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## Soil properties and productivity of cabbage (*Brassica oleracea* L. var. *capitata*) under integrated nutrient management system in acid inceptisol of Meghalaya

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### Abstract

A field experiment was conducted during *rabi* 2017-18 at School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya to study the effect of various organic and inorganic nutrient sources on quality, productivity of cabbage (*Brassica oleracea* L. var. *capitata*) and soil properties in acid Inceptisol of Meghalaya. Cabbage cv. Wonder Ball was used as test crop with eight different combinations of doses of Farm Yard Manure (FYM), Vermicompost (VC) and recommended doses of NPK fertilizers (RDF). The treatment combination consists of control (T<sub>1</sub>), 100% RDF (T<sub>2</sub>), 100% N through FYM (T<sub>3</sub>), 100% N through VC (T<sub>4</sub>), 50% RDF + 50% N through FYM (T<sub>5</sub>), 75% RDF + 25% N through FYM (T<sub>6</sub>), 50% RDF + 50% N through VC (T<sub>7</sub>) and 75% RDF + 25% N through VC (T<sub>8</sub>). The experiment was laid out in RBD and replicated thrice. The experimental soil was having pH 4.87, SOC 1.24 %, Alkaline KMnO<sub>4</sub>- N 160 kg/ha, available P<sub>2</sub>O<sub>5</sub> 18.60 kg/ha and available K<sub>2</sub>O 238.4 kg/ha. The experimental results revealed that treatment T<sub>7</sub> with 50% RDF + 50% N through VC produced highest cabbage yield (60.44 t/ha) which was statistically comparable with T<sub>5</sub> of 50% RDF + 50% N through FYM (54.33 t/ha). The yield obtained in T<sub>5</sub> was almost same as obtained with 100% RDF alone (T<sub>2</sub>). The quality of cabbage with respect to head compactness, head shape index also followed the same trend. The combined application of 50% RDF + 50% N through VC in T<sub>7</sub> maintained good soil physical, chemical and biological health after harvest indicating best suitable option for higher production of quality cabbage in acid Inceptisol of Meghalaya.

**Keywords:** Integrated nutrient management, cabbage, quality, yield, soil health, acid soil

### Introduction

Vegetables play an important role in a balanced diet of human beings by providing not only energy-rich food but also supplying vitamins and minerals. Comparatively, vegetables are one of the cheapest sources of natural nutritive foods. In developing countries like India, where the pressure of population on land is continuously increasing, vegetables may play a significant role in supplying a balanced diet. Although, India has emerged as second largest vegetable producing country in the world, but the present level of production is not sufficient to make pace with the growing population. It is anticipated that the nation will require around 225 million tons vegetable by the year 2025 against the limitations of expansion of the cultivable land area. Cabbage is known to play predominant role in Indian meal as it possess high nutritive value supplying essential vitamins, proteins, carbohydrates and vital minerals amongst *Cruciferaeae*. However, productivity of cabbage in our country stands with just 22.6 t/ha which is far behind other developed countries, where as Meghalaya stands with just 21.57 t/ha (MoA, GoI, 2014) <sup>[1]</sup> due to existing acidity related stress (Sailo and Sanjay-Swami, 2019) <sup>[2]</sup>. In Meghalaya, the acid soils are found under different acidic ranges like moderately acidic soils (1.19 million ha), and slightly acidic soils (1.05 million ha) (Yadav and Sanjay-Swami, 2019) <sup>[3]</sup>. Soil health/fertility is the most crucial factor in deciding the agricultural productivity in the region (Lyngdoh and Sanjay-Swami, 2018) <sup>[4]</sup>.

The modern agricultural technology emphases wide spread use of chemical fertilizers (off farm inputs) as a source of nutrients. Indiscriminate use of inorganic fertilizers leads to nutrient imbalance in soil causing ill effect on soil health and microflora.

