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# INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, QUALITY AND SOIL STATUS UNDER *KHARIF* SESAME (*SESAMUM INDICUM* L.)- CHICKPEA (*CICER ARIETINUM* L.) CROP SEQUENCE UNDER MIDDLE GUJARAT CONDITION

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**ABSTRACT**

Field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, A.A.U., Anand during *kharif* and *rabi* seasons of 2012-13 and 2013-14 to study the Integrated nutrient management in *kharif* sesame (*Sesamum indicum* L.) and its residual effect on succeeding chickpea (*Cicer arietinum* L.) under middle Gujarat condition. Application of 50% RDN from inorganic fertilizer + 50% RDN from vermicompost to sesame recorded significantly higher seed yield (503 kg $ha^{-1}$), stover yield (1192 kg $ha^{-1}$), harvest index (30.16 %) and oil yield (242 kg $ha^{-1}$). Integrated nutrient management treatments recorded significantly higher organic carbon, available S, available N and available $P_2O_5$ in the soil after harvest of the sesame crop. Application of 20 kg S $ha^{-1}$ recorded significantly higher seed yield of sesame (493 kg $ha^{-1}$) in pooled analysis. The significantly higher values of organic carbon and available S content in the soil were recorded under 40 kg S $ha^{-1}$, however, the significantly higher value of available N and available $P_2O_5$ in the soil were recorded under 20 kg S $ha^{-1}$. The effect of 50% RDN from vermicompost + 50% RDN from castor cake gave significantly maximum seed yield (1881 kg $ha^{-1}$) and haulm yield (5667 kg $ha^{-1}$) and The effect of 20 kg S $ha^{-1}$ gave significantly higher seed yield (1726 kg $ha^{-1}$) and the highest haulm yield (5237 kg $ha^{-1}$) of succeeding chickpea in the pooled analysis, respectively.

## INTRODUCTION

The country has now been achieving self-sufficiency in cereal food production but vegetable oil is also necessary in suitable proportion as this has been proved to be indispensable for maintaining balanced human nutrition. The oil seed crop like sesame is also face the same problem in Gujarat because of its low productivity due to its cultivation in marginal land and no fertilizer is applied to the oilseed crops. This situation calls for a reorientation in our agricultural strategy to achieve a rapid breakthrough in the productivity of oil seeds specially sesame, on an enduring basis. In India, sesame occupies about 17.50 lakh hectares area with annual production of 6.13 lakh tones having an average productivity of 350 kg $ha^{-1}$ (Anonymous, 2014). Sesame is cultivated on a large area in states of Maharashtra, Uttar Pradesh, Rajasthan, Orissa, Andhra Pradesh, Tamil Nadu, West Bengal, Gujarat and Karnataka. In Gujarat, it occupies an area of about 73,608 hectares with an annual production of 27,511 tones.

Sesame-Chickpea is one of the most prevalent cropping sequences followed in Middle Gujarat. Integrated nutrient management give the valuable information about the effect of chemical fertilizer alone and in combination with organic manure on the soil fertility and crop productivity under intensive cropping. Integration of inorganic with organic manures will not only sustain the crop production, but also will be effective in improving soil health and enhancing the nutrient use efficiency. Integrated use of organic manure and chemical fertilizers in sesame helps maintaining stability in crop production, besides improving soil physical conditions (verma *et al.*, 2012). Higher yield of sesame can be obtained by integrated use of fertilizer along with FYM, vermicompost and Azospirillium (purushottam, 2005 and Jaishankar and wahab, 2005). Interaction of nitrogen and vermicompost showed the highest seed yield (kg $ha^{-1}$) and oil per cent was obtained with applying the 10 tone $ha^{-1}$ vermicompost with 37.5 kg $ha^{-1}$ of nitrogen rate. (Sajadinik *et al.* 2011). Integrated use of 50% RDF + 50% N through FYM or vermicompost + *Azospirillum* recorded 12.2, 20 and 15.6 % higher yield over 100 % RDF respec-tively (Ghose *et al.*, 2013). Application of higher doses of inorganic nutrients along with neematex (1 tone $ha^{-1}$) increased the various growth, yield and quality parameters along with soil nutrient status (Nayek *et al.*, 2014). Application of 75 % RDF + 5 t FYM ha-1 + Bio-fertilizer registered higher number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, test weight, seed yield and stover yield as compared to rest of the treatments (Lakhran *et al.*, 2015).

