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INFLUENCE OF VERMICOMPOST AND CHEMICAL FERTILIZERS ON MACRONUTRIENTS CONTENT IN DIFFERENT ORGANS AND OIL CONTENT IN SEEDS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Abstract

Effects of vermicompost and chemical fertilizers on the concentration and uptake of NPKS in different organs as well as well as oil content of sunflower (*cv.* BARI-2) were evaluated. The experiment consisted of 16 treatments, viz.: VC_1 Control, VC_2, VC_3, VC_4, VC_5, VC_6, VC_7, VC_8, VC_9, VC_{10}, VC_{11}, VC_{12}, VC_{13}, VC_{14}, VC_{15} and VC_{16}. Results showed that the concentration, uptake of macronutrients (NPKS) and oil content of seeds of the crop increased significantly ($P< 0.05$) with increasing rate of the amendments over the control in most of the cases. Combination of the treatments showed better performance than their individual application. Maximum values of NPKS concentration in different organs of sunflower were 0.42, 0.23, 1.95 and 0.12% for stem., 0.57, 0.33, 2.66 and 0.20% for root., 2.61, 0.42, 2.77 and 0.19% for leaf., 2.30, 0.65, 2.65 and 0.20% for petiole., 0.76, 0.71, 2.21and 0.26% for inflorescence and 4.86, 0.69, 1.08 and 0.16% for seed were recorded in treatments 5t VC ha^{-1} +$N_{120}P_{90}K_{150}$ kg ha^{-1} and 7.5t VC ha^{-1} +$N_{120}P_{90}K_{150}$ kg ha^{-1}, respectively in most of the cases. Significantly ($P < 0.05\%$) the highest content of oil (46.9%) in seed was found in the treatment 7.5t VC ha^{-1} +$N_{80}P_{60}K_{100}$ kg ha^{-1}. The overall findings of this study indicated that vermicompost in combination with chemical fertilizers could be applied to achieve better yield of sunflower in the costal belt of Bangladesh.

Introduction

Sunflower (*Helianthus annuus* L.) is one of the important oil seed crops grown worldwide (Sharma *et al.* 2014). It contains about 45-50% oil and 26% protein (Jadhay and Dishpande 1990). Sunflower hold promise because of its short duration, thermo and photo insensitivity, drought tolerance, suitable in existing crop rotation, high oil content and having characteristics like wide adaptability with low diseases and insect incidence (Sharma *et al.* 2014., Godavari *et al.* 2017). Shortage of edible oils from the past has been met through imports, spent a huge amount of foreign exchange every year. Bangladesh produced 0.358 million tons of edible oil against the annual demand of 1.6 million tons while the remaining 1.242 million tons of the country's requirements is met through imports (Khatun *et al.* 2016).

Bangladesh could achieve self-sufficiency in agriculture by an increased combined use of organic manures and chemical fertilizers. Human beings and cattle were adversely affected due to the residues of the agro-chemicals used in food products (Joshi *et al.* 2013). Organic manure is an eco-friendly, economically viable and ecologically sound that also played a significant role in soil biology, chemistry and physics. Huge quantity of wastes *i.e.* human, livestock, crop residue, nutrient rich bio- fertilizer (vermicompost) and weeds can be converted for sustainable land restoration practices (Suthar 2009, Joshi and Sigh 2013). A study revealed that vermicompost may be potential source of nutrients for field crops if applied in suitable ratios with synthetic fertilizers (Suthar 2009). Vermicompost contains some plant growth hormones and humic acids which

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improve the growth and yield of plant crops (Zaman *et al*. 2018). Humic acid enhances the soil moisture content and vermicompost retains more water than other manures (Godavari *et al.* 2017). Addition of vermicompost and chemical fertilizers to the field crop could be a very good option considering the nutrient availability for maintaining soil fertility and productivity (Zaman *et al.* 2018).