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The problem is more severe under acidic soils which are under intensive cropping. The energy crisis and high fertilizer costs have created considerable concern for use of organic materials as a source of plant nutrients (Sanjay-Swami and Singh, 2020) [5]. Integrated use of organic and inorganic fertilizers can improve crop productivity (Mal *et al.*, 2013) [6]. Soil organic matter (SOM) plays a key role in soil fertility sustenance. Use of chemical fertilizers in combination with organic manure is essentially required to improve soil health (Bajpai *et al.*, 2006) [7]. Association of organic matter and nutrient availability has been confirmed by the high coefficients of correlation between the soil attributes (Sakal *et al.*, 1996) [8]. There is an urgent need to develop nutrient management package involving use of renewable resources of plant nutrients available to the farmers of Meghalaya. Although FYM is commonly used organic manure but is not adequately available. The huge amounts of farm wastes can be recycled effectively by preparing vermicompost (Sanjay-Swami, 2012) [9]. Vermicompost application improves bulk density, water holding capacity, and humic substances of the soil (Sanjay-Swami and Bazaya, 2010) [10]. Its application also improves soil biology by increasing population of beneficial microbes and enzyme activities (Sharma and Garg, 2017) [11]. Therefore, the present investigation was carried out to study the effect of vermicompost and FYM in combination with inorganic fertilizers on cabbage yield, quality, nutrient uptake and improvement in soil health of acid Inceptisol of Meghalaya.

### Materials and methods

The experiment was conducted at School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya during *rabi* 2017-18. For raising cabbage nursery, the growing medium was prepared by thorough mixing of top soil, fine sand and well rotted FYM in a ratio 2:1:1 and transferred to plastic seedling tray of 50 cavities with each cavity of 38 mm depth with upper and lower diameter of 32 x 20 mm<sup>2</sup>. The seeds of F<sub>1</sub> hybrid Wonder Ball were placed in each cavity. Light irrigation was given after sowing for easy and quick germination. Germination started after 4-5 days. Irrigation was provided regularly until the seedlings attained the age 30 days. The uniform cabbage seedlings were deported safely for transplanting in the experimental field. The nursery of the

cabbage seedlings and crop in field after 30 days of transplanting are depicted in Figure 1 and 2, respectively.



Fig 1: Ready to transplant cabbage nursery raised in plastic seedling trays



Fig. 2: Cabbage in field 30 days after transplanting

The trial was conducted in Randomized Block Design (RBD) with eight treatments *viz.*, control (T<sub>1</sub>), 100% RDF (T<sub>2</sub>), 100% N through FYM (T<sub>3</sub>), 100% N through VC (T<sub>4</sub>), 50% RDF + 50% N through FYM (T<sub>5</sub>), 75% RDF + 25% N through FYM (T<sub>6</sub>), 50% RDF + 50% N through VC (T<sub>7</sub>), 75% RDF + 25% N through VC (T<sub>8</sub>) and replicated thrice. All the agronomic practices were followed through out the crop growing period. The experimental soil was having pH 4.87, SOC 1.24%, Alkaline KMnO<sub>4</sub>- N 160 kg/ha, available P<sub>2</sub>O<sub>5</sub> 18.60 kg/ha and available K<sub>2</sub>O 238.4 kg/ha. The N, P and K content in FYM on dry weight basis was 0.55, 0.24 and 0.34 percent while vermicompost was superior in N, P and K content with 2.10, 1.22 and 1.53 percent, respectively. The recorded meteorological parameters during the crop growing season are presented in Figure 3.

