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Effects of integrated nutrient management on yield attributes and yield of *kharif* sesame (*Sesamum indicum* L.) and its residual effect on succeeding chickpea (*Cicer arietinum* L.) 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. Fifteen treatment combinations given in *kharif* sesame crop comprised of five nitrogen management treatments i.e. N_1: 100% Recommended dose of nitrogen (RDN) from inorganic fertilizer, N_2: 50% RDN from inorganic fertilizer + 50% RDN from Vermicompost (VC), N_3: 50% RDN from inorganic fertilizer + 50% RDN from Castor cake (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 super imposed on the same lay out. The experiment was conducted on the same site during both the years without changing the randomization of treatments.

The various growth and yield attributing characters like periodical plant height, leaf area index (LAI), dry matter production of plant, number of capsules plant^{-1} were significantly affected due to nitrogen management treatments. These attributes were significantly higher in application of 100% RDN from inorganic fertilizers. Whereas, number of branches plant^{-1} and number of seeds capsule^{-1} were significantly higher under the treatment having 50% RDN from inorganic fertilizer + 50% RDN from vermicompost.

The significantly higher seed yield (503 kg ha^{-1}) and stover yield (1192 kg ha^{-1}) were recorded under treatment N_2 (50% RDN from inorganic fertilizer + 50% RDN from vermicompost) in the pooled analysis. The highest net return of Rs. 52,730 ha^{-1} was secured with treatment of 100% RDN from inorganic fertilizer with the maximum B:C ratio of 4.48.

The residual effect of treatment N_5 (50% RDN from vermicompost + 50% RDN from castor cake) gave significantly maximum seed yield (1881 kg ha^{-1}) and haulmyield of (5667 kg ha^{-1}) of chickpea than all other treatments in the pooled analysis. This treatment also gave the highest net realization of Rs. 47,512 ha^{-1} and benefit to cost ratio (3.59) from chickpea crop over residual effect of rest of the nitrogen management treatments in average of two years.

The various growth and yield attributing characters like number of branches plant^{-1}, number of capsules plant^{-1}, 1000-seeds weight and harvest index of sesame crop were significantly higher under application of 20 kg S ha^{-1}.

Significantly higher seed yield of sesame (493 kg ha^{-1}) in pooled analysis was produced with application of 20 kg S ha^{-1}. The highest net returns of Rs. 49,053 ha^{-1} was incurred by application of 20 kg S ha^{-1} with maximum B:C RATIO value of 3.69 in sesame crop.

Residual 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}) in the pooled analysis and the maximum net return of succeeding chickpea crop.

The highest net return of Rs. 90,113 ha^{-1} was secured with treatment N_2 (50% RDN from inorganic fertilizer + 50% RDN from VC) with B:C ratio value of 3.40. Application of 20 kg S ha^{-1} recorded the highest net realization of Rs. 91,246 ha^{-1} and B:C ratio of 3.47 in sesame-chickpea sequence in average of two years.

Key words : Chickpea, RDN, inorganic fertilizer Vermicompost, Caster cake

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INTRODUCTION

Sesame is the oldest oil seed crop cultivated in the world. It is believed that sesame was probably originated in Africa and introduced into India by the earliest human migrants from Africa.

Except for a brief period of satisfaction during 1986-90 wherein country had witnessed near self sufficiency in vegetable oils, in-spite of continuous increase in domestic oilseeds production, only of 50 % the requirement of vegetable oil is met and nearly half is made through import as a huge cost of 9.7 billion US dollars as incurred during 2011-12 (Hegde *et al.*, 2012). Sesame is one of the important oilseeds crops in Indian agriculture. Through the ages, the sesame seeds have been a source of food and oil and seed oil is still the main source of fat used in cooking. Sesame oil has many medicinal values as it is good for respiratory disorders, eye-infections and digestive ailments.

Sesame cultivated on a large area in the states of Maharashtra, Uttar Pradesh, Rajasthan, Orissa, Andhra Pradesh, Madhya Pradesh, Tamil nadu, West Bengal, Gujarat, Karnataka, Kerala and Punjab and to a limited extent, in Tripura and Himachal Pradesh. By virtue of its early maturing, sesame fits well into a number of multiple cropping systems either as a catch crop or a sequence crop in *rabi* and pre-*kharif* seasons. India rank first in area, production and export of sesame in the world. Sesame ranks third in terms of total oilseed area and fourth in terms of total oilseed production in India. The average production of sesame in India is very low (274 kg ha^{-1}) (Anonymous, 2012). It is one of the important oilseed crops in Gujarat and mainly grown in marginal land with minimum care. Lack of proper nutrient management is one of the major causes for low yields. Balanced fertilization with NPK was proved beneficial in all the oil seed crops, both under rainfed and irrigated conditions. Integrated use of organic and inorganic fertilizers in a balanced proportion for sustainable production of sesame was therefore emphasized by Deshmukh *et al.* (2002).

Sesame-Chickpea is one of the most prevalent cropping sequences followed in Middle Gujarat. Integrated nutrient management provide 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 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). Further combined application of organic and inorganics during kharif season in sesame exerts significant residual effect on succeeding chickpea (Purushottam, 2005).

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 researchers. About 37 per cent soils of the Gujarat are found sulphur efficient. The soