*Original Research Article*

# Evaluation of different approaches of fertilizer recommendation using soluble and conventional fertilizers on Cabbage (*Brassica oleraceae* var. *capitata*) yield, nutrient requirement and economics


## ABSTRACT

A field experiment was conducted at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru, Karnataka to study the influence of different approaches of fertilizer application using soluble and conventional fertilizers on yield, nutrient requirement and economics of cabbage under drip fertigation. The results revealed that significant higher marketable cabbage yield of 62.55 t $ha^{-1}$ was recorded in LMH approach followed by STCR inorganic approach (62.03 t $ha^{-1}$) using soluble fertilizers and STCR integrated plant nutrition approach (61.31 t $ha^{-1}$) using soluble fertilizers. Similarly higher nutrient uptake (N, $P_2O_5$ and $K_2O$ kg $ha^{-1}$) was recorded in LMH approach followed by STCR inorganic approach using soluble fertilizers and STCR integrated plant nutrition approach using soluble fertilizers. However, nutrient requirement (NR) of N, $P_2O_5$ and $K_2O$ was highest in absolute control followed by LMH approach. Value cost ratio (VCR) worked out was found to be higher (13.37) in STCR inorganic approach using conventional fertilizers followed by STCR integrated approach using conventional fertilizers.



**Keywords:** STCR yield target; cabbage; soluble fertilizers; nutrient requirement; value-cost ratio;


## INTRODUCTION

Evaluation of soil fertility status helps the farming community to use fertilizer nutrients according to the nutrient demand of the crop. Therefore, soil testing is considered as a procedure for the recommendation of doses and kind of fertilizer nutrients for different crops. Usually the available nutrient status of soil *i.e.* low, medium and high was considered in making the basis for fertilizer nutrient recommendations for different crops. Among the various methods of fertilizer recommendations the soil test crop response (STCR)- targeted yield approach is unique in the sense that this method not only indicates the soil test-based fertilizer dose but also the level of yield the farmer can hope to achieve if good agronomic practices are adopted in crop cultivation. However soil testing would become a useful tool when it is based on intimate knowledge of soil-crop-variety-fertilizer-climate and management practices interaction for a given situation (Kanwar 1971).

Cabbage (*Brassica oleracea* var. *capitata*) is an important cole crop belongs to the family Brassicaceae. It is well recognized for its nutritive value and health benefits. It is used against ailments like gout, diarrhea, stomach and coeliac troubles. Cabbage has anti-cancer property, it protects against several cancers, especially lung, colon, breast, ovarian, bladder, bowel cancer due to the presence of indole-3-carbinol (FAO, 2000).

Water is the scarce input that can severely limit the agricultural production unless it is carefully conserved and managed. Therefore, the adoption of modern irrigation techniques is needed to be emphasized to increase water use efficiency and covering more area under cultivation. Fertigation through drip irrigation is the most effective and efficient way of supplying nutrients through water to crop plants and not only conserve the water but also boost the yield of vegetables by achieving higher nutrient use efficiency. Water-soluble fertilizers are fertilizer nutrients with different grades of NPK fertilizers that are completely water-soluble and characterized by high purity, no inert matter, low salt index and higher nutrient use efficiency that ultimately improve yield and quality of the crop.

Soil test based fertilizer nutrient recommendation is based on the hypothesis that an increasing or decreasing the available nutrient in the soil will directly influence crop yield. The targeted yield concept was primarily based on the quantitative idea of the need for fertilizers in line with crop yield and nutritional requirements, the percentage of the soil nutrient available and the fertilizer applied (Ramamoorthy *et al.,* 1967). Soil test crop response (STCR) targeted yield approach is one of the site-specific nutrient application strategy. Since fertilizer is a costly input the scientific and efficient utilization of this input is the call of the day. In this input utilization STCR approach of fertilizer nutrient application plays a vital role as a comprehensive approach of fertilizer utilization wherein fertilizer nutrient is applied based on yield target, site specification, crop specification and soil test values. However there is a need to evaluate the STCR-targeted yield approach in comparison with the other approaches for yield variation, nutrient uptake, nutrient requirement and economics so that its validity can be further scrutinized.