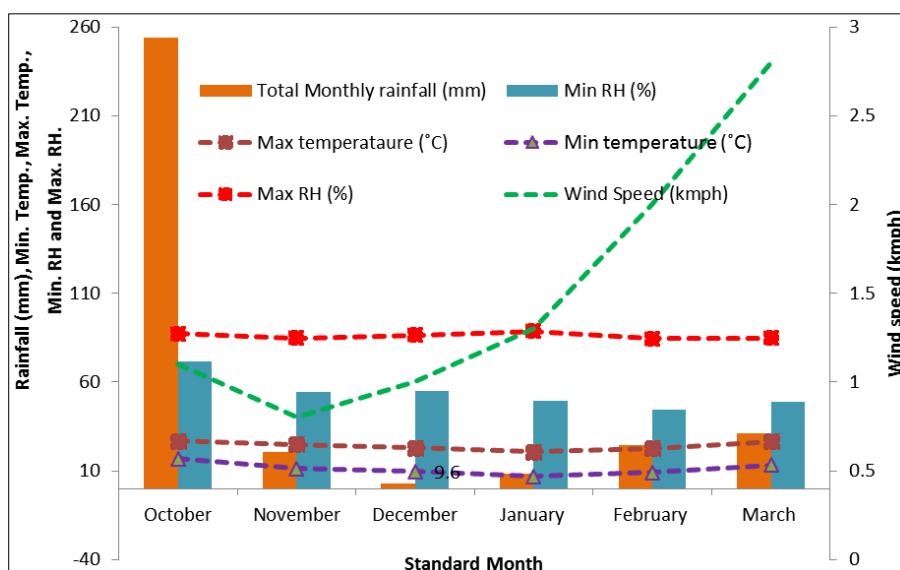


Fig 3: Monthly average values of metrological parameters during the crop growth period (October 2017 to March, 2018)

The head shape index was calculated from transverse length and longitudinal length of the cabbage after harvest through the formula given below:

$$\text{HSI} = \frac{\text{Transverse length (cm)}}{\text{Longitudinal length (cm)}}$$

The head compactness was determined from the original data as per formula given by Pearson (1931):

$$Z = \frac{C}{W} \times 100$$

Z = Index of compactness

C = net weight of head (g)

W = average of equatorial and polar diameter of head (cm)

The plot-wise yield of cabbage head was recorded in kilograms and then converted into tonne per hectare and the mean values were statistically analysed. For analysis of soil physio-chemical and microbiological properties after harvest of cabbage, soil samples were collected treatment wise from the plant rhizospheric region using a PVC pipe (1 inch inner diameter). The soil samples were collected from 15 cm depth and processed for analysis of various soil physical and chemical properties. For analysing microbiological properties of soil, fresh soil samples were collected and immediately stored in the refrigerator at 2°C, until further analysis. N, P and K uptake was determined with the help of their content and dry matter yield of cabbage. The data recorded for various parameters were analysed statistically by following procedure of Gomez and Gomez (1984) [12].

## Results and discussion

### Head shape index (HSI):

The effect of different treatments on head shape index (HSI) in between and within the treatments were negligible (Table 1). As a result, the data was statistically non-significant. However, small variations were recorded due to different treatments. Head shape was recorded ranging from 0.96 in T<sub>1</sub> (control) to 0.98 in T<sub>4</sub> (100% N through VC) which indicated a better head shape in T<sub>4</sub>. It was consequently followed by T<sub>3</sub> (100% N through FYM) and T<sub>4</sub> (50% RDF + 50% through VC) which was statistically at par. Interestingly, all the organic manure, sole and in combination treatments showed higher HSI over T<sub>2</sub> (100% RDF treatment) and T<sub>1</sub> (control treatment). It was found that head shape index was positively correlated (R<sup>2</sup>=0.494) with net weight of cabbage. Therefore, head shape index could also be apparently indicated by the net weight of cabbage. The lower HSI value may be inferred that flat or drum head type was not desirable from the view points of market and consumers. The above finding reveals that HSI value might be duly influence by different nutrient treatment and concentration in the soil. This finding is in concurrent with the finding of Mohanty and Hossain (1998) [13] and Singh *et al.* (2010) [14].