Irrespective of the crops, sulphur is now rightly called as the fourth essential plant nutrient after N, P and K, but for oilseed crops, it is as important as phosphorus. Presently, its importance is recognized due to its wide spread deficiency in the soil. The beneficial role of sulphur in increasing crop production, particularly in the oilseeds and pulse crops has been reported by several research workers. About 37 per cent soils of the Gujarat are found sulphur deficient. The soils of middle Gujarat are light in texture and mostly in medium and deficient range in S availability; which resulted in the reduction in yield and quality of the sesame crop. Sulphur is a constituent of three amino acids commonly found in plants viz., cystine, cystenine and methionines, which are essential components of proteins. Number of branches plant$^{-1}$, seeds capsule$^{-1}$ and seed yield increased significantly up to 20 kg S ha$^{-1}$, whereas oil content increased significantly up to 40 kg S ha$^{-1}$ (Chaudhary and Patel, 2007). The result indicated that the number of seeds capsule$^{-1}$, test weight and seed yield increased significantly with successive increase in the levels of sulphur from 10 to 30 kg ha$^{-1}$ (Patel *et al*., 2009). Application of sulphur @ 40 kg ha$^{-1}$ registered higher plant height, seed yield and stover yield as compared to rest of the treatments (Bhosale *et al*., 2011). Application of sulphur @ 30 kg ha$^{-1}$ along with the recommended dose of N, P and K resulted in better seed yield and other yield attributes such as number of capsules plant$^{-1}$, thousand seed weight (Mathew *et al*., 2011). Application of sulphur @ 45 kg ha$^{-1}$ significantly improved the yield and related traits of sesame like number of capsules plant$^{-1}$, 1000-seed weight, biological and seed yields (Shah *et al*., 2013). Results showed that application of sulphur @ 40 kg ha$^{-1}$ significantly enhanced the growth and yield attributing characters as well as yield of sesame (Shelke *et al*., 2014).

Combined application of available organic source along with optimal dose of inorganic fertilizers assure high and sustained productivity in a oil seed-legume cropping system due to regulated nutrient supply and reduced losses, beside lowering costs. The information on the use of organic manures like castor cake, vermicompost and sulphur for sesame crop as well as their effects on sesame-chickpea sequence is scanty. With this background, the present investigation was carried out to find out the optimum combination of organic and inorganic sources of nitrogen in middle Gujarat conditions for economically higher sesame production and their effect on succeeding chickpea and nutrient status of the soil after harvest of sesame.

## MATERIALS AND METHODS

A field experiment was conducted during *kharif* and *rabi* season in 2012-13 and 2013-14 at Anand (situated at 22°-35′ N latitude and 72°-55′ E longitude with an altitude of 45.1 m above the mean sea level). The chemical test values of soil were 7.40 pH, 0.25 dS/m EC, 0.33 % low in organic carbon, low in available nitrogen (N) (195.2 kg ha$^{-1}$), medium in available phosphorus (32.41 kg ha$^{-1}$) and low in available sulphur (8.23 mg kg$^{-1}$). The total rainfall received during the crop growth period was 876 mm in 2012-13 and 1259.6 mm in 2013-14. Fifteen treatment combinations given in *kharif* sesame crop comprised of five nitrogen management treatments *i.e.* $N_1$: 100% RDN from inorganic fertilizer, $N_2$: 50% RDN from inorganic fertilizer + 50% RDN from VC, $N_3$: 50% RDN from inorganic fertilizer + 50% RDN from CC, $N_4$: 25% RDN from inorganic fertilizer + 37.5% RDN from VC + 37.5% RDN from CC and $N_5$: 50% RDN from VC + 50% RDN from CC and three sulphur levels *i.e.* $S_1$ (00 kg ha$^{-1}$), $S_2$ (20 kg ha$^{-1}$) and $S_3$ (40 kg ha$^{-1}$) were tested in a factorial randomized block design with four replications. The succeeding chickpea (*rabi*) crop was superimposed on the same lay out. The experiment was conducted on the same site during both the years without changing the randomization of treatments. The organic manures and fertilizers were applied in the experimental plots before sowing as per the treatments. Small furrows were opened manually in each plot keeping the distance of 45 cm between the rows and fertilizers were applied uniformly in the furrows at the time of sowing as basal dose. The nitrogen was applied through urea and phosphorus was applied through diamonium phosphate. Treatment wise vermicompost, castor cake and sulphur were manually incorporated in soil before sowing of the crop as per the treatments. The plot size for each treatment was 4.5 m × 6.0 m. The common seed treatment was given with the fungicide Mancozeb @ 3 g kg$^{-1}$ before sowing. Sowing was done manually in line in the previously opened furrows at 45 cm apart using the seed rate of 2.5 kg ha$^{-1}$ on 14$^{th}$ July in 2012 and 20$^{th}$ July in 2013. The seeds were covered with soil manually for better germination. Chickpea was sown in the same plots as a residual crop after harvesting of sesame. Sowing was done manually in line in the previously opened furrows at 30 cm apart using the seed rate of 60 kg ha$^{-1}$ on 14$^{th}$ October in 2012 and 11$^{th}$ October in 2013. No irrigation was required to apply sesame crop. Six irrigation applied to chickpea during crop growth period. Both the crops were kept free from major insect pests and diseases. The seed yield, stover yield and harvest index recorded from sesame crop. Available N, P, S and organic carbon were estimated following the standard procedures. Seed oil content was analyzed by Nuclear Magnetic Resonance (NMR) technique suggested by Tiwari *et al*. (1974). Seed protein content was calculated by multiplying nitrogen content (%) of seed with the conversion factor of 6.25 as reported by *Gupta et al*. (1972). Determination of available nitrogen was done by alkaline permanganate method suggested by Subbiah and Asija (1956). The estimation of available P was done by using Olsen's extract (0.5 N sodium bicarbonates solution of pH 8.5) as suggested by Olsen *et al*. (1954) and determined as standard chloride reduced blue color. Available sulphur was extracted with $CaCl_2$ (0.15%) and was determined by turbid metric method, using spectrophotometer at 420 nm (Jackson, 1973). Organic carbon was determined by Walkley and Black (1934) wet digestion method and it is expressed in percentage. For data analysis proper and authentic results the standard method for FRBD data analysis given by Cocharan and Cox (1967).