Although excessive nitrogen fertilization can generate environmental hazard, it may also affect sunflower grain quality and decrease its oil content. In such a situation, organic fertilizers play a major role (Chandrasekhar *et al.* 2005). Information on the combined effects of inorganic and organic fertilizers on sunflower plant are scanty. Thus, the present study was undertaken in the field at the coastal belt to evaluate the impacts of vermicompost and NPK fertilizers on concentration and uptake of NPKS in different organs and oil content in seeds of sunflower (*Helianthus annuus* L.).

Materials and Methods

A field study was carried out at the research farm of Charfasson Government. College campus, Bhola, during rabi season in 2016-2017. The physical and chemical properties of the experimental soil were: pH (8.36), organic carbon (0.36%) (Wet oxidation method**,** Walkley and Black 1934), 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 Lancaster1965), sand (12.3%), silt (54.34%) and clay (36.36%), textural class- silty clay loam, the maximum water retentive capacity was (37%).

Seeds of BARI-2 (Keroni-2) variety of sunflower were collected from BADC, Barisal. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 3.0 m x 2.0 m. There were 16 treatments *viz.* VC (vermicompost)$_1$: Control (-0 t ha^{-1} VC and 0 t ha^{-1} NPK), VC$_2$: 2.5t VC ha^{-1}, VC$_3$: 5t VC ha^{-1}, VC$_4$: 7.5t VC ha^{-1}, VC$_5$: $N_{40}P_{30}K_{50}$ kg ha^{-1}, VC$_6$:$N_{80}P_{60}K_{100}$ kg ha^{-1}, VC$_7$: $N_{120}P_{90}K_{150}$ kg ha^{-1}, VC$_8$: 2.5t VC ha^{-1}+$N_{40}P_{30}K_{50}$ kg ha^{-1}, VC$_9$:2.5t VC ha^{-1}+$N_{80}P_{60}K_{100}$ kg ha^{-1}, VC$_{10}$:2.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1}, VC$_{11}$:5t VC ha^{-1}+ $N_{40}P_{30}K_{50}$ kg ha^{-1}, VC$_{12}$: 5t VC ha^{-1}+$N_{80}P_{60}K_{100}$ kg ha^{-1}, VC$_{13}$:5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1}, VC$_{14}$:7.5t VC ha^{-1}+$N_{40}P_{30}K_{50}$ kg ha^{-1}, VC$_{15}$:7.5t VC ha^{-1}+$N_{80}P_{60}K_{100}$ kg ha^{-1} and VC$_{16}$:7.5t VC ha^{-1}+$N_{120}P_{90}K_{1\ 50}$kg ha^{-1} , respectively, following the procedures of (BARC 2012). Vermicompost, N (Urea), P (TSP) and K (MoP) were applied at the time of final land preparation. Seeds were sown on 16 December 2016 maintaining row to row distance 40 cm and seed to seed 25 cm. Intercultural practices i.e. weeding, spading, fencing, pesticide application *etc.* were done as needed. Plants were harvested at 90 daya after sowing. Different plant parts like stem, root, leaf, petiole, inflorescence and seed were separated and dried in sun and oven at 65^{0}C. The dry weight of different parts of plants and seeds were recorded and kept in paper bags. For total NPKS contents in root, stem, leaf, petiole, inflorescence and seed were digested with sulfuric- perchloric acid (for N) and nitric – perchloric acid (for PKS). Elemental analyses were done using standard methods as follows. The uptake of nutrients by different organs was worked out by multiplying the nutrient concentration and dry matter yield of the plant parts. Estimation of oil content in the seed 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 calculated by LSD test.

Results and Discussion

The concentration and uptake of nitrogen, phosphorus, potassium and sulfur in the root of sunflower are presented in Table 1. The highest values were observed in VC$_{13}$ and VC$_{16}$

treatments, respectively. Concentration and uptake of potassium and sulfur ranged from 0.54 - 2.66 and 0.07 - 0.20%, and 11.6 - 341.8 and 1.5 - 23.8 mg plant^{-1} root respectively (Table 1). Maximum values of potassium and sulfur concentration were observed in the same treatment, 5t VC ha^{-1} +$N_{120}P_{90}K_{150}$ kg ha^{-1}. Highest values of potassium and sulfur uptake were recorded in 7.5t VC ha^{-1}+$N_{80}P_{60}K_{100}$ kg ha^{-1} and 2.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1} treatments, respectively (Table 1). These findings are in consent with the observations of Kademani *et al.* (2003) who observed that the highest uptakes of NPK of different organs of sunflower crops were recorded in vermicompost treatment followed by FYM, cotton stock and maize residue.

Table 1. Effects of vermicompost and chemical fertilizers on the concentration (conc.) and uptake of NPKS in root of sunflower.

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})
VC_1 Control	0.32	6.8	0.13	2.8	0.54	11.6	0.07	1.5
VC_2	0.33	12.9	0.14	5.8	0.75	29.3	0.10	3.9
VC_3	0.34	13.2	0.16	6.2	0.89	34.5	0.12	4.7
VC_4	0.37	19.2	0.16	8.3	1.03	53.5	0.13	6.7
VC_5	0.44	19.4	0.16	7.1	1.08	47.8	0.08	3.5
VC_6	0.40	40.4	0.15	15.2	1.18	119.3	0.09	9.1
VC_7	0.45	84.9	0.17	32.1	1.31	247.2	0.07	13.2
VC_8	0.41	23.8	0.18	10.5	1.23	71.5	0.12	7.0
VC_9	0.42	44.6	0.18	19.1	1.39	147.8	0.13	13.8
VC_{10}	0.46	73.1	0.18	28.6	1.59	252.7	0.15	23.8
VC_{11}	0.38	14.2	0.20	7.5	1.77	66.2	0.14	5.2
VC_{12}	0.43	38.3	0.23	20.5	2.02	180.0	0.17	15.1
VC_{13}	0.57	61.7	0.32	34.7	2.66	288.1	0.20	21.7
VC_{14}	0.33	31.9	0.22	21.3	2.42	233.8	0.11	10.6
VC_{15}	0.42	57.4	0.24	32.8	2.50	341.8	0.14	19.1
VC_{16}	0.46	58.0	0.33	41.6	2.34	294.8	0.16	20.2
LSD at 5%	0.04	4.14	0.04	4.01	0.34	16.14	0.053	4.28

The concentration and uptake of nitrogen and phosphorus in stem of sunflower plant ranged from 0.22 - 0.42 and 0.05 - 0.23%, and 15.2 - 304.1 and 3.50 - 115.8 mg plant^{-1}, respectively (Table 2). Concentrations of nutrients increased with doses of both vermicompost and NPK fertilizers in most of the treatments. The highest values of the nutrients (nitrogen and phosphorus) were observed in treatments, $N_{120}P_{90}K_{150}$kg ha^{-1}, 7.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}; and 5t VC ha^{-1}+ $N_{120}P_{90}K_{150}$kg ha^{-1} and $N_{120}P_{90}K_{150}$kg ha^{-1} respectively. Concentration and uptake of potassium and sulfur varied from 0.72 - 1.95 and 0.03 - 0.12%, and 49.7 – 999.1 and 2.1 - 76.8 mg plant^{-1} respectively. The highest values were recorded in 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1} and 2.5t VC ha^{-1}+ $N_{120}P_{90}K_{150}$ kg ha^{-1}, 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1}, 7.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1}; and 7.5t VC ha^{-1}+$N_{80}P_{60}K_{100}$ kg ha^{-1} and 2.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1} respectively. Manjunatha *et al.* (2009) observed that application of recommended dose of NPK along with vermicompost (7.5 t ha^{-1}) recorded significantly higher available N, P and K in sunflower.

Table 2. Effects of vermicompost and chemical fertilizers on the concentration (conc.) and uptake of NPKS in stem of sunflower.