### Head compactness

Head compactness was generated on the basis of Z-value of head compactness as per the method of Pearson (1931) [15]. The highest head compactness was recorded with the T<sub>7</sub>- 50% RDF + 50% N through VC treatment i.e. 10.89 which increased the head compactness by 75.08 per cent over control (Table 1). Application of sole organic manure numerically exceeded in head compactness over the sole application of inorganic fertilizer, but statistically at par with each other. The treatments T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub> were statistically at par with T<sub>2</sub>-100% RDF which clearly indicates that dose of

chemical fertilizer could be minimized by 25-50 percent with organic manures. This might be due to effects of bridging the nutrient supply with demand of cabbage during growth and development in combined treatments (T<sub>7</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>8</sub>) of farm yard manure and vermicompost along with inorganic nutrient source. The relative effectiveness of different nutrient sources in head compactness of cabbage could be stated as: chemical fertilizers < organic sources < integrated sources. A similar finding had been reported by Pande and Singh (2015) [16].

**Table 1:** Effect of organic and inorganic nutrient sources on Head Shape Index, Cabbage Head Compactness and head yield of cabbage (*Brassica oleracea* L. var. *capitata*) in acid Inceptisol

Treatments	Head compactness	Head shape Index	Yield t/ha
T <sub>1</sub>	6.228	0.960	34.26
T <sub>2</sub>	7.228	0.964	53.92
T <sub>3</sub>	7.555	0.971	44.97
T <sub>4</sub>	8.808	0.974	47.18
T <sub>5</sub>	9.688	0.977	54.33
T <sub>6</sub>	9.221	0.971	48.79
T <sub>7</sub>	10.892	0.980	60.44
T <sub>8</sub>	9.317	0.971	49.20
SE(m)±	0.473	NS	2.29
CD(P≤0.05)	1.436	NS	6.35

### Head yield

The cabbage head yield data showed that maximum head yield of cabbage was found in treatment T<sub>7</sub> (50% RDF + 50% N through VC) as presented in Table 1. The percent increase in T<sub>7</sub> over T<sub>2</sub> (100% RDF) was 12.02 percent. However, it was at par with other treatments *viz.*, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>. The integration of vermicompost and FYM increased head yield over RDF (120:60:60), reflecting their fertilizer use efficiency in terms of head yield. The higher yield in combined treatments (T<sub>7</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>8</sub>) might be due to favourable soil condition and synchronized release of nutrients throughout the crop growth period (Murali and Setty, 2004) [17].

### Soil organic carbon

Integrated nutrient management through farm yard manure (FYM) and vermicompost (VC) in both sole and combined treatment apparently affected the soil organic carbon (SOC) status of soil (Table 2). The SOC content varied between 1.44 per cent in T<sub>1</sub> (control) to 1.66 per cent in T<sub>3</sub> (100% N FYM). The per cent increase in T<sub>3</sub> over T<sub>2</sub> (100% RDF) was 41.88 per cent. Whereas, in T<sub>2</sub>, increase in SOC over T<sub>1</sub> (control) was 2.63 per cent. The magnitude of increase in SOC over initial (1.24%) was higher in FYM treatment over VC treatment in both sole and combined treatment respectively. The result also revealed, all the sole (T<sub>3</sub> and T<sub>4</sub>) and combined (T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>) treatments showed statistically higher significant over T<sub>1</sub> (control).

The increase in SOC content in the manurial treatment combinations is attributed to direct addition of organic manure in the soil which stimulated the growth and activity of micro-organisms and also due to better root growth, resulting in the higher production of biomass, crop stubbles and residues (Moharana *et al.*, 2012) [18]. The subsequent decomposition of these materials might have resulted in the enhanced carbon content of soil. These results are in agreement with the findings of Majumdar *et al.* (2008) [19] and Nayak *et al.* (2012) [20]. Addition of organic nutrient source might have created environment conducive for formation of

humic acid and stimulated the activity of soil micro-organism, resulting in an increase in the organic carbon content of the soil (Srilatha *et al.*, 2013, Gupta *et al.*, 2019a&b) [21, 22, 23].