## MATERIALS AND METHODS

A field experiment was conducted to evaluate the different approaches of fertilizer application during *Kharif* season of 2018-19 at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka. The experimental site belonging to Vijayapura series was classified as *Kandic Paleustalf* and was sandy clay loam in texture with acidic pH (5.78) and electrical conductivity of 0.085 dS $m^{-1}$. The Initial soil organic carbon was low (4.50 g $kg^{-1}$), available nitrogen was low (266.16 kg $ha^{-1}$), available Bray's phosphorus ($P_2O_5$) was medium (56.93 kg $ha^{-1}$) and ammonium acetate extractable potassium ($K_2O$) was low (117.90 kg $ha^{-1}$). In this experiment, different fertilizer recommendation approaches including water-soluble fertilizers and conventional fertilizers were compared to assess the response of cabbage crop to various approaches of fertilizer recommendation including the STCR targeted yield equation developed at the same centre for cabbage crop under fertigation. The experiment was laid out in randomized complete block design (RCBD) having seven treatments and replicated thrice. The treatments combinations consists of STCR approach of fertilizer recommendations for targeted cabbage yield of 33 t $ha^{-1}$ through inorganics like only soluble fertilizers (Calcium nitrate, Mono potassium phosphate and Mono ammonium phosphate and Sulphate of potash), only conventional fertilizers (Urea, Single super phosphate and Muriate of potash) and through integrated approach like soluble fertilizers along with sheep manure at the rate of 25 t $ha^{-1}$, and conventional fertilizer along with sheep manure at the rate of 25 t $ha^{-1}$. Other treatment combinations include general blanket recommended dose as per standard package of practices, LMH (Low-Medium-High) approach, commonly used in soil testing laboratories and absolute control (Table 1).

**Table 1: Treatments details used in the experiment**

| | | |
|---|---|---|
| $T_1$ | : | STCR approach at 33 t $ha^{-1}$ through soluble fertilizers (Inorganics). |
| $T_2$ | : | STCR approach at 33 t $ha^{-1}$ through soluble fertilizers and sheep manure (Integrated). |
| $T_3$ | : | STCR approach at 33 t $ha^{-1}$ through conventional fertilizers (Inorganics). |
| $T_4$ | : | STCR approach at 33 t $ha^{-1}$ through conventional fertilizers and sheep manure (Integrated). |
| $T_5$ | : | Package of practices (Recommended dose of fertilizers) |
| $T_6$ | : | LMH (Soil Testing Laboratory method) |
| $T_7$ | : | Absolute control |

The following STCR fertilizer adjustment equation developed by AICRP on STCR, UAS, Bengaluru centre during 2017-18 under fertigation for Zone-5 was used for STCR treatments.

| **STCR- Inorganics (NPK alone) equation** | **STCR- IPNS (Integrated plant nutrient supply) equation** |
|---|---|
| FN = 4.4750 T - 0.1342 STV ($KMnO_4$ – N) | FN = 4.1600 T - 0.1209 STV ($KMnO_4$ – N) - 0.858 OM |
| $FP_2O_5$ = 3.5822 T - 0.1954 (Bray's - $P_2O_5$) | $FP_2O_5$ = 2.6736 T - 0.1248 (Bray's - $P_2O_5$) - 0.256 OM |
| $FK_2O$ = 3.8005 T - 0.1140 (Am. Acetate - $K_2O$) | $FK_2O$ = 4.3324 T - 0.1119 (Am. Acetate - $K_2O$) - 0.870 OM |

Where, FN, $FP_2O_5$ and $FK_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$ respectively; T is the yield target in t $ha^{-1}$; SN, SP and SK are available soil nutrients as $KMnO_4$-N, Bray's-$P_2O_5$ and $NH_4OAc$-$K_2O$ in kg $ha^{-1}$ respectively and OM is amount of sheep manure (organic manure) added in t $ha^{-1}$.

Using this fertilizer adjustment equation the quantity of fertilizer nutrients required with or without FYM for achieving the target of 33 t $ha^{-1}$ cabbage yield worked out. The quantity of fertilizer nutrients (NPK) applied for each treatment is mentioned in Table 2.