## RESULTS AND DISCUSSION

### Effects of Treatments on Yield of Sesame

#### Effects of nitrogen management

The significantly higher seed yield (503 kg ha$^{-1}$) was recorded under the treatment $N_2$ (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) and it was significantly superior over treatments $N_5$ (50 % RDN from vermicompost + 50 % RDN from castor cake) and $N_4$ (25 % RDN from inorganic fertilizer + 37.5 % RDN from vermicompost + 37.5 % RDN from castor cake), but it was remained at par with treatments $N_1$ (100 % RDN from inorganic fertilizer) and $N_3$ (50 % RDN from inorganic fertilizer + 50 % RDN from castor cake) on pooled basis (Table 1). The treatments $N_2$, 19.99, $N_1$ and $N_3$ gave 18.92 and 17.79 per cent higher yield, respectively over treatment $N_5$. Application of integrated nutrient management with 50 % from chemical fertilizer and 50 % from organic i.e. castor cake or vermicompost gave balance nutrition and also provide vital microbs. Also increased the availability of both the native and applied nitrogen in the soil and substantially enhance their uptake by the plant this leading to overall improvement in the yield attributing characters like number of capsules plant$^{-1}$, number of seeds capsule$^{-1}$ and 1000- seeds weight. Vermicompost increases the density of microbes and also provides sufficient energy to remain active. The vermicompost provide the vital macronutrients *viz.*, N, P, K, Ca, Mg and micronutrients such as Fe, Mo, Zn, and Cu etc. and also create salutary soil environmental condition for the crop growth. Above findings are in accordance with those reported by Shaikh *et al*. (2010), Sajadinik *et al*.(2011), Verma *et al*. (2012), Ghosh *et al*. (2013) and Verma *et al*. (2013). The treatment $N_2$ (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) recorded the significantly higher stover yield (1192 kg ha$^{-1}$) and it was significantly superior to treatments $N_5$ and $N_4$, but remained at par with treatments $N_1$ and $N_3$ (Table 2). Numerically the significantly higher value of harvest index (30.16 per cent) was recorded under treatment $N_2$ (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) in the pooled analysis, respectively, but treatment $N_1$ (100 % RDN from inorganic fertilizer) was remained at par (Table 1).

**Effects of sulphur levels**

Significantly the higher seed yield (493 kg ha$^{-1}$ in the pooled analysis) was recorded under treatment $S_2$ (20 kg S ha$^{-1}$) over treatment $S_1$ (00 kg S ha$^{-1}$) and remained at par with treatment $S_3$ (40 kg S ha$^{-1}$) and the increase was by 10.78 and 6.47 per cent, respectively in pooled analysis (Table 1). Application of 20 kg S ha$^{-1}$ recorded higher sulphur use efficiency as compared to its next dose of 40 kg S ha$^{-1}$ in sesame. The declining rate of yield increases with 40 kg S ha$^{-1}$ as compared to 20 kg S was responsible for lower agronomic sulphur use efficiency at higher rate of sulphur application. Similarly, decline in yield at 40 kg S ha$^{-1}$ might be ascribed to greater increase in sulphur uptake (Table.1). The increase in seed yield with application of sulphur might be due to the maximum metabolic activity at this level i.e. 20 kg S ha$^{-1}$ resulting increased total dry matter there by seed yield. The increase in nitrate reductase activity and chlorophyll content due to sulphur application was might be resulted due to the availability of sulphur in the plant medium that help in producing sulphur containing amino acid. As a result, synthesis of nitrate reductase enzyme increased and it enhanced the reduction of $NO_3$ - to reduce N ultimately resulting in higher accumulation of sugar there by increased total dry matter and seed yield of sesame. These findings are in close agreement with those reported by Chaudhary and Patel (2007), Patel *et al*. (2009), Mathew *et al*. (2011), Longkumer and Gohain (2012), Mondal *et al*. (2013), Thentu *et al*. (2014) and Verma *et al*. (2014). Higher value of stover yield (1170 kg ha$^{-1}$) was recorded under treatment $S_2$ (20 kg S ha$^{-1}$) in pooled analysis (Table 1). This increase might be due to that sulphur made the plants more efficient in photosynthetic activity and thereby enhancing carbohydrate metabolism in the plant and increase plant height. Finally the beneficial effects of all attributes were reflected on stover yield. Other result for increasing in stover yield might be due to maximum utilization of nutrient, water, solar radiation and increase metabolic activity produced maximum stover yield. Similar results were observed by Bhosale *et al*. (2011), Mathew *et al*. (2011), Longkumer and Gohain (2012) and Mondal *et al*. (2013). Significantly higher harvest index (29.59 per cent) was recorded under treatment $S_2$ (20 kg S ha$^{-1}$) than other treatments and significantly lower