### Soil pH

The effect of organic and inorganic nutrient sources on soil pH was very little between the treatments and was statistically non-significant. A slight increase in pH as compared to initial value was recorded in soil treated with organic sources in both sole (T<sub>3</sub> and T<sub>4</sub>) and combined (T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>) application whereas, slight decrease in soil pH as compared to initial value was found in sole application of inorganic source which is presented in Table 2. The increase in pH might be due to decrease of Al<sup>3+</sup> and release of basic cations during decomposition of manures, where as application of nitrogenous fertilizers decreases the pH due to residual acidity of fertilizers. A similar result has been reported in the findings of Zhang *et al.* (2008); Yaduvanshi and Sharma (2016) [24, 25].

### Soil bulk density

It is discernible from Table 2 that application of recommended doses of fertilizers alone (T<sub>2</sub>) or with farm yard manure (T<sub>3</sub>) and vermicompost (T<sub>4</sub>), decreased the value of bulk density. Similarly, a small decreased in bulk density was also observed in combined treatments (T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>) of organic and inorganic. However, the differences among the treatments were non-significant. The lower bulk density in surface soil was attributed to the higher SOC (Tripathi *et al.*, 2014) [26]. Higher SOM, better aggregation and increased root growth with balanced fertilization was also reported by Chalwade *et al.*, (2006) [27]; and Bandyopadhyay *et al.*, (2010) [28].

**Table 2:** Effect of organic and inorganic nutrient sources on SOC (%), pH, bulk density (g/cm<sup>3</sup>) and soil moisture (%)

Treatments	SOC	pH	Bulk density	Soil moisture
T <sub>1</sub>	1.14	4.86	1.43	19.06
T <sub>2</sub>	1.17	4.85	1.42	20.21
T <sub>3</sub>	1.66	4.92	1.41	22.67
T <sub>4</sub>	1.63	4.90	1.41	22.18
T <sub>5</sub>	1.53	4.88	1.42	21.67
T <sub>6</sub>	1.59	4.89	1.42	21.99
T <sub>7</sub>	1.44	4.87	1.42	20.21
T <sub>8</sub>	1.49	4.88	1.42	21.78
<i>P</i> ≤ 0.05	0.07	NS	NS	NS
SEm ±	0.20	NS	NS	NS

T<sub>1</sub>- Control; T<sub>2</sub>-100% RDF; T<sub>3</sub>-100% N through FYM; T<sub>4</sub>-100% N through VC; T<sub>5</sub>- 50% RDF + 50% N through FYM; T<sub>6</sub>- 25% RDF + 75% N through FYM; T<sub>7</sub>- 50% RDF + 50% N through VC; T<sub>8</sub>- 25% RDF + 75% N through VC

\*Recommended doses of fertilizers (RDF) = 120:60:60: N:P:K (kg/ha)

### Soil moisture

The perusal of the data presented in Table 2 shows the effect of different treatments on soil moisture per cent. It indicates that highest (22.67 per cent water) soil moisture was found in treatment T<sub>3</sub> (100% N through FYM) and lowest in (19.06 per cent) under T<sub>1</sub> (control) treatment. The per cent increase in soil moisture per cent in T<sub>3</sub> over T<sub>1</sub> was 18.94 per cent. However, all treatments were found statistically at par with one another. Among the sole treatment of organic and inorganic, organic treatment showed higher soil moisture per cent. The treatment T<sub>7</sub> and T<sub>5</sub> with vermicompost were found more effective on soil moisture as compared to T<sub>8</sub> (25% RDF + 75% N through FYM) and T<sub>6</sub> (50% RDF + 50% N through

FYM) with farm yard manure, respectively. The higher water retention may be due to better aggregation and higher SOC in surface soil (Thangasamy *et al.*, 2017) [29]. The amount of water retained at field capacity primarily depends on capillary effect, pore size distribution and soil structure (Hillel, 2004) [30].