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})
VC_1 Control	0.22	15.2	0.05	3.50	0.72	49.7	0.03	2.1
VC_2	0.26	58.5	0.08	18.0	0.80	180.0	0.05	11.3
VC_3	0.27	58.6	0.11	23.9	0.98	212.7	0.07	15.2
VC_4	0.32	98.2	0.12	36.8	1.24	380.7	0.10	30.7
VC_5	0.36	89.3	0.12	29.8	1.30	322.4	0.05	12.4
VC_6	0.37	171.7	0.15	69.6	1.50	696.0	0.06	27.8
VC_7	0.42	304.1	0.16	115.8	1.38	999.1	0.08	59.9
VC_8	0.38	111.7	0.14	41.2	1.55	455.7	0.09	26.5
VC_9	0.37	136.2	0.13	47.8	1.60	588.8	0.11	40.5
VC_{10}	0.38	242.2	0.18	115.2	1.56	998.4	0.12	76.8
VC_{11}	0.34	63.6	0.17	31.8	1.70	317.9	0.10	18.7
VC_{12}	0.37	131.7	0.16	57.0	1.85	658.6	0.11	39.2
VC_{13}	0.40	200.8	0.23	115.5	1.95	978.9	0.12	60.2
VC_{14}	0.27	108.5	0.19	76.4	1.80	723.6	0.10	40.2
VC_{15}	0.36	214.2	0.17	101.2	1.68	999.6	0.11	65.5
VC_{16}	0.42	230.2	0.16	87.7	1.82	997.4	0.12	65.8
LSD at 5%	0.04	27.11	0.053	8.51	0.24	84.12	0.053	5.97

The concentration and uptake of nitrogen and phosphorus in leaf of sunflower plant ranged from 1.87 - 2.61 and 0.12 - 0.42%, and 93.5 - 476.2 and 6.0 - 65.1 mg plant^{-1} leaf respectively (Table 3). The highest values of nitrogen and phosphorus concentration were recorded in 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1} treatment, and 2.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1} and 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1} treatments, for their uptake. Concentration and uptake of potassium and sulfur in leaf of sunflower varied from 0.84 - 2.77 and 0.06 - 0.19%, and 42.0 - 446.0 and 3.0 - 30.6 mg plant^{-1} leaf respectively (Table 3). The highest values for both concentration and uptake of potassium and sulfur were observed in the same treatment, 7.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$ kg ha^{-1} where the highest amounts of vermicompost and NPK fertilizers added. . The result of the concentration of N, P and K of the present experiment are in agreement with Marr and Cresser (1983). Sharma *et al.* (2014) also reported that conjunctive nutrient treatment, vermicompost + chemical fertilizers proved quite superior to other set of treatments in improving the uptake of N, P, K, S and micronutrients in different organs of sunflower.

The concentration and uptake of nitrogen and phosphorus in the petiole of sunflower ranged from 0.39 - 2.30 and 0.09 - 0.65% and 6.6 - 165.6 and 1.5 - 46.8 mg plant^{-1} respectively (Table 4). Concentration and uptake of potassium and sulfur in petiole varied from 0.83 - 2.65 and 0.06 - 0.20% and 14.1 - 190.8 and 1.0 - 15.4 mg plant^{-1} respectively (Table 4). The maximum values of nitrogen, phosphorus and potassium (NPK) for both concentration and uptake in petiole were recorded in the same treatment, 7.5t VC ha^{-1} + $N_{120}P_{90}K_{150}$ kg ha^{-1}. Treatment, 5t VC ha^{-1} +

$N_{120}P_{90}K_{150}$kg ha^{-1} showed the highest concentration and uptake of sulfur in the petiole of the same treatment. These findings are in consistent with the observations of Bader and Qureshi (2014) who reported that composted rice husk improved mineral nitrogen and phosphorus contents of sunflower plants. Suthar (2009) reported that vermicomposted manure may be a potential source of plant nutrients for sustainable crop production. Marr and Cresser (1983) concluded that the typical concentrations of elements (N, Ca, Mg, P, and micronutrients) in dried healthy foliage.