**Table 1: Seed yield, Stover yield, harvest index, oil content and oil yield of sesame as influenced by various treatments**

| Treatments | Seed yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) | Harvest index (%) | Oil content (%) | Oil yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|
| Nitrogen management (N) | | | | | |
| $N_1$: 100% RDN from inorganic fertilizer | 494 | 1170 | 29.68 | 47.38 | 235 |
| $N_2$: 50% RDN from inorganic fertilizer + 50% RDN from vermicompost | 503 | 1192 | 30.16 | 47.55 | 242 |
| $N_3$:50% RDN from inorganic fertilizer + 50 % RDN from castor cake | 469 | 1148 | 28.93 | 47.22 | 219 |
| $N_4$:25% RDN from inorganic fertilizer + 37.5 % RDN from vermicompost + 37.5 % RDN from castor cake | 443 | 1118 | 28.27 | 47.19 | 209 |
| $N_5$: 50 % RDN from vermicompost + 50 % RDN from castor cake | 427 | 1104 | 27.90 | 47.11 | 201 |
| S.Em. ± | 13 | 24 | 0.40 | 0.47 | 5 |
| C.D. at 5 % | 37 | 67 | 1.10 | NS | 15 |
| Sulphur levels (S) | | | | | |
| $S_1$: 00 kg ha$^{-1}$ | 445 | 1126 | 28.42 | 46.23 | 206 |
| $S_2$: 20 kg ha$^{-1}$ | 493 | 1178 | 29.59 | 48.03 | 237 |
| $S_3$: 40 kg ha$^{-1}$ | 464 | 1140 | 28.95 | 47.62 | 221 |
| S.Em. ± | 10 | 19 | 0.30 | 0.36 | 4 |
| C.D. at 5 % | 30 | NS | 0.90 | 1.02 | 11 |
| Significant Interaction (N × S) | - | - | - | - | - |
| C.V. % | 10.27 | 10.21 | 6.81 | 4.87 | 11.22 |

**Table 2: Effects of different treatments on soil fertility status after harvesting of sesame and seed, haulm and protein content of chickpea**

| Treatments | Soil fertility status after harvest of sesame | | | | Succeeding chickpea | | |
|---|---|---|---|---|---|---|---|
| Nitrogen management (N) | Organic carbon (%) | Available N(kg $ha^{-1}$) | Available P(kg $ha^{-1}$) | Available S(mg $kg^{-1}$) | Seed yield (kg $ha^{-1}$) | Haulm yield (kg $ha^{-1}$) | Protein content (%) |
| $N_1$: 100% RDN from inorganic fertilizer | 0.35 | 245 | 35.93 | 11.08 | 1422 | 4289 | 19.54 |
| $N_2$: 50% RDN from inorganic fertilizer + 50% RDN from VC | 0.40 | 252 | 39.31 | 11.72 | 1674 | 5052 | 18.48 |
| $N_3$:50% RDN from inorganic fertilizer + 50 % RDN from CC | 0.37 | 254 | 40.44 | 12.39 | 1615 | 4908 | 19.60 |
| $N_4$:25% RDN from inorganic fertilizer + 37.5 % RDN from VC + 37.5 % RDN from CC | 0.39 | 239 | 37.21 | 12.23 | 1726 | 5200 | 18.36 |
| $N_5$: 50 % RDN from VC + 50 % RDN from CC | 0.38 | 232 | 36.97 | 12.71 | 1881 | 5667 | 19.42 |
| S.Em. ± | 0.01 | 3 | 0.56 | 0.23 | 30 | 81. | 0.26 |
| C.D. at 5 % | 0.02 | 9 | 1.59 | 0.66 | 81 | 230 | 0.74 |
| Sulphur levels (S) | | | | | | | |
| $S_1$: 00 kg $ha^{-1}$ | 0.33 | 235 | 32.14 | 9.19 | 1607 | 4863 | 19.24 |
| $S_2$: 20 kg $ha^{-1}$ | 0.37 | 251 | 41.80 | 11.87 | 1726 | 5237 | 19.10 |
| $S_3$: 40 kg $ha^{-1}$ | 0.43 | 249 | 39.98 | 15.02 | 1652 | 4974 | 18.91 |
| S.Em. ± | 0.01 | 3 | 0.43 | 0.18 | 22 | 59 | 0.20 |
| C.D. at 5 % | 0.02 | 7 | 1.23 | 0.51 | 59 | 178 | NS |
| Significant Interaction (N × S) | N×S | - | S×NY ×N×S | Y×N×S | - | - | N×S |
| C.V. % | 10.70 | 6.54 | 7.19 | 9.44 | 8.70 | 8.71 | 6.62 |

harvest index (28.42 per cent) was recorded under the treatment $S_1$ (00 kg S $ha^{-1}$) in the pooled analysis.