**Table 2**: Details of initial soil test values and nutrients applied to cabbage through different approaches of fertilizer recommendation as per the treatments

| **Treatments** | **Initial soil test values (kg $ha^{-1}$)** | | | **Sheep manure applied (t $ha^{-1}$)** | **Fertilizer nutrient applied (kg $ha^{-1}$)** | | |
|---|---|---|---|---|---|---|---|
| | **N** | **$P_2O_5$** | **$K_2O$** | | **N** | **$P_2O_5$** | **$K_2O$** |
| **$T_1$** | 260.81 | 55.01 | 122.00 | 0 | 112 | 108 | 112 |
| **$T_2$** | 270.84 | 45.22 | 126.50 | 25 | 59 | 77 | 104 |
| **$T_3$** | 261.34 | 60.57 | 132.40 | 0 | 113 | 106 | 113 |
| **$T_4$** | 270.35 | 69.97 | 121.75 | 25 | 59 | 74 | 109 |
| **$T_5$** | 254.24 | 58.45 | 111.80 | 25 | 150 | 100 | 125 |
| **$T_6$** | 275.60 | 54.08 | 116.60 | 25 | 167 | 100 | 163 |
| **$T_7$** | 269.50 | 55.22 | 94.20 | 0 | 0 | 0 | 0 |

Twenty-two days old cabbage seedlings were transplanted to the experimental plots at a spacing of 45 cm X 30 cm. Conventional fertilizers as per the specific, treatments ($T_3$, $T_4$, $T_5$ and $T_6$) were applied on the day of transplanting. Nitrogen was applied as urea (50% as basal dose), phosphorus as single super phosphate (100% dose) and potassium as muriate of potash (100 % dose) before transplanting cabbage and after 30 days top dressing was done with remaining 50 percent of N dose. Soluble fertilizers for the specific treatments ($T_1$ and $T_2$) were applied through fertigation at 30 percent of recommended fertilizer doses as basal dose and remaining 70 percent dose as 10 percent at each time at 8 days interval. The head yield per plot was computed based on net plot area occupied by cabbage crop and was converted into head yield in tons per hectare. At harvest random cabbage heads as per treatments were collected, dried, powdered and used for analysing the concentration of NPK by adopting the standard procedures outlined by Jackson (1973). Soil samples collected from the experimental plots after crop harvest were processed and analysed for available nitrogen, phosphorus and potassium by following standard procedures (Jackson 1973). After analysing the major nutrient concentrations in cabbage samples, uptake of these nutrients by cabbage, nutrient requirement (NR), response yard stick (RYS) and value-cost ratio (VCR) were computed by using the standard formulae shown below:

$$\text{Nutrient requirement (NR) (kg t}^{-1}) = \frac{\text{Total uptake of NPK(kg ha}^{-1}\text{) by cabbage}}{\text{Head yield of cabbage (t ha}^{-1})}$$

$$\text{Response yard stick (kg kg}^{-1}) = \frac{\text{Yield response}^{*}\text{ (kg ha}^{-1})}{\text{Total fertilizer applied (kg N, }P_2O_5\text{ and }K_2O\text{ ha}^{-1})}$$

*Yield response = Treated yield (kg $ha^{-1}$) - control yield (kg $ha^{-1}$).

$$\text{VCR (value cost ratio)} = \frac{\text{Cost of Head yield above the control yield}}{\text{Cost of fertilizer and sheep manure added}}$$

The data collected with respect to yield, nutrient uptake and available nutrient status were subjected to statistical analysis. The level of significance used in F and t-test was P= 0.05. Critical difference (CD) values were calculated for P= 0.05 whenever F-test was found significant.

## RESULTS AND DISCUSSION

**Cabbage yield:** Significantly higher marketable cabbage yield was recorded in $T_6$ (62.55 t $ha^{-1}$) which received the nutrient dose as per LMH approach (167:100:163 kg NPK $ha^{-1}$ along with sheep manure at 25 t $ha^{-1}$) through soil testing laboratory method followed by STCR inorganic approach ($T_1$) through soluble fertilizers (62.03 t $ha^{-1}$). However, it was found to be on par with all the STCR target of 33 t $ha^{-1}$ treatments (both soluble and conventional fertilizer application through inorganic and integrated approach) including fertilizer nutrient application through package of practices ($T_5$) except absolute control ($T_7$) where no fertilizers or sheep manure was added. Increased fertilizer nutrient application along with 25 t $ha^{-1}$ of sheep manure results in increased nutrient availability at the vicinity of root surface of cabbage, which leads to increased uptake of all the essential plant nutrients. All these favourable conditions might have resulted in greater translocation and accumulation of carbohydrates and protein in cabbage. Ultimately resulted in improved yield parameters and yield of cabbage in LMH approach followed by STCR inorganic and integrated approach using soluble fertilizer for the target yield of 33 t $ha^{-1}$. These results are in close agreement with those of Verma and Maurya (2013) and Harpal *et al.* (2018) in cabbage crop. They reported that increased application of NPK fertilizers along with FYM enhances the availability of essential macronutrients in soils, which resulted in increased nutrient uptake and finally improves the yield of cabbage.

