EFFECT OF ORGANIC SOURCE OF NUTRIENTS ON SOIL PHYSICO-CHEMICAL PROPERTIES, GROWTH AND YIELD OF CABBAGE (*Brassica oleracea var. capitata*)

ABSTRACT

Aims: Organic source of nutrient has effect on soil physico-chemical properties, growth and yield of cabbage. To determine the effect of organic source of nutrients on soil physio-chemical properties, growth and yield of cabbage (Brassica oleracea var. capitata).
Place and duration of study: Field experiment was conducted on acidic sandy loam soil of Horticulture farm at Agriculture and Forestry University (AFU), Rampur, Chitwan, from 5th December 2020 to 26th March 2021.
Methodology: The experiment was laid out in Randomized Complete Block Design with three replications. Special NPK granules, Carbon based, Vermicompost, Obifert, Neem seed cake, Poultry manure, Farm Yard Manure (FYM), Mustard oil seed cake and Goat manure were used as treatments along with control.
Results: Application of poultry manure significantly increased plant height (22.33cm) with least number of unfolded leaves (7.33), highest head diameter (106.40 cm) and head yield (45.51 t/ha) of cabbage. Bulk density was not statistically significantly influenced by the application of organic source of nutrients. Significantly higher available Phosphorous content in soil was found with the application of mustard oil seed cake (118.58 kg/ha) and available Potassium content was higher with the application of Goat manure (206.69 kg/ha). Nitrogen content of cabbage head (3.25%) and cabbage root (1.43%) was significantly higher with the application of Poultry manure. Mustard oil seed cake obtained highest Nitrogen harvest index (94.46%) and Nitrogen recovery percentage (66.47%). The yield efficiency (228.13kg head/kg N) was highest with the application of poultry manure.
Conclusion: To attain highest yield of cabbage with higher Nutrient use efficiency and enhanced physico-chemical properties of soil, application of Poultry manure might be optimum for acidic sandy loam soil of Chitwan.

Keywords: *Cabbage, Organic source of nutrients, Physico-chemical properties, Poultry manure*

1. INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.), a cool season leafy vegetables, is cultivated in 8,530 ha with the production of 469,726 Mt in Nepal. In Chitwan, it is cultivated in 340 ha, with the total production of 4760 Mt [1]. In the pursuit of food production and economic growth, wide amount of chemical fertilizers is being applied to the crops worldwide resulting in productivity deterioration and serious physico-chemical degradation of soil [2]. Those fertilizers which are derived from animal or plant matter are organic source of nutrients and soil physico-chemical conditions can be modified through their application due to balance of nutrient level and organic matter abundance [3].
Organic manures enhances phosphorous availability in soil, soil organic carbon, nitrogen use efficiency, efficient nutrient cycling, reduces pH of alkaline soils and reduces bulk density [4]. Soil porosity, soil moisture contents and water holding capacity is enhanced and soil compaction and bulk density is reduced through the addition of organic fertilizers [5]. Organic matter added through organic source of nutrients benefits soil quality through their humified fractions [5] as it is the most stable organic carbon reservoir in the soil that stabilizes soil structure [6].

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Continuous use of synthetic fertilizers has led to nutrient imbalances, increased soil acidity, degradation in soil properties and organic matter loss [7]. To attain self-sufficiency in vegetable production, intensive use of chemical fertilizers has led to the declination of soil organic matter, deteriorating soil health, underground water depletion and residue remains in food products causing hazards to human and animal health. About 27-75% of soil organic carbon have been depleted in most soils of the world through intensive agricultural practices [8].

Soil organic matter level and soil microbial activities could be enhanced by use of organic amendments which is vital for nutrient turnover and long term productivity of soil [9]. Being cheap, there are various advantages of using organic source of nutrients leading to improvement of soil structure and texture, aeration thus increased soil water retention abilities and stimulates healthy root development [10]. Use of organic source of nutrients could be one of the viable approaches to meet the growing concerns about the food safety and quality, rejuvenation of declining soil health and organic matter and an alternative solution to the farmers to reduce their dependence on chemical fertilizers. Under this context the experiment was conducted to evaluate the different organic source of nutrients.