**Effect of Treatments on Quality of Sesame**

**Effects of nitrogen management**

Application of 50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost treatment ($N_2$) recorded the highest oil content (47.57 %) and the (47.19 %) was lowest recorded in $N_5$ (50% RDN from vermicompost + 50 % RDN from castor cake) treatment in pooled results (Table 1). This could be explained on the basis of better and timely availability of required quantity nutrient in crop root zone, resulting from its solubilization caused by the organic acid produced from the decaying organic matter. The above findings are in close conformity with those reported by Sajadinik *et al.* (2011), Verma *et al.* (2012), Ghosh *et al.* (2013) and Nayek *et al.* (2014). In pooled results significantly higher oil yield kg $ha^{-1}$ was recorded under the treatment $N_2$ (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) over treatments $N_3$, $N_4$ and $N_5$, but treatment $N_1$ (100 % RDN from inorganic fertilizers) was remained at par.

**Effects of sulphur levels**

The significantly higher oil content (48.03 %) was recorded under treatment $S_2$ (20 kg S $ha^{-1}$) than treatment $S_1$ and remained at par with treatment $S_3$ (40 kg S $ha^{-1}$) (Table 1). This might be due to sulphur play important role in synthesis of essential amino acids like, Cysteine, Cystine, Methionine and certain vitamins like Biotin, Thiamine, Vitamin B, as well as formation of ferodoxin an iron- containing plant protein that act as electron carrier in the photosynthetic process and chlorophyll, which required for the production of oil. Similar results were also obtained by Chaudhary and Patel (2007), Mondal *et al.* (2013), Thentu *et al.* (2014) and Verma *et al.* (2014). The significantly highest oil yield kg $ha^{-1}$ (237 kg $ha^{-1}$) was recorded under treatment $S_2$ (20 kg S $ha^{-1}$) than treatments $S_1$ (00 kg S $ha^{-1}$) and $S_3$ (40 kg S $ha^{-1}$).

**Effect on Nutrient Status of the Soil after Harvest of Sesame Crop**

**Effect of nitrogen management**

The treatment $N_2$ (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) recorded significantly higher organic carbon content (0.40 %) in the soil after harvest of the sesame crop, but remained at par with treatments $N_4$ and $N_5$ on pooled basis (Table 2). The treatment $N_2$ recorded 14.73, 6.14, 5.02 and 1.97 per cent higher organic carbon content in the soil than the treatments $N_1$, $N_3$, $N_4$ and $N_5$ respectively, in the pooled analysis. Addition of organic matter in to the soil through organic manures helped in modifies the soil reaction favorably to enhance the availability of organic carbon content and resulted in improvement of the soil fertility. Similar observations had also been reported by Jat and Ahlawat (2006), Akbari *et al.* (2010), Javia *et al.* (2010) and Munji *et al.* (2010). The treatment $N_3$ (50 % RDN from inorganic fertilizers + 50 % RDN from castor cake) recorded (9.48, 6.27 and 3.67 per cent) higher available nitrogen in the soil than treatments $N_5$, $N_4$ and $N_1$ in pooled analysis, respectively (Table 2). Addition of inorganic and organic fertilizer in the soil helped to modify the soil reaction favorably to enhance the avaibility of nitrogen and resulted in improvement of the soil fertility. Similar results were observed by Jat and Ahlawat (2006), Akbari *et al.* (2010), Javia *et al.* (2010), Munji *et al.* (2010), Tripathy and Bastia (2012) and Vijayakumari and Hiranmai (2012). Significantly higher available phosphorus (40.44 kg $ha.^{-1}$) in the soil was recorded under treatment $N_3$ (50 % RDN from inorganic fertilizer + 50 % RDN from castor cake) than other treatments, but it was remained at par with treatment $N_2$ (Table 2). The treatment $N_3$ (50 % RDN from inorganic fertilizers + 50 % RDN from castor cake) recorded (12.55, 9.38, 8.68 and 2.87 per cent) higher available phosphorus in the soil than treatments $N_1$, $N_5$, $N_4$ and $N_2$ in pooled analysis, respectively. Similar results were observed by Jat and Ahlawat (2006), Akbari *et al.* (2010), Javia *et al.* (2010), Munji *et al.* (2010), Tripathy and Bastia (2012) and Vijayakumari and Hiranmai (2012). Significantly higher sulphur in the soil (12.71 mg $kg^{-1}$) was recorded under treatment $N_5$ (50 % RDN from vermicompost + 50 % RDN from castor cake) than other treatments, but it was remained at par with treatments $N_3$ and $N_4$ in pooled results (Table 2). The treatment $N_5$ recorded 14.71, 8.44, 3.92 and 2.50 per cent higher available sulphur in the soil than treatments $N_1$, $N_2$, $N_4$ and $N_3$ in pooled analysis, respectively. Similar results were observed by Akbari *et al*. (2010) and Javia *et al*. (2010).