Table 3. Effects of vermicompost and chemical fertilizers on the concentration (conc.) and uptake of NPKS in leaf of sunflower.

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})
VC_1 Control	1.87	93.5	0.12	6.0	0.84	42.0	0.06	3.0
VC_2	1.88	110.9	0.17	10.0	1.14	67.3	0.08	4.7
VC_3	1.89	136.1	0.18	13.0	1.25	90.0	0.09	6.5
VC_4	1.96	168.6	0.20	17.2	1.54	132.4	0.11	9.5
VC_5	2.00	120.0	0.20	12.0	1.75	105.0	0.07	4.2
VC_6	2.04	344.8	0.22	37.2	1.78	300.8	0.06	10.1
VC_7	2.06	344.0	0.26	43.4	1.87	312.3	0.07	11.7
VC_8	2.10	140.7	0.23	16.1	1.88	126.0	0.11	7.4
VC_9	2.14	158.4	0.24	17.8	1.94	143.7	0.13	9.6
VC_{10}	2.48	476.2	0.32	61.4	2.06	395.5	0.15	28.8
VC_{11}	2.42	167.0	0.30	20.7	2.21	152.5	0.12	8.3
VC_{12}	2.53	265.7	0.33	34.7	2.33	244.7	0.14	14.7
VC_{13}	2.61	404.6	0.42	65.1	2.72	421.6	0.16	24.8
VC_{14}	2.10	186.9	0.36	32.0	2.53	225.2	0.13	11.6
VC_{15}	2.53	303.6	0.38	45.6	2.61	313.2	0.17	20.4
VC_{16}	2.34	376.7	0.38	61.2	2.77	446.0	0.19	30.6
LSD at 5%	0.16	30.35	0.053	4.92	0.06	20.91	0.053	2.77

The concentration and uptake of nitrogen, phosphorus, potassium and sulfur in inflorescence are presented in Table 5. The concentration and uptake of nitrogen and phosphorus varied from 0.22 - 0.76 and 0.10 - 0.71% and 9.8 - 278.2 and 4.9 - 218.0 mg plant^{-1} inflorescence of sunflower respectively (Table 6). Concentration and uptake of potassium and sulfur ranged from 0.59 - 2.21 and 0.06 - 0.26%, and 28.9 - 678.5 and 2.9 - 80.5 mg plant^{-1} inflorescence respectively (Table 5). Treatment, 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}, showed the highest concentration and uptake of nitrogen and uptake of sulfur. However, the highest values of concentration and uptake of rest of the nutrients were observed in the same treatment, 7.5t VC ha^{-1}+ $N_{120}P_{90}K_{150}$kg ha^{-1}. 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. Yankaraddi *et al.* (2009) also showed that application of FYM + rice hull ash recorded the highest nutrient content and nutrient uptake in rice plant.

Table 4. Effects of vermicompost and chemical fertilizers on the concentration and uptake of NPKS in the petiole of sunflower.

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})
VC_1 Control	0.39	6.6	0.09	1.5	0.83	14.1	0.06	1.0
VC_2	0.44	8.8	0.14	2.8	0.87	17.4	0.09	1.8
VC_3	0.46	11.0	0.17	4.1	0.91	21.8	0.10	2.4
VC_4	0.47	14.1	0.24	7.2	0.97	29.1	0.13	3.9
VC_5	0.91	25.5	0.27	7.6	1.40	39.2	0.07	2.0
VC_6	0.82	39.4	0.28	13.4	1.56	74.9	0.08	3.8
VC_7	0.93	70.7	0.29	22.0	1.71	130.0	0.09	6.8
VC_8	0.88	32.6	0.34	12.6	1.51	55.9	0.15	5.6
VC_9	1.10	46.2	0.36	15.1	1.57	65.9	0.17	7.1
VC_{10}	1.07	66.3	0.44	27.3	1.63	101.1	0.17	10.5
VC_{11}	1.11	32.2	0.41	11.9	1.69	49.0	0.16	4.6
VC_{12}	1.18	51.9	0.42	18.5	1.75	77.0	0.18	7.9
VC_{13}	1.46	112.4	0.57	43.9	2.20	169.4	0.20	15.4
VC_{14}	1.49	58.1	0.39	15.2	2.00	78.0	0.14	5.5
VC_{15}	2.00	98.2	0.55	27.0	2.40	117.6	0.17	8.3
VC_{16}	2.30	165.6	0.65	46.8	2.65	190.8	0.19	13.7
LSD at 5%	0.43	10.05	0.22	3.63	0.16	9.92	0.053	2.09