2. MATERIAL AND METHODS

The research was conducted in the Horticulture farm of Agriculture and Forestry University, Rampur, Chitwan starting from 5th December. The area is situated in central Terai of Nepal in Bagmati Province. The experimental site is situated at 27^0 37' North latitude and 84^0 25' east longitudes with an elevation of 256 m above sea level. Composite soil sample was taken and analyzed to determine the initial physico-chemical property. Final soil sample after the harvest of cabbage was taken from each plot at the depth of 15 cm and analyzed separately. Nitrogen content of cabbage shoot and root was analyzed using Micro Kjeldhal Distillation unit [11].

Table 1. Physico-chemical properties of the soil of the experimental site at Rampur, Chitwan, 2020/21

S.N.	Properties	Average content	Rating	Methods and references
1.	Physical properties			
	Texture			
	Sand (%)	65.20	Sandy loam	Hydrometer [11].
	Silt (%)	24.00		
	Clay (%)	10.80		
	Bulk density	1.25g/cm^3		Core Sampler [12].
2.	Chemical properties			
	Soil pH	5.57	Acidic	Beckman Glass Electrode pH meter [13].
	Soil organic matter (%)	1.62	Low	Walkely and Black [11].
	Total nitrogen (%)	0.08	Low	Micro Kjeldhal Distillation [14].
	Available phosphorus (kg ha^{-1})	50	Medium	Modified Olsen's method [15].
	Available potassium (kg ha^{-1})	105	Medium	Ammonium acetate method [16].

Source: Department of Agriculture, Hariharbhawan and Soil Science Laboratory of AFU. Rating based on [17].

The experiment was laid out in Randomized Complete Block Design (RCBD) consisting of 10 treatments and 3 replications. Treatments were organic source of nutrients and were randomly allocated. The treatments were (T_1: control, T_2: special NPK granules, T_3: Carbon based, T_4: Vermicompost, T_5: Obifert, T_6: Neem Seed cake, T_7: Poultry manure, T_8: Farm Yard Manure, T_9: Mustard oil seed cake, T_{10}: Goat manure). Individual plot size was 2m in length and 2m in width and total experimental area was 196m^2. NT-766, F1 hybrid, late season variety of cabbage was sown and transplanted at 30 DAS. Plant were

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spaced at 40 cm in between rows and 40 cm in between plants. Each plot consisted of 5 rows with 5 plants in each row. Nutrient dose of organic source was calculated according to recommended dose of nutrient that is 140-50-80 N, P_2O_5, K_2O kg ha^{-1}.

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The central five plants were tagged for data collection. The morphological characteristics of the 5 tagged plants were recorded at every 20 days interval starting form 20 days after transplanting till harvesting and their mean was calculated.

Table 2. Nutrient content, pH and Moisture percentage and amount of organic manures used

S.N.	Manures	Nutrient content			Moisture percentage	pH	Amount (t/ha)
		N(%)	P_2O_5(%)	K_2O(%)			
1	Special NPK Granules	3.04	1.11	1.01	11.7	6.7	0
2	Carbon based	1.53	1.67	1.19	41	5.3	5.14
3	Vermicompost	2.03	7.73	2.03	54.7	7.1	12.9
4	Obifert	1.83	6.42	5.13	35.4	8.2	10.67
5	Neem seed cake	1.68	0.71	2.96	32.6	6.3	10.36
6	Poultry manure	3.82	3.30	3.68	26.3	8.9	11.05
7	Farm Yard Manure	2.16	2.18	2.44	79.9	8.5	4.63
8	Mustard oil seed cake	4.59	3.24	2.05	11.7	5.3	11.66
9	Goat manure	1.04	1.41	2.08	40.7	8.7	3.41