**Effect of sulphur levels**

The treatment $S_3$ (40 kg S $ha^{-1}$) recorded significantly highest organic carbon content (0.43 %) in the soil after harvest of the sesame crop than the treatments $S_1$ (00 kg S $ha^{-1}$) and $S_2$ (20 kg S $ha^{-1}$) (Table 2). The treatment $S_3$ (40 kg S $ha^{-1}$) recorded 31.60 and 17.02 per cent higher organic carbon content in the soil than treatments $S_1$ and $S_2$ in pooled results. These results are in agreement of those reported by Mathew *et al*. (2011). The treatment $S_2$ (20 kg S $ha^{-1}$) recorded significantly higher available nitrogen (251 kg N $ha^{-1}$) in the soil after harvest of the sesame crop than the treatment $S_1$ (00 kg S $ha^{-1}$), however treatment $S_3$ was remained at par (Table 2). The treatment $S_2$ (20 kg S $ha^{-1}$) recorded 6.80 and 0.80 per cent higher available nitrogen in the soil than the treatments $S_1$ and $S_3$ in pooled analysis. Similar observations had also been reported by Mathew *et al*. (2011). In pooled analysis the treatment $S_2$ (20 kg S $ha^{-1}$) recorded significantly higher available phosphorus (41.80 kg $P_2O_5$ $ha^{-1}$) in the soil after harvest of the sesame crop than the treatments $S_1$and $S_3$ and the increase was 30.05 and 4.55 per cent, respectively (Table 2). Similar observations had also been reported by Ravichandran *et al*. (2003). The treatment $S_3$ (40 kg S $ha^{-1}$) recorded significantly higher available sulphur (15.02 mg $kg.^{-1}$) in the soil after harvest of the sesame crop than the treatments $S_1$ and $S_2$ and the increase was 63.43 and 26.62 per cent in available sulphur in the soil than treatments $S_1$ and $S_2$ in pooled analysis (Table 2). Similar observations had also been reported by Saren *et al*. (2004) and Mathew *et al*. (2011).

**Effect of Treatments on Succeeding Chickpea**

**Effect of treatments on seed and haulm yields**

**Effect of nitrogen management**

It was observed that the increase in seeds yield (1881 kg $ha.^{-1}$) of chickpea under treatment $N_5$ (50 % RDN from vermicompost + 50 % RDN from castor cake) over treatment $N_4$ was 8.98 per cent, over $N_3$, increase was 16.47, over $N_2$, increase was 12.36 and over $N_1$ it was 32.27 per cent in the pooled analysis, respectively (Table 3).

Likewise, the increase in haulm yield (5667 kg $ha.^{-1}$) of chickpea was maximum with ($N_5$) (50 % RDN from vermicompost + 50 % RDN from castor cake) and the increase was 8.98 per cent over treatment $N_4$, it was 15.39 per cent over treatment $N_3$, it was 12.17 per cent over treatment $N_2$ and it was 32.12 per cent over treatment $N_1$ in the pooled analysis, respectively (Table 2).

These results were ascribed to higher C: N ratio at initial stage of the crop under organic manure treatments. Organic manure is an essential ingredient of the balance dose of fertilizer, which has directly influenced the plant growth and development of crop canopy through better utilization of photosynthesis. Moreover, at later stages of growth, more photosynthets are diverted and accumulated in the pod, which led to maximum seed and haulm yield. Further, residual macro and micro elements available through organic treatments provided better soil environment and physical condition for better root development, plant growth and yield. These findings are similar to those of Purushottam (2005), Jat and Ahlawat (2006), Malligawada (2010), and Ghosh *et al*. (2013).

**Effect of sulphur levels**

Significantly higher seed and haulm yields (1726 and 5237 kg $ha.^{-1}$) were recorded under treatment $S_2$ (20 kg S $ha^{-1}$) and the increase was 7.40 and 7.60 per cent respectively over treatment $S_1$ (00 kg S $ha^{-1}$), respectively (Table 2). Moreover, increase under treatment $S_2$ was might be ascribed to comparatively more addition of nitrogen also left over residual phosphorus applied to sesame that led to enhance the available nitrogen and phosphorus in the soil after harvest of sesame. Therefore improved nutrient status of the soil might have increased the yield attributes of chickpea crop. Similar results were also reported by Srinivasrao *et al*. (2010).