### Soil available nitrogen

The soil available nitrogen content in all treatments (T<sub>2</sub> to T<sub>8</sub>) was statistically significant over T<sub>1</sub> (control) as presented in Table 3. The highest available nitrogen was recorded in T<sub>7</sub> (50% RDF + 50% N through VC) with 275.97 kg/ha which was followed by T<sub>5</sub> (50% RDF + 50% N through FYM) with 267.67 kg/ha. In general, application of sole manures (T<sub>3</sub> and T<sub>4</sub>), inorganic fertilizers (T<sub>2</sub>) and combined (T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>) application improved the soil available nitrogen status of soil as compared to control treatment (T<sub>1</sub>). The per cent increase in T<sub>7</sub> over T<sub>2</sub> (100% RDF) in soil available nitrogen was 6.45 per cent. Whereas, increase in T<sub>2</sub> over T<sub>1</sub> for soil available nitrogen was 42.83 per cent. Among the sole treatment of organic and inorganic, inorganic treatment showed higher soil available nitrogen. However, the degree of response was of lower order as compared to sole inorganic treatment. The treatment T<sub>7</sub> and T<sub>5</sub> with vermicompost were found superior as compared to T<sub>8</sub> (25% RDF + 75% N through FYM) and T<sub>6</sub> (50% RDF + 50% N through FYM) with farm yard manure, respectively.

The higher soil available nitrogen in vermicompost treatments in both sole and combined treatments might be due to lower C: N ratio in vermicompost as compared to farm yard manure. While the higher soil available nitrogen in T<sub>5</sub> and T<sub>7</sub> as compared to T<sub>6</sub> and T<sub>8</sub> might be due to faster mineralization as compared to T<sub>6</sub> and T<sub>8</sub>. The lower soil available nitrogen in sole application (T<sub>3</sub> and T<sub>4</sub>) of organic manures as compared to sole application of inorganic fertilizer (T<sub>2</sub>) might be due to microbial demand of available nitrogen in the sole organic treatments. The lower content in untreated plots is a result of mining of available nitrogen with continuous cropping without fertilization during the crop period. These results are in line with the findings of Gupta *et al.* (2019a&b) [31, 32], who also observed that available nitrogen content in soil increased with the use of recommended dose of fertilizer in combination with manure.

### Soil available phosphorus

The soil available phosphorus content in all treatments (T<sub>2</sub> to T<sub>8</sub>) was statistically significant over T<sub>1</sub> (control) as presented in Table 3. The highest soil available phosphorus was recorded in T<sub>7</sub> (50% RDF + 50% N through VC) with 28.16 kg/ha which was followed by T<sub>5</sub> (50% RDF + 50% N through FYM) with 27.09 kg/ha. In general, application of manures (T<sub>3</sub> and T<sub>4</sub>), inorganic fertilizers (T<sub>2</sub>) and combined (T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>) application improved the soil available phosphorus status of soil as compared to control treatment. The per cent increase in T<sub>7</sub> over T<sub>2</sub> (100% RDF) in soil available phosphorus was 5.42 per cent. Whereas, increase in T<sub>2</sub> over T<sub>1</sub> for soil available phosphorus was observed to be 64.36 per cent. Among the sole treatment of organic and inorganic, inorganic treatment showed higher soil available phosphorus. However, the degree of response was of lower order as compared to sole inorganic treatment. The treatment T<sub>7</sub> and T<sub>5</sub> with vermicompost were found superior as compared to T<sub>8</sub> (25% RDF + 75% N through FYM) and T<sub>6</sub> (50% RDF + 50% N through FYM) with farm yard manure, respectively. The higher soil available phosphorus in vermicompost treatments