2.1 Nitrogen use efficiency parameters

Following parameters were taken as a measure of Nitrogen use efficiency [18].

$$\text{Nitrogen harvest index (\%)} = \frac{\text{Nitrogen uptake by cabbage head}}{\text{Total Nitrogen uptake}} \times 100$$

$$\text{Nitrogen Fertilizer recovery efficiency (\%)} = \frac{\text{Total Nitrogen uptake in fertilized plot} - \text{Total Nitrogen uptake in control plot}}{\text{Total Nitrogen applied}} \times 100$$

$$\text{Yield efficiency (\%)} = \frac{\text{Cabbage yield in fertilized plot}\left(\frac{kg}{ha}\right) - \text{Cabbage yield in unfertilized plot}\left(\frac{kg}{ha}\right)}{\text{Total Nitrogen applied}}$$

All the data were taken using standard techniques. ANOVA was done and significant data were subjected to DMRT for mean comparison [19].

3. RESULTS AND DISCUSSION

3.1 Number of unfolded leaves

More number of unfolded leaves means less formation of cabbage head thus more number of unfolded leaves in control might be due to less availability of plant nutrient. Less number of unfolded leaves with Poultry manure is mainly attributed to timely supply of plant nutrient, resulting proper plant growth and timely wrapping of leaves [20]. Similar result was reported by [21].

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Table 3. Number of unfolded leaves per plant of cabbage as influenced by organic source of nutrients at Rampur, Chitwan, 2020/21

Treatments	Number of unfolded leaves			
	20 DAT	40 DAT	60 DAT	At harvest
Control	7.20	10.93	10.37^{a}	9.10^{a}
Special NPK granules	7.67	10.87	8.67^{d}	7.93^{bcd}

Carbon based	7.00	10.60	9.47^{abcd}	8.23^{abcd}
Vermi compost	7.60	10.87	9.00^{cd}	8.37^{abc}
Obifert	8.00	10.60	8.67^{d}	7.73^{cd}
Neem seed cake	6.73	10.93	10.20^{ab}	8.80^{ab}
Poultry manure	7.67	10.67	8.53^{d}	7.33^{d}
Farm yard manure	7.17	10.47	9.93^{abc}	8.67^{abc}
Mustard oil seed cake	6.33	10.07	9.47^{abcd}	8.60^{abc}
Goat manure	7.93	10.27	9.27^{bcd}	8.20^{abcd}
Sem (±)	0.05	0.05	0.03	0.03
LSD (0.05)	Ns	Ns	0.88	0.88
CV, %	11.86	7.98	8.88	6.16
Grand mean	7.33	10.63	9.36	8.41

Note: DAT, days after transplanting; ns, non-significant; Mean separated by DMRT and columns represented with the same letter(s) are non-significant at 5% level of significance.

3.2 PLANT HEIGHT

At 20 DAT vermi-compost and obifert obtained tallest plant height of cabbage which might be due to plant growth associated with humus content excreted by earthworm that contains humic acid [22]. Tea like structure of vermi-compost might have improved the soil porosity, water holding capacity and structure of the soil and enhanced availability of the plant growth promoting substances thus increasing plant height of the cabbage [23]. Increase in plant height might be due to improvement in the availability of some minerals in soil, rapid mineralization of organic Nitrogen and availability to the crop according to crop needs with application of poultry manure.