**Effect of treatments on protein content in chickpea seeds**

**Effect of nitrogen management**

Significantly higher seed protein content (19.60 %) was observed under the treatment $N_3$ (50 % RDN from inorganic fertilizer + 50 % RDN from castor cake) than the treatments $N_2$ and $N_4$, but it remained at par with treatments $N_1$ and $N_5$ in pooled analysis (Table 2). The remarkable increase in the protein content in the seeds under treatments $N_3$ was mainly due to the favorable residual effect of organic manure and available nitrogen from mineralization of the organic manure on the growth and yield of chickpea thus, more accumulation of N in chickpea increased the protein content in chickpea seeds.

**Effect of sulphur levels**

Higher protein content (19.24 %) was recorded under treatment $S_1$ (00 kg S $ha^{-1}$) over treatments $S_2$ (20 kg S $ha^{-1}$) and $S_3$ (40 kg S $ha^{-1}$) in pooled analysis (Table 2).

## REFERENCES

**Akbari, K. N., Sutaria, G. S., Vora, V. D., Hirpara, D. S. and Padmani, D. R. 2010.** Response of oil seed crops to VC under rain fed conditions. *Asian J. Soil Science*. **5(1):** 172-174.

**Anonymous 2014.** Agricultural situation in India, Directorate of Economics and Statistics. *Department of Agriculture and co-operation, Ministry of Agriculture, Government of India*, New Delhi.

**Bhosale, N. D., Dabhi, B. M., Gaikwad, U. P. and Chavan, A. B. 2011.** Growth, yield and quality parameters of sesame influenced by different levels of potash and sulphur. *International Journal of Forestry and Crop Improvement*. **2(2):** 1212-123.

**Chaudhari, S. R. and Patel, D. B. 2007.** Response of sesame to different levels of phosphorus and sulphur under north Gujarat agro climatic conditions. *GAU Research J.* **32(1&2):** 31-33.

**Cochran, W. G. and Cox, G. M. 1967.** Experimental Designs, *Jhon Willey and Sons. Inc.* New York. pp. 546-568.

**Ghosh, A. K., Duary, B. and Ghosh, D. C. 2013.** Nutrient management in sum-mer sesame and its residual effect on succeeding kharif black gram. *International J. Bio-resource and Stress Management*. **4(4):** 541-546.

**Gupta, B. R., Patak, R. K., Bhan, S. and Singh, A. 1972.** Effect of NPK on yield, nutrient uptake and quality of *toria* (*Brassica compestries* Var. *toria*). *Indian J. Agronomy*. **17:** 88-91.

**Jackson, M. L. 1973.** Soil chemical analysis. Prentice Hall of India Pvt. Ltd. New Delhi.

**Jat, R. S. and Ahlawat, I. P. S. 2006.** Direct and residual effect of VC, bio fertilizers and phosphorus on soil nutrient dynamics and productivity of chickpea-fodder maize sequence. *J. Sustainable Agriculture*. **28(1):** 51-54.

**Javia, R. M., Vora, V. D., Sutaria, G. S., Akabari, K. N. and Padmani, D. R. 2010.** Effect of nutrient management on productivity of sesame and soil fertility of sandy loam soils under rain fed condition. *An Asian J. Soil Science*. **1:** 80-82.

**Jaishankar, S. and Wahab, K. 2005.** Effect of integrated nutrient management on the growth, yield components and yield of sesame. *Sesame and Safflower Newsletter*. **20:** 48-50.

**Lakhran, H., Sadhu, A. C. and Kumavat, S. 2015.** Quality and yield potential of summer sesame (*Sesamum indicum* L.) as influenced by sowing time and nutrient management in middle Gujarat. *The Bioscan*. **10(3):** 1409-1411.

**Longkumer, I. T. and Gohain, T. 2012.** Effect of sulphur and calcium on growth and yield of sesame under rain fed condition of Nagaland. *Annales Plant Soil Research*. **14(1):** 58-60.

**Malligawada, L. H. 2010.** Studies on the effect of in-situ soil moisture conservation and nutrient management practices on the productivity of sesame and sorghum in sequence cropping system. *19th World Congress of Soil Science, Soil Solutions for a Changing World, 1 -6, August, 2010, Brisbane, Australia.*

**Mathew, J., George, S. and Indira, M. 2011.** Effect of sulphur and boron on the performance of sesame (*Sesamum indicum* L.) in on attukara sandy soil of Kerala, India. *Indian J. Agricultural Science*, **47(3):** 214-219.

**Mondal, M. M. A., Badruddin, M. B., Malek, M. A., Hossain, M. B. and Puteh, A. B. 2013.** Optomization of sulphur requirement to sesame (*Sesamum indicum* L.) genotypes using tracer techniques. *Bangladesh J. Botany*. **41(10):** 7-13.

**Munji, R., Babalad, H. B., Kumara, B. H. P. and Pushpa, V. 2010.** Effect of organics and fermented organics on yield; soil available N, $P_2O_5$, $K_2O$ Kg ha$^{-1}$ and microbial count in sesame. *Asian J. Soil Science*. **5(2):** 379-385.