in both sole and combined treatments might be due to lower C: N: P ratio in vermicompost and higher concentration (1.22% P in vermicompost and 0.24% P in farm yard manure) of as compared to farm yard manure. On the other hand, organic manures on decomposition solubilize insoluble organic P fractions through release of various organic acids, thus resulting into a significant improvement in available phosphorus status of the soil (Sanjay-Swami and Singh, 2019)<sup>[33]</sup>. The lower soil available phosphorus in sole application (T<sub>3</sub> and T<sub>4</sub>) of organic manures as compared to sole application of inorganic fertilizer (T<sub>2</sub>) might be due microbial demand of available phosphorus in the sole organic treatments. The lower content in untreated plots is a result of mining of available phosphorus with continuous cropping without fertilization during the crop period (Gupta *et al.*, 2019a&b)<sup>[34, 35]</sup>.

**Table 3:** Effect of organic and inorganic nutrient sources on soil available macronutrients

Treatments	Available N kg/ha	Available P <sub>2</sub> O <sub>5</sub> kg/ha	Available K <sub>2</sub> O kg/ha
T <sub>1</sub>	181.49	16.25	171.21
T <sub>2</sub>	259.24	26.71	191.38
T <sub>3</sub>	238.34	23.55	175.28
T <sub>4</sub>	246.70	24.91	182.09
T <sub>5</sub>	267.61	27.09	202.95
T <sub>6</sub>	255.06	25.53	181.10
T <sub>7</sub>	275.97	28.16	208.89
T <sub>8</sub>	263.42	27.88	185.36
P <sub>≤0.05</sub>	14.49	1.54	NS
SEM±	43.95	4.62	NS

T<sub>1</sub>- Control; T<sub>2</sub>-100% RDF; T<sub>3</sub>-100% N through FYM; T<sub>4</sub>-100% N through VC; T<sub>5</sub>- 50% RDF + 50% N through FYM; T<sub>6</sub>- 25% RDF + 75% N through FYM; T<sub>7</sub>- 50% RDF + 50% N through VC; T<sub>8</sub>- 25% RDF + 75% N through VC

\*Recommended doses of fertilizers (RDF) = 120:60:60: N:P:K (kg/ha)

### Soil available potassium

The soil available potassium content in all treatments (T<sub>1</sub> to T<sub>8</sub>) was statistically non-significant as presented in Table 3. The highest soil available potassium was recorded in T<sub>7</sub> (50% RDF + 50% N through VC) with 208.89 kg/ha which was followed by T<sub>5</sub> (50% RDF + 50% FYM) with 202.95 kg/ha. In general, application of manures, inorganic fertilizers and combined application improved the soil available potassium status of soil as compared to control treatment. The per cent increase in T<sub>7</sub> over T<sub>2</sub> (100% RDF) in soil available potassium was 9.14 per cent. Whereas, T<sub>2</sub> increase over T<sub>1</sub> in soil available potassium was 11.78 per cent. Among the sole treatment of organic and inorganic, inorganic treatment (T<sub>2</sub>) showed higher soil available potassium. However, the degree of response was of lower order as compared to sole inorganic treatment. The treatment T<sub>7</sub> and T<sub>5</sub> with vermicompost were found superior as compared to T<sub>8</sub> (25% RDF + 75% N through FYM) and T<sub>6</sub> (50% RDF + 50% N through FYM) with farm yard manure, respectively.

The higher soil available potassium in vermicompost treatments in both sole and combined treatments might be due to lower C: N: P: K ratio in vermicompost and higher concentration (1.53 % K in vermicompost and 0.34% K in farm yard manure) as compared to farm yard manure. Application of organic manure may have caused reduction in potassium fixation and consequently increased potassium content due to interaction of organic matter with clay besides the direct addition to the available K pools of soil (Ururkar

*et al.*, 2010)<sup>[36]</sup>. Such increase in the content of available potassium with the integrated use of organics and chemical fertilizers has also been reported by Kumar and Singh (2010)<sup>[37]</sup> and Gupta *et al.*, (2019a&b)<sup>[38, 39]</sup>.

