0.053	6.13	1.17

RDF=Recommended doses of fertilizer, CD= Cow dung, Conc. = Concentration

Oil content is the most important product of sunflower plant. Treatments of various combinations of cow dung and NPK fertilizers significantly ($P<0.05$) increase in oil content of seeds over the control in most of the cases (Table 6). However, the four treatments *viz.* 2.5t CD ha^{-1}, 2.5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}, 5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} and 7.5t CD ha^{-1}+$N_{40}P_{30}K_{50}$kg ha^{-1} produced lower rate of oil compare to control (Table 6). The variations in oil content among the treatments were found significant. The highest content of oil (51.8%) was recorded in the treatment 5t CD ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}. The treatment, 5t CD ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} produced the lowest yield of oil (35.6%) in sunflower seed (Table 6). Present findings are in good agreement with Esmaeilian *et al.* (2012) and Shogi-Kalkhoran *et al*. (2013). Similar results were also found by Gul *et al.* (2021).

Akbari *et al.* (2011) reported that the highest oil content in sunflower seed was recorded in the treatments 100% FYM and 50% FYM + 50% N, respectively. Nouraein *et al*. (2019) observed that the highest seed yield and oil percentage were recorded for plants grown with F_3 (20t ha^{-1} FYM) and F_4 (40t ha^{-1} FYM), respectively. Seleiman *et al*. (2020) recommended that the combined application of NPS and both rice straw biochar (RSB, 8t ha^{-1}) and cow-manure biochar (CMB, 8t ha^{-1}) was better as a result of their positive influence on sunflower oil quality and yield. The combined application of cow dung and

chemical fertilizers would be convenient for seed and oil production under climatic conditions of southern Bangladesh.

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