**Nayek, S. S., Brahmchari, K. and Chowdhury, R. 2014.** Integrated approach in nutrient management of sesame with special reference of its yield, quality and nutrient uptake. *The Bioscan*. **9(1):** 101-105.

**Olsen, S. R., Cole, V. C., Watandble, F. S. and Dean, L. A. 1954.** Estimation of available phosphorus in soil by extraction with sodium hydrogen carbonate, U.S.D.A. Circular. **939:** 19.

**Patel, P. N., Patel, P. G. and Patel, B. T. 2009.** Response of sesame varieties to different levels of nitrogen and sulphur in loamy sand soils of north Gujarat. *GAU Research J.* **34(2):** 150-151.

**Purushottam, G. 2005.** Integrated nutrient management in sesame (*Sesamum indicum* L.) and its residual effect on succeeding chickpea (*Cicer arietinum* L.). *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.

**Ravichandran, M. V., Vaiyapuri, V. and Amudha, A. 2003.** Effect of sulphur levels and organics on seed quality and nutrient up take of sesame. *Research Crops*. **36:** 153-158.

**Sajadinik, R., Yadavi, A., Balouchi, H. R. and Farajee, H. 2011.** Effect of chemical (urea), organic (VC) and biological (nitroxin) fertilizers on quantity and quality yield of sesame (*Sesamum indicum* L.). *J. Agricultural Science*. **12(2):** 87-101.

**Saren, B. K., Nandi, P. and Tudu, S. 2005.** Effect of irrigation and sulphur on yield attributes and yield, oil content and oil yield and consumptive use efficiency of *summer* sesame (*Sesamum indicum* L.). *J. Oil seed Research*. **22(2):** 283-284.

**Shah, M. A., Manaf, A., Hussain, M., Farooq, S. and Hye, M. Z. 2013.** Sulphur fertilization improves the sesame productivity and economic returns under rain fed conditions. *International J. Agriculture & Biology*. **15(6):** 1301-1306.

**Shaikh, A. A., Desai, M. M., Kamble, R. S. and Tambe, A. D. 2010.** Yield of *summer* sesame (*Sesamum indicum* L.) as influence by integrated nutrient management. *International Journal of Agricultural Science*. **6(1):** 144-146.

**Shelke, R. I., Kalegore, N. K. and Wayase, K. P. 2014.** Effect of levels of phosphorus and sulphur on growth, yield and quality of sesame (*Sesamum indicum* L.). *J. Agricultural Sciences*. **10(3):** 108-111.

**Srinivasarao, Ch., Masood, A., Venkateswarlu, S., Rupa, T.R., Singh, K. K., Sumanta, K. and Prasad, J. V. N. S. 2010.** Direct and residual effects of integrated sulphur fertilization in maize (*Zea mays*)-chickpea (*Cicer arietinum*) cropping system on typicustochrept. *Indian J. Agronomy*. **55(4):** 259-263.

**Subbiah, B. V. and Asija, H. L. 1956.** A rapid procedure for estimation of the available nitrogen in soil. *Current Science*. **25:** 259-260.

**Thentu, T. L., Nawlakhe, S. M., Mankar, D. D., Shrinivasrao, M. and Gauri, V. B. 2014.** Growth, yield and quality of summer sesame as influenced by the fertilizer and sulphur levels. *J. Soils and Crops*. **24(1):** 143-147.

**Tiwari, P. N., Gamber, P. N. and Rajan, T. N. 1974.** Rapid and non-destructive determination of oil in oil seeds. *Journal of Oil Chemical Science*. **51:** 1049.

**Tripathy, S. and Bastia, D. K. 2012.** Irrigation and nutrient management for yield augmentation of *summer* sesame (*Sesamum indicum* L.). *J. Crop and Weed*. **2:** 54-58.

**Verma, S., Saxena, R. and Singh, H. 2012.** Integrated nutrient management in sesame (*Sesamum indicum* L.). *J. Life Science*. **9(4A):** 576-579.

**Verma, S., Singh, H. and Saxena, R. 2013.** Relative performance of sesame (*Sesamum indicum* L.) under organic, inorganic and integrated nutrient management. *The Indian J. Agricultural Sciences*. **83(2):** 78-83.

**Verma, R. K., Yadav, S. S., Puniya, M. M., Yadav, L. R., Yadav, B. L. and Shivran, A. C. 2014.** Effect of phosphorus and sulphur fertilization on growth and yield of sesame (*Sesamum indicum* L.) under loamy sand soils of Rajasthan. *Annales of Agriculture Research*. **35(1):** 65-70.

**Vijaykumari, B. and Hiranmai, Y. R. 2012.** Influence of fresh composted and poultry manure on the growth characters of sesame (*Sesamum indicum* L.). *J. Organic Systems*. **7(1):** 13-19.

**Walkey, A. and Black, I. A. 1934.** Estimation of organic carbon by the chromic acid titration method. *Soil Science*. **37:** 29-38.