Table 5. Effects of vermicompost and chemical fertilizers on the concentration conc.) and uptake of NPKS in the inflorescence of sunflower.

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})
VC_1 Control	0.22	9.8	0.10	4.9	0.59	28.9	0.06	2.9
VC_2	0.24	18.5	0.14	10.8	0.74	57.0	0.12	9.2
VC_3	0.27	19.7	0.16	11.7	0.81	59.1	0.15	11.0
VC_4	0.40	35.2	0.19	16.8	0.92	81.1	0.17	15.0
VC_5	0.45	47.7	0.25	26.5	1.10	116.6	0.06	6.4
VC_6	0.49	100.0	0.27	55.1	1.38	281.5	0.09	18.4
VC_7	0.42	160.9	0.34	130.2	1.50	574.5	0.10	38.3
VC_8	0.44	117.5	0.37	98.8	1.43	381.3	0.13	34.7
VC_9	0.63	138.6	0.39	85.8	1.53	336.6	0.16	35.2
VC_{10}	0.67	127.3	0.44	83.6	1.55	294.5	0.18	34.2
VC_{11}	0.61	81.1	0.42	55.9	1.52	202.2	0.22	29.3
VC_{12}	0.68	168.6	0.45	111.6	1.57	389.4	0.21	52.1
VC_{13}	0.76	278.2	0.49	179.3	1.81	662.5	0.22	80.5
VC_{14}	0.70	190.4	0.46	125.1	1.77	481.4	0.24	65.3
VC_{15}	0.72	204.5	0.55	156.2	1.95	553.8	0.25	71.0
VC_{16}	0.68	208.8	0.71	218.0	2.21	678.5	0.26	79.8
LSD at 5%	0.053	12.35	0.189	8.57	0.106	26.92	0.427	6.9

Nitrogen, phosphorus, potassium, sulfur and oil content in seeds of sunflower are presented in Table 6. The concentration and uptake of nitrogen and phosphorus in seeds ranged from 2.80 - 4.86 and 0.33 - 0.69%, and 226.0 - 2655.8 and 26.6 - 382.5 mg plant^{-1} respectively. The highest values of concentration of nitrogen was recorded in 2.5t VC ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1} and that of phosphorus in 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1}, 7.5t VC ha^{-1} +$N_{80}P_{60}K_{100}$kg ha^{-1} and 7.5t VC ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} treatments, and uptake of nitrogen and phosphorus in 5t VC ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} and 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} treatments respectively. Similarly, concentration and uptake of potassium and sulfur in seeds varied from 0.56 - 1.08 and 0.10 - 0.16%, and 42.2 - 571.0 and 8.1 - 92.2 mg plant^{-1}, respectively (Table 6). The highest values for concentration and uptake of potassium were observed in 7.5t VC ha^{-1} +$N_{80}P_{60}K_{100}$kg ha^{-1} and 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} treatments respectively. However, the same treatment, 5t VC ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} showed that maximum concentration and uptake of sulfur in sunflower seed. 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 and its seeds.Similarly, Zaman *et al.* (2018) also reported that the highest N, P, K and S uptake of stevia were found in the treatment vermicompost + chemical fertilizer.

Table 6. Effects of vermicompost and chemical fertilizers on the concentration and uptake of NPKS and oil content in seeds of sunflower.