Table 4. Plant height of cabbage as influenced by organic source of nutrients at Rampur, Chitwan, 2020/21

Treatments	Plant height (cm)			
	20 DAT	40 DAT	60 DAT	At harvest
Control	5.66^{c}	9.31	20.63	16.10^{c}
Special NPK granules	7.45^{ab}	12.01	20.93	18.23^{bc}
Carbon based	6.45^{abc}	10.90	20.40	16.67^{c}
Vermi compost	7.77^{a}	11.47	21.33	18.40^{abc}
Obifert	7.77^{a}	12.13	21.41	20.13^{abc}
Neem seed cake	5.75^{c}	9.41	20.80	16.93^{c}
Poultry manure	6.90^{abc}	12.61	22.21	22.33^{a}
Farm yard manure	5.99^{bc}	9.97	20.80	19.67^{abc}
Mustard oil seed cake	6.41^{abc}	10.79	21.80	19.53^{abc}
Goat manure	7.29^{abc}	12.71	22.07	22.07^{ab}
Sem(±)	0.05	0.08	0.07	0.12
LSD (0.05)	1.49	ns	ns	3.57
CV, %	12.91	12.83	5.90	10.94
Grand mean	6.74	11.13	21.17	19.01

3.3 CANOPY WIDTH

Highest canopy width at earlier days of cabbage growth i.e. 20 DAT might be due to prevailing auxins, cytokinins and gibberellin, humic acid excreted by the earthworm along with enhancement of water holding capacity and structure of soil with application of vermicompost. Balanced nutrient composition in the Poultry manure might have led to highest canopy width of cabbage [24]. Mustard oil seed cake obtained highest canopy width at harvest which might be associated to high initial Nitrogen content of manure.

Table 5. Canopy width of cabbage as influenced by organic source of nutrients at Rampur, Chitwan, 2020/21

Treatments	Canopy width (cm)			
	20 DAT	40 DAT	60 DAT	At harvest
Control	16.40^{d}	33.88^{d}	43.23^{c}	40.70^{c}
Special NPK granules	21.56^{ab}	39.62^{abc}	49.70^{ab}	45.53^{abc}
Carbon based	18.67^{abcd}	36.38^{abc}	43.77^{c}	41.17^{c}
Vermi compost	22.13^{a}	37.94^{bcd}	46.83^{bc}	43.23^{bc}
Obifert	22.17^{a}	41.63^{ab}	49.90^{ab}	45.43^{abc}
Neem seed cake	18.25^{bcd}	34.96^{cd}	49.54^{ab}	42.81^{bc}
Poultry manure	20.62^{abc}	43.21^{a}	51.77^{a}	47.93^{ab}
Farm yard manure	18.86^{abcd}	35.62^{abc}	46.23^{bc}	44.37^{abc}
Mustard oil seed cake	16.95^{cd}	37.08^{bcd}	49.97^{ab}	49.40^{a}
Goat manure	20.54^{abc}	39.21^{abc}	48.53^{ab}	46.21^{abc}
Sem(±)	0.11	0.15	0.14	0.16
LSD (0.05)	3.32	4.34	4.07	4.87
CV, %	9.86	6.66	4.95	6.36
Grand mean	19.62	37.95	47.95	44.68

Note: DAT, days after transplanting; Mean separated by DMRT and columns represented with the same letter(s) are non-significant at 5% level of significance

3.4 YIELD AND YIELD COMPONENTS

Enhanced availability of the growth promoting substances with the application of vermi compost might have enhanced head height of cabbage. Higher yield might be due to least value of C/N ratio of the poultry manure and quick nutrient release for uptake by cabbage and higher head yield parameters [24-25]. As application of poultry manure increased growth parameters leading to synthesis of more plant metabolites thus increasing head diameter and yield of cabbage. Assistance of poultry manure in enhancement of plant vital processes subsequently increased plant yield [26] and higher initial nitrogen content of Mustard oil seed cake assisted higher yield of cabbage**.**

Table 6. Head height, head diameter, yield of cabbage as influenced by organic source of nutrients at Rampur, Chitwan, 2020/21