### DTPA extractable micronutrients

The amount of available Fe, Mn, Cu and Zn (4.71, 43.73, 34.97 and 91.33 mg/kg respectively) was maximum with T<sub>3</sub> (100% N through FYM) treatment which was slightly followed by T<sub>4</sub> (100% N through VC) as presented in Table 4. The effect of organic and inorganic sources on DTPA extractable Fe and Mn was found to be statistically non-significant while on DTPA extractable Cu and Zn, statistically significant higher in all organic source treatments (T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub>) over sole inorganic application (T<sub>2</sub>) and control (T<sub>1</sub>) were recorded. The per cent increase in T<sub>3</sub> over T<sub>2</sub> (100% RDF) was in Fe 10.30, Mn 21.23, Zn 74.39 and Cu 91.40 percent, respectively.

**Table 4:** Effect of organic and inorganic nutrient sources on DTPA extractable micronutrients (mg/kg)

Treatments	Iron	Manganese	Zinc	Copper
T <sub>1</sub>	4.15	33.48	45.37	14.68
T <sub>2</sub>	4.27	36.07	52.37	18.27
T <sub>3</sub>	4.71	43.73	91.33	34.97
T <sub>4</sub>	4.64	42.04	86.65	31.31
T <sub>5</sub>	4.45	40.24	67.31	27.26
T <sub>6</sub>	4.40	41.31	70.37	29.55
T <sub>7</sub>	4.38	37.45	58.15	24.55
T <sub>8</sub>	4.40	39.69	64.89	27.33
P <sub>≤0.05</sub>	NS	NS	3.99	1.65
SEM±	NS	NS	12.09	4.99

T<sub>1</sub>- Control; T<sub>2</sub>-100% RDF; T<sub>3</sub>-100% N through FYM; T<sub>4</sub>-100% N through VC; T<sub>5</sub>- 50% RDF + 50% N through FYM; T<sub>6</sub>- 25% RDF + 75% N through FYM; T<sub>7</sub>- 50% RDF + 50% N through VC; T<sub>8</sub>- 25% RDF + 75% N through VC

\*Recommended doses of fertilizers (RDF) = 120:60:60: N:P:K (kg/ha)

Among the combined treatments of organic and inorganic, the plot receiving farm yard manure showed higher concentration of soil available Fe and Mn due to addition of organic manure in a larger quantity as compared to vermicompost. Higher availability of Fe and Mn in organic manure treated plots may be due to mineralization of organically bound forms of Fe and Mn in the organic manure and formation of organic chelates of higher stability which decreased their susceptibility to adsorption, fixation and precipitation resulting in their enhanced availability in soil (Kher, 1993)<sup>[40]</sup>. Organic sources *viz.* FYM and vermicompost which might have also contributed to its enhanced availability in soil. Behera and Singh (2009)<sup>[41]</sup> found that the addition of organic matter to soil encouraged micro-organisms, which under certain conditions aided in the liberation of trace elements. Build-up of copper and zinc and was observed with the application of organic sources especially FYM and vermicompost which may be due to the fact that Cu and Zn forms Cu-humus complex and Zn-humus of relatively high stability with humus that decrease its susceptibility to fixation or precipitation in soil and increases its availability. These results were also found in consonance with Kumar *et al.* (2010)<sup>[42]</sup>.

### Conclusion

The present investigation demonstrated that application of 50 per cent nitrogen through vermicompost along with 50 per

cent of the recommended dose of fertilizers (T<sub>7</sub>) is the most effective combination for increasing yield of cabbage, improving quality, and soil health as compared to sole application of organic manure or inorganic fertilizers indicating the best suitable option for production of quality cabbage in acid Inceptisol of Meghalaya.

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