## Post harvest soil nutrient status

Available nitrogen content in soil after harvest of cabbage crop varied considerably among the different treatments of fertilizer recommendations. Significantly higher (281.83 kg $ha^{-1}$) available nitrogen was recorded in LMH approach ($T_6$) followed by $T_5$ where nutrients were applied as per package of practices as compared to inorganic approach of nutrient application ($T_1$, and $T_3$). Interestingly, it has been found to be on par with treatments of integrated approach of nutrient application ($T_2$, $T_4$ and $T_5$). Significantly, lower soil available nitrogen (259.47 kg $ha^{-1}$) was noticed in absolute control ($T_7$). Soil available nitrogen after harvest of cabbage was improved in all the treatments of fertilizer nutrient application (both integrated and inorganic approach) except in absolute control ($T_7$) where soil available nitrogen was reduced over its initial content (Table 3). Significantly higher available nitrogen in LMH approach after harvest of cabbage was attributed to direct application of increased fertilizer dose of nitrogen (167 kg $ha^{-1}$ of N) coupled with addition of sheep manure contributed to increased available nitrogen through mineralisation process followed by $T_5$ (package of practices) owing to the direct application of 150 kg $ha^{-1}$ of N through fertilizer coupled with contribution of N from sheep manure. In both the STCR integrated approaches using soluble and conventional fertilizers ($T_2$ and $T_4$) the improved available nitrogen after harvest of cabbage crop was mainly due to mineralization of applied sheep manure along with direct addition of inorganic nitrogen fertilizers which contributed to the pool of available nitrogen and also improved water and nutrient holding capacity in integrated approach in contrast with other STCR inorganic treatments ($T_1$ and $T_3$). The decreased in available nitrogen content in absolute control was mainly due to loss of native N through crop removal and leaching of $NO_3^-$-N during rainfall.

**Table 3. Influence of different approaches of fertilizer application on cabbage yield, post-harvest soil nutrient status, nutrient uptake and nutrient requirement**

| Harvests Treatments | Cabbage yield (t $ha^{-1}$) | Post harvest soil nutrient status (kg $ha^{-1}$) | | | Nutrient uptake (kg $ha^{-1}$) | | | Nutrient requirement (kg $t^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ |
| **$T_1$ –** STCR* (Inorganics through soluble fertilizers) | 62.03 | 263.69 | 71.69 | 127.8 | 138.29 | 42.91 | 134.51 | 2.23 | 0.69 | 2.16 |
| **$T_2$ -** STCR (Integrated through soluble fertilizers and SM) | 61.31 | 272.32 | 79.58 | 144.03 | 133.79 | 42.66 | 132.92 | 2.18 | 0.71 | 2.17 |
| **$T_3$ -** STCR (Inorganics through conventional fertilizers) | 59.09 | 267.56 | 67.12 | 138.74 | 105.35 | 31.77 | 103.20 | 1.78 | 0.53 | 1.75 |
| **$T_4$ -** STCR (Integrated through conventional fertilizers and SM) | 58.52 | 276.86 | 83.14 | 140.76 | 121.78 | 34.42 | 111.88 | 2.08 | 0.58 | 1.91 |
| **$T_5$ -** Package of practices | 60.42 | 278.18 | 83.32 | 148.45 | 125.22 | 36.71 | 116.07 | 2.07 | 0.61 | 1.92 |
| **$T_6$ -** LMH (STL) | 62.55 | 281.83 | 84.15 | 162.24 | 145.74 | 50.02 | 134.96 | 2.33 | 0.80 | 2.18 |
| **$T_7$ -** Absolute control | 18.84 | 259.47 | 50.33 | 87.4 | 52.42 | 16.12 | 47.33 | 2.78 | 0.82 | 2.51 |
| **SEm±** | **2.89** | **3.96** | **5.94** | **7.43** | **8.86** | **4.73** | **10.69** | **0.24** | **0.09** | **0.20** |
| **CD @ 5 %** | **8.92** | **12.21** | **18.3** | **22.9** | **27.31** | **14.59** | **32.92** | **NS** | **NS** | **NS** |