Treatment	Head height (cm)	Head diameter (cm)	Yield (t/ha)
Control	10.23^{d}	91.45^{e}	13.58^{e}
Special NPK granules	13.43^{ab}	98.47^{cd}	39.34^{abc}
Carbon based	11.61^{bcd}	99.91^{bcd}	28.64^{d}
Vermi compost	14.02^{a}	98.43^{cd}	33.23^{bcd}
Obifert	14.21^{a}	104.41^{ab}	41.95^{a}
Neem seed cake	11.13^{cd}	94.96d^{e}	27.80^{d}
Poultry manure	13.40^{ab}	106.40^{a}	45.51^{a}
Farm yard manure	11.73^{bcd}	95.98^{de}	31.11^{cd}
Mustard oil seed cake	13.01^{abc}	102.08^{abc}	43.00^{a}
Goat manure	13.49^{ab}	100.23^{bcd}	41.25^{ab}
Sem(±)	0.07	0.17	0.29
LSD (0.05)	2.00	5.09	8.47
CV, %	9.25	2.99	14.30
Grand mean	12.63	99.23	34.04

Note: Mean separated by DMRT and columns represented with the same letter(s) are non-significant at 5% level of significance

3.5 SOIL PARAMETERS

3.5.1 Effect of organic source of nutrients in bulk density of soil

There was no any significant difference in the bulk density of soil with the application of organic source of nutrients in the soil. However, application of organic source of nutrients decreased bulk density from 1.25g/cm^3 (Fig 1) to mean bulk density 1.04 g/cm^3.

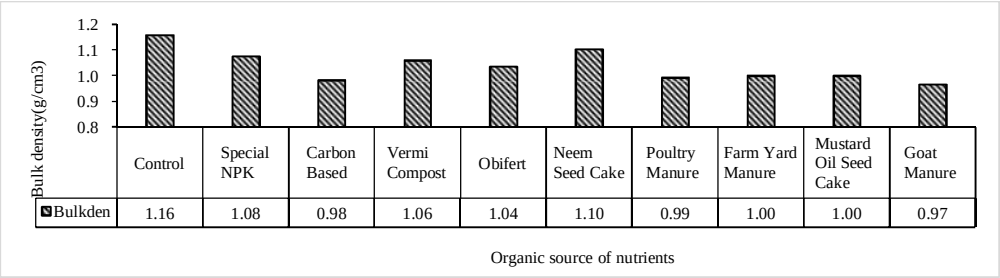

Figure 1. Effect of organic source of nutrients in bulk density of the soil at Rampur, Chitwan, 2020/21

3.5.2 Effect of organic source of nutrients in chemical properties of soil

Application of organic manures increased organic matter content of the soil which might be due to slow mineralization. The rise of soil pH due to addition of organic manures might be due to the consumption of H^+ by the humic substances which have large number of carboxyl and phenolic functional groups and initial alkaline nature of organic manures. Application of vermicompost increased pH of acidic soil as reported by [27]. [28] reported increase in soil pH with the application of poultry manures. Increase in Nitrogen content might be due to mineralization of soil organic matter releasing substantial amount of Nitrogen, phosphorous and micronutrients. Increased microbiological activity due to richness of organic manures and high population of bacteria, actionmycetes and fungi increases mineralization of organic nitrogen and nutrient becomes available to the plants. Phosphorous content of the soil has been increased by the application of organic manure due to accumulation of the phosphorous in the soil surface as plant cannot fully utilize the phosphorous applied through organic fertilization. Similar findings were reported by [29]. Soil potassium content and release was increased by the application of goat manure and poultry manure in sandy loam soil as reported by [30]. Organic manures upon decomposition results in the dissolution of some of the soil potassium containing minerals through organic acids i.e. humic and fulvic acids leading to release of the potassium ions in the soil and increases its concentration in the soil solution.