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})	
Control	2.80	226.0	0.33	26.6	0.56	42.2	0.10	8.1	41.9
VC_2	3.03	327.5	0.38	41.1	0.64	69.2	0.12	13.0	33.9
VC_3	3.48	560.6	0.34	54.8	0.74	119.2	0.14	22.6	34.9
VC_4	3.57	586.9	0.40	65.8	0.79	129.9	0.15	24.7	36.9
VC_5	3.24	614.0	0.45	85.3	0.83	157.3	0.14	26.5	30.6
VC_6	4.27	1225.9	0.48	137.8	0.81	232.6	0.14	40.2	35.1
VC_7	4.46	1313.0	0.51	150.1	0.82	241.4	0.15	44.2	29.7
VC_8	2.99	866.5	0.44	127.5	0.85	246.3	0.13	37.7	44.8
VC_9	3.97	1285.9	0.54	174.9	0.85	275.3	0.14	45.3	33.1
VC_{10}	4.86	2151.5	0.61	270.0	0.84	371.9	0.14	62.0	45.9
VC_{11}	4.28	1654.2	0.60	231.9	0.87	336.3	0.15	58.0	32.0
VC_{12}	4.61	2655.8	0.61	351.4	0.95	547.3	0.16	92.2	45.3
VC_{13}	4.45	2467.1	0.69	382.5	1.03	571.0	0.15	83.2	46.7
VC_{14}	3.88	1782.5	0.66	303.2	0.96	441.0	0.14	64.3	37.9
VC_{15}	4.57	2172.6	0.69	328.0	1.08	513.4	0.14	66.6	46.9
VC_{16}	4.81	1738.3	0.69	249.4	1.04	375.9	0.15	54.2	43.8
LSD at 5%	0.30	63.58	0.105	29.09	0.04	23.67	0.024	10.41	3.99

Suthar (2009) reported that vermicomposted manure may be a potential source of plant nutrients for sustainable crop production. Sharma *et al.* (2014) also reported that conjunctive nutrient treatment, vermicompost + chemical fertilizers proved quite superior to other set of treatments in improving the uptake of N, P, K, S and micronutrients in sunflower.

Per cent oil content of sunflower seed showed a wide variation among the treatments of vermicompost and NPK fertilizers (Table 6). The treatments showed a decrease in percent oil content in all the treatments significantly ($P< 0.05$) when compared with the control except the

treatments of 2.5t VC ha^{-1} + $N_{120}P_{90}K_{150}$kg ha^{-1}, 5t VC ha^{-1}+$N_{120}P_{90}K_{150}$kg ha^{-1} and 7.5t VC ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1}. The maximum and minimum values of per cent oil content ranged from 29.7-46.9% recorded in 7.5t VC ha^{-1}+$N_{80}P_{60}K_{100}$kg ha^{-1} and $N_{120}P_{90}K_{150}$kg ha^{-1} treatments, respectively, which was the highest dose of NPK fertilizers (Table 6). These observations are in good agreement with the observations of Godavari *et al.* (2017) who reported that application of 100 per cent NPK (RDF) with vermicompost @ 2.5 t ha^{-1} recorded the highest oil yield. Joshi and Singh (2013) found that oil content (%) in the four treatments such as VC @ 5t ha^{-1}, 10t ha^{-1}, 20t $ha^{-1}$and NPK (RDF) showed a significant increase of 1.0, 1.1, 1.2 and 1.25%, respectively, as compared to control (0.97%) in wheat (*Triticum aestivum* L.).

From the above study, it may be concluded that the combined application of vermicompost and NPKS fertilizers can be the best integrated approach for macronutrients (NPKS) and oil contents in different organs and seeds of sunflower (*Helianthus annus* L.) plants grown in the coastal belt of Bangladesh under field conditions. It further indicates vermicompost in combination with chemical fertilizers could be applied to achieve better concentration, uptake of PKS in different organs and seeds and oil content in seeds of sunflower.

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