**Note:** *STCR (Soil Test Crop Response) targeted yield of cabbage at 33 t $ha^{-1}$, SM: Sheep manure, LMH: Low, Medium, High. STL: Soil testing laboratory method

Due to different nutrient recommendation approaches, the phosphorus content of post-harvest soil was significantly different (Table 3). Significantly higher available phosphorus content in soil (84.15 kg $ha^{-1}$) was observed in $T_6$ (LMH approach) followed by $T_5$ (package of practices). However, it was found to be on par with all the treatments of fertilizer nutrient recommendations excluding absolute control ($T_7$), which has significantly lower available phosphorus content (50.33 kg $ha^{-1}$) in soil. There was improvement in available phosphorus content after harvest of cabbage in all the treatments of various fertilizer nutrient recommendations except absolute control where there was decrease over its initial content. The significantly higher available phosphorus in LMH approach ($T_6$) followed by $T_5$ (package of practices) might be due to application of higher dose of phosphatic fertilizers (100 kg $P_2O_5$ $ha^{-1}$) and sheep manure at 25 t $ha^{-1}$ that have led to the build-up of phosphorus in soil through mineralization process and direct application of phosphatic fertilizers. The decreased available phosphorus was recorded in absolute control (no fertilizers or sheep manure was applied) after harvest of cabbage was due to crop removal.

These results are in accordance with findings of Ashwini (2007) who reported that the increased available P in the soil after harvest of finger millet crop due to application of FYM along with chemical fertilizers. Similarly, Basavaraja *et al.* (2017) revealed the higher available phosphorus in STCR- IPNS approach due to acidulation of soil by the applied organic matter which helped in solubilizing the fixed P thereby enhanced the available P. Application of nutrient doses as per LMH approach ($T_6$) recorded significantly higher available potassium content in soil after harvest of cabbage followed by $T_5$ (package of practices) and STCR integrated approach through conventional fertilizer ($T_4$) as compared to STCR inorganic approach including both soluble and conventional fertilizers ($T_1$ and $T_3$). However, it was found to be statistically on par with all the treatments of integrated approach of nutrient recommendations ($T_2$, $T_4$ and $T_5$). In all the treatments of different fertilizer nutrient recommendations there was an improvement in the available potassium content after harvest of cabbage except in absolute control ($T_7$) where there was a reduction over its initial content (Table 3).

Significantly higher available potassium in soil after harvest of cabbage crop in LMH approach ($T_6$) followed by package of practices ($T_5$) was attributed to application of higher doses of potassium (163 kg $K_2O$ $ha^{-1}$ in $T_6$ and 125 kg $K_2O$ $ha^{-1}$ in $T_5$) through conventional fertilizers along with 25 t $ha^{-1}$ of sheep manure, whereas in STCR integrated approaches of nutrient recommendations through soluble and conventional fertilizers ($T_2$ and $T_4$) increased available potassium after harvest of cabbage was due to direct contributed to the pool of available potassium in soil through direct application of potassium fertilizers through soluble fertilizers and mineralisation of sheep manure. Many studies conducted in different parts of India reported the buildup of available potassium due to application of farmyard manure in combination with inorganic fertilizers. (Apoorva, 2008). Higher K availability in soil might be due to additive effect of organic manures along with inorganic fertilizers, which increased exchangeable K by reducing K fixation, leading to increased available K (Ramachandrappa *et al.*, 2014).