Table 7. Soil chemical properties as influenced by organic source of nutrients at Rampur, Chitwan, 2020/21

Treatment	OM (%)	pH	N (%)	P_2O_5 (%)	K2O (%)
Control	1.03^{b}	5.83	0.05^{b}	53.34^{c}	75.92^{f}
Special NPK granules	2.29^{a}	6.43	0.11^{a}	82.70^{abc}	115.90^{e}
Carbon based	2.42^{a}	6.10	0.12^{a}	100.79^{ab}	122.09^{de}
Vermicompost	2.85^{a}	5.90	0.14^{a}	106.36^{a}	142.23^{cde}
Obifert	2.39^{a}	6.30	0.12^{a}	79.56^{abc}	189.51^{ab}
Neem seed cake	2.69^{a}	5.87	0.13^{a}	62.12^{bc}	154.77^{bcd}
Poultry manure	2.76^{a}	6.03	0.14^{a}	116.17^{a}	175.87^{abc}
Farm yard manure	2.66^{a}	5.97	0.13^{a}	76.92^{abc}	187.99^{ab}
Mustard oil seed cake	2.66^{a}	6.07	0.13^{a}	118.58^{a}	119.46^{de}
Goat manure	2.51^{a}	6.33	0.13^{a}	76.92^{abc}	206.69^{a}
Sem(±)	0.027	0.017	0.001	1.301	1.18
LSD (0.05)	0.79	ns	0.04	38.66	35.13
CV, %	18.96	4.97	19.80	25.80	13.74
Grand mean	2.43	6.08	0.12	87.35	149.04
Initial soil data	1.62	5.57	0.08	50	105

Note: ns, non-significant; OM: Organic matter, pH: Potential of Hydrogen ion, N: Total nitrogen, P_2O_5= Available phosphorous, K_2O= Potassium; Mean separated by DMRT and columns represented with the same letter(s) are non-significant at 5% level of significance

3.6 NITROGEN CONTENT IN THE ROOT AND HEAD OF CABBAGE AND TOTAL NITROGEN UPTAKE BY CABBAGE

Increased nitrogen content and uptake with the application of poultry manure might be due to rapid mineralization, higher nutrient utilization efficiency and higher initial nitrogen content. Similarly, increased nitrogen uptake with the application of poultry manures might be due to availability of some minerals in the soil and especially transfer of nutrients from root zone to crop plant (Hameed, Khalaf and Farhan, 2017).

Table 8. Nitrogen content and Total Nitrogen Uptake as influenced by different organic manures at Rampur, Chitwan, 2020/21

Treatment	N % cabbage	N % root	TNU kg/ha
Control	1.10^{d}	0.92^{d}	14.70^{f}
Special NPK granules	2.05^{bc}	1.17^{bc}	64.99^{cde}
Carbon based	1.76^{c}	1.20^{bc}	43.71^{e}
Vermi compost	1.78^{c}	1.12^{bc}	50.70^{de}
Obifert	2.35^{b}	1.20^{bc}	74.13^{bcd}
Neem seed cake	1.95^{bc}	1.08^{cd}	43.34^{e}
Poultry manure	3.25^{a}	1.43^{a}	107.70^{a}
Farm yard manure	2.03^{bc}	1.27^{abc}	48.17^{e}
Mustard oil seed cake	3.18^{a}	1.33^{ab}	96.13^{ab}
Goat manure	2.46^{b}	1.13^{bc}	77.24^{bc}
Sem(±)	0.017	0.01	0.80
LSD (0.05)	0.50	0.19	24.25
CV, %	13.38	9.38	22.67
Grand mean	2.19	1.18	62.08

Note: NUC: Nitrogen uptake by cabbage; NUR: Nitrogen uptake by cabbage root; TNU: Total Nitrogen Uptake, ns, non-significant; Mean separated by DMRT and columns represented with the same letter(s) are non-significant at 5% level of significance.

3.7 NUTRIENT USE EFFICIENCY PARAMETERS

3.7.1 Nitrogen harvest index

Highest nitrogen harvest index was found for mustard oil seed cake (94.46%) followed by goat manure, poultry manure and Obifert. There was statistically highly significant difference in nitrogen harvest index between control and other treatments (Figure 2.) while effect of poultry manure, goat manure and obifert was statistically similar. Organic fertilizers elicited the mean nitrogen harvest index of 90.9% while control exhibited 75.76%.