Significantly higher nitrogen uptake (145.74 kg $ha^{-1}$) was recorded in LMH approach ($T_6$) followed by STCR target of 33 t $ha^{-1}$ through inorganic approach using soluble fertilizers ($T_1$) as compared to STCR target of 33 t $ha^{-1}$ through inorganic approach using conventional fertilizers ($T_3$) and $T_7$ (absolute control). However, it was on par with all the treatments except $T_3$ and $T_7$. Significantly, lower uptake of nitrogen (52.42 kg $ha^{-1}$) was recorded in absolute control ($T_7$). Due to different nutrient recommendation approaches, the phosphorus uptake by cabbage crop was significantly differed among the treatments (Table 3). Significantly higher phosphorus uptake (50.02 kg $ha^{-1}$) was recorded in $T_6$ (LMH approach) followed by $T_1$ (STCR target of 33 t $ha^{-1}$ through inorganic approach using soluble fertilizers) (42.91. kg $ha^{-1}$) as compared to STCR target of 33 t $ha^{-1}$ through inorganic approach using conventional fertilizers ($T_3$), STCR target of 33 t $ha^{-1}$ through integrated approach using conventional fertilizers ($T_4$) and $T_7$ (absolute control). Significantly, lower uptake of phosphorus (16.12 kg $ha^{-1}$) was noticed in absolute control ($T_7$). Statistically significant difference was observed with respect to potassium uptake by cabbage crop as influenced by different fertilizer nutrient recommendation approaches (Table 3). Significantly higher potassium uptake (134.96. kg $ha^{-1}$) was recorded in $T_1$ (STCR target of 33 t $ha^{-1}$ through inorganic approach using soluble fertilizers) followed by $T_6$ (LMH approach). However, it was found to be on par with all the treatments of various fertilizer recommendation approaches except absolute control ($T_7$) where no fertilizers or sheep manure was applied, which recorded significantly lower uptake of potassium (47.33 kg $ha^{-1}$).

## Nutrient requirement of Cabbage

The results of the present study shows that nutrient requirement (NR) of nitrogen was highest (2.78 kg $t^{-1}$) in Absolute control ($T_7$) followed by LMH approach (2.33 kg $t^{-1}$) and lowest nutrient requirement of nitrogen was recoded in STCR targeted yield of 33 t $ha^{-1}$ through inorganics using conventional fertilizers ($T_3$). Highest nutrient requirement of phosphorus (0.82 kg $t^{-1}$) was recorded in Absolute control ($T_7$) followed by LMH approach (0.80 kg $P_2O_5$ $t^{-1}$) and lowest nutrient requirement of phosphorus was recoded in STCR targeted yield of 33 t $ha^{-1}$ through inorganics using conventional fertilizers ($T_3$). The nutrient requirement of potassium was found to be highest in (2.51 kg $t^{-1}$) in Absolute control ($T_7$) followed by STCR targeted yield of 33 t $ha^{-1}$ through inorganics using soluble fertilizers ($T_1$) and lowest potassium requirement (1.75 kg $t^{-1}$) of cabbage was recorded in STCR targeted yield of 33 t $ha^{-1}$ through inorganics using conventional fertilizers ($T_3$).

**Table 4: Cabbage crop response, response yard stick and value cost ratio of cabbage crop production as influenced by various approaches of fertilizer nutrient application**

| Treatment details | Cabbage yield (t $ha^{-1}$) | Yield response (t $ha^{-1}$) | RYS (kg $kg^{-1}$) | VCR |
|---|---|---|---|---|
| **$T_1$ –** STCR* (Inorganics through soluble fertilizers) | 62.03 | 43.19 | 130.48 | 1.69 |
| **$T_2$ -** STCR (Integrated through soluble fertilizers and SM) | 61.31 | 42.47 | 176.76 | 1.91 |
| **$T_3$ -** STCR (Inorganics through conventional fertilizers) | 59.09 | 40.25 | 121.32 | 13.37 |
| **$T_4$ -** STCR (Integrated through conventional fertilizers and SM) | 58.52 | 39.68 | 164.47 | 5.24 |
| **$T_5$ -** Package of practices | 60.42 | 41.58 | 110.89 | 5.09 |
| **$T_6$ -** LMH (STL) | 62.55 | 43.71 | 102.37 | 5.13 |
| **$T_7$ -** Absolute control | 18.84 | - | - | - |

**Note**: *STCR (Soil Test Crop Response) targeted yield of cabbage at 33 t $ha^{-1}$, SM: Sheep manure, LMH: Low, Medium and High, STL: Soil testing laboratory method, RYS: Response yard stick, VCR: Value cost ratio

**Cabbage yield response**

The yield response indicates the additional yield obtained over control plot due to fertilizer nutrients application through different approaches. The highest yield response of 43.71 t $ha^{-1}$ was noticed where NPK fertilizers along with sheep manure was applied as per LMH approach followed by 43.19 t $ha^{-1}$ in targeted yield of 33 t $ha^{-1}$ through inorganics using soluble fertilizers ($T_1$). However, the lower yield response of 39.68 t $ha^{-1}$ was recorded in STCR target of 33 t $ha^{-1}$ through integrated approach using conventional fertilizers ($T_4$).

**Response yard stick (RYS)**

Response yardstick indicates how efficiently the crop to get maximum economic produce utilizes the applied fertilizer nutrients in total. Yield obtained in kg per kg of NPK applied in that particular ratio of each treatment. The higher response yard stick (176.76 kg $kg^{-1}$) was noticed in STCR target yield of 33t $ha^{-1}$ through integrated approach using soluble fertilizers ($T_2$) followed by targeted yield of 33 t $ha^{-1}$ through integrated approach (164.47 kg $kg^{-1}$) using conventional fertilizers ($T_4$). The lower RYS (102.37 kg $kg^{-1}$) was recorded in LMH approach ($T_6$).

**Value cost ratio (VCR)**

The higher value cost ratio (VCR) of 13.37 was recorded where fertilizer nutrients were applied through STCR inorganic approach for a yield target of 33 t $ha^{-1}$ using conventional fertilizers ($T_3$) followed by 5.24 in STCR target of 33 t $ha^{-1}$ through integrated approach using conventional fertilizers ($T_4$). The lower value cost ratio of 1.69 was recorded in STCR inorganic approach for a yield target of 33 t $ha^{-1}$ using soluble fertilizers ($T_1$).

The higher yield response obtained in LMH approach followed by STCR inorganic approach through soluble fertilizers as compared to other approaches of fertilizer recommendations was due to higher cabbage yield obtained in these approaches (Table 4). However, response yard stick (RYS) worked out was found to be higher in STCR target of 33 t $ha^{-1}$ with integrated approach using soluble fertilizers (176.76 kg $kg^{-1}$) followed by STCR target of 33 t $ha^{-1}$ with integrated approach (164.47 kg $kg^{-1}$) using conventional fertilizers.

Higher RYS in STCR target of 33 t $ha^{-1}$ with integrated approach using both soluble and conventional fertilizers indicated that the NPK fertilizer nutrients were applied in a balanced way in right proportion and in right place as per the crop need without any nutrient losses through excessive usage and was effectively utilized by the crop to achieve the yield target as compared to other treatments. The results of this study are in accordance with Basavaraja *et al.* (2017) who reported that application of NPK fertilizers were efficiently utilized by the crop under STCR approach compared to other approaches in maize crop due to balanced and precise dose of NPK fertilizer application based on soil test and yield targets.

Value cost ratio (VCR) worked out was found to be higher (13.37) in STCR target of 33 t $ha^{-1}$ through inorganic approach using conventional fertilizers ($T_3$) followed by STCR target of 33 t $ha^{-1}$ through integrated approach using conventional fertilizers ($T_4$). This higher VCR in these treatments was mainly associated with lower levels of NPK fertilizer application (conventional fertilizers) and no sheep manure application resulted in higher yields. Even though higher yields were recorded in STCR integrated and inorganic approaches, using soluble fertilizers the VCR was lower mainly due to high cost of soluble fertilizers and sheep manure. These results are in accordance with Basavaraja *et al*. (2017) in finger millet crop, who reported higher VCR in STCR inorganic approach over integrated approach due to high cost of FYM. Government of India provided subsidy for conventional fertilizers (Urea, SSP and MOP) whereas soluble fertilizers did not receive any subsidy from government despite of its higher nutrient use efficiency. It is one of the reason for high VCR in conventional fertilizers applied plots under inorganic and integrated approach as compared to STCR soluble fertilizer treatments under inorganic and integrated approach.

## SUMMARY

The fertilizer recommendations based on STCR approach for specific targeted yield of cabbage through fertigation using soluble fertilizers under integrated approach provides balanced way of supplying water and nutrients without any excessive or under usage of fertilizer nutrients without compromising on yield. Hence, this approach can be used successfully to maintain soil sustainability and achieving higher productivity.



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