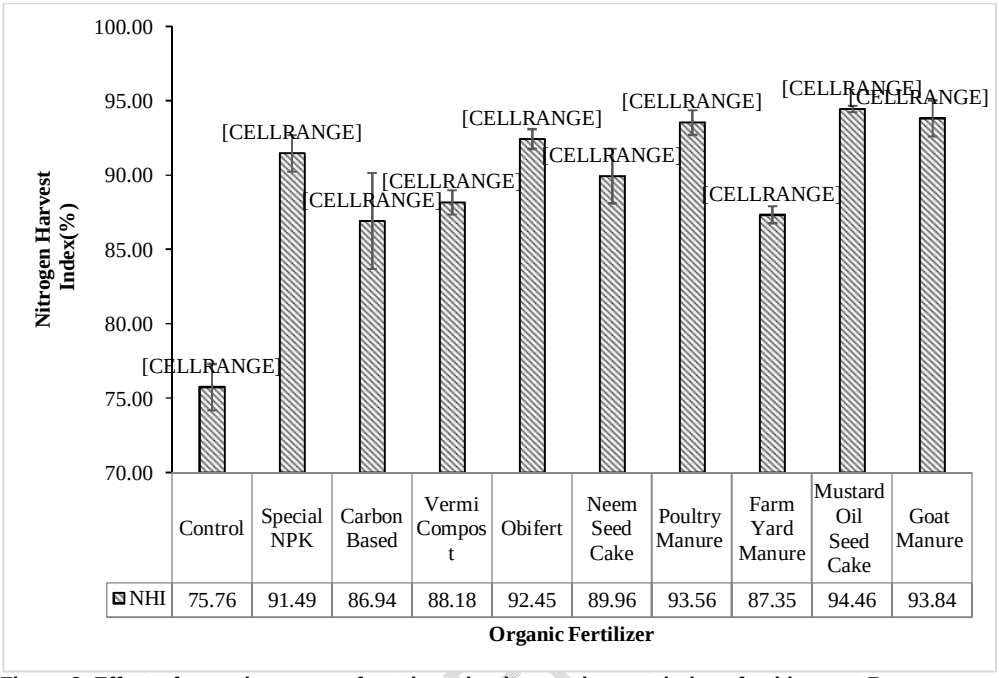

Figure 2. Effect of organic source of nutrients in nitrogen harvest index of cabbage at Rampur, Chitwan, 2020/21

3.7.2 Nitrogen Fertilizer Recovery percentage

Highest nitrogen fertilizer recovery was shown by poultry manure (66.47%) followed by mustard oil seed cake (58.2%), goat manure (44.72%) and obifert (42.49%) while lowest was shown by neem seed cake (20.49%). Nitrogen fertilizer recovery percentage was statistically significantly different between the treatments while it was similar between the carbon based, FYM and neem seed cake (Figure 3.)

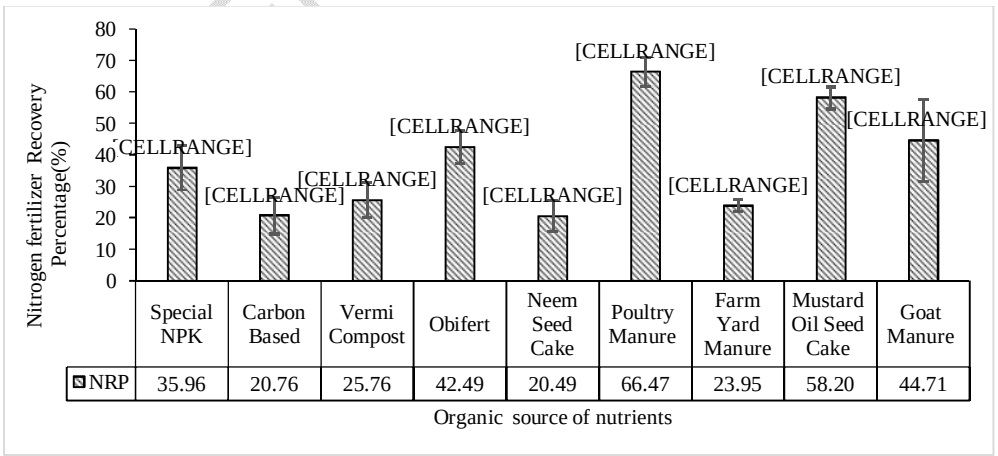

Figure 3. Effect of organic source of nutrients in Nitrogen Recovery percentage of cabbage at Rampur, Chitwan

3.7.3 Yield efficiency

Highest yield efficiency was shown by poultry manure (228.13%) followed by mustard oil seed cake (210.18%) and obifert (202.65%) while the lowest was shown by carbon based organic fertilizer. Significant difference was seen in yield efficiency between the poultry manure and carbon based fertilizer. Yield efficiency was statistically similar by the carbon based, neem seed cake and FYM (Figure 4.)

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Due to higher mobilization of nutrients for uptake by plant and due to higher initial nutrient content of Mustard oil seed cake might have enhanced Nitrogen Harvest Index of Cabbage. Highest recovery of Nitrogen with the application of poultry manure might be due to the balanced nutrient composition and rapid mineralization with steady release of nutrients matching the crop needs and efficient uptake and recovery of Nitrogen. Highest nitrogen uptake due to its balanced nutrient composition and rapid mineralization favored cell division and cell elongation which in turn led to better plant growth and assimilation of more photosynthates and ultimately higher yield efficiency with the application of poultry manure.

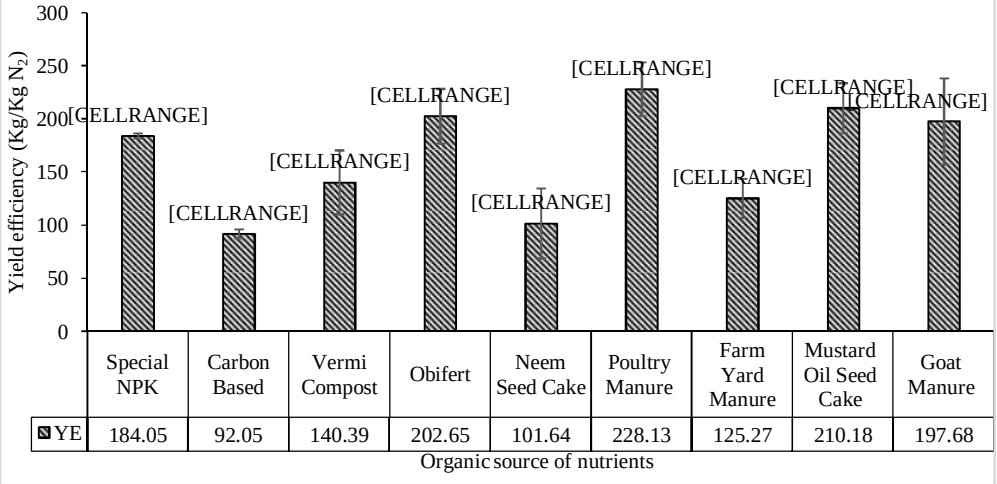

Figure 4. Effect of organic source of nutrients in yield efficiency of cabbage at Rampur, Chitwan, 2020/21

4. CONCLUSION

Application of organic manure enhances the soil physico-chemical properties and are effective in promoting growth and yield of cabbage. Poultry manure was found efficient in increasing growth, yield attributes and yield of cabbage due to balanced initial nutrient content and rapid mineralization with efficient release of nutrients. Poultry manure was efficient in enhancing physico-chemical properties of soil representing its effectiveness in rejuvenating soil health and properties. Nutrient use efficiency was enhanced by application of poultry manure.

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Comment [O18]: add latest data reference

Comment [O19]: follow the reference format

Comment [O20]: make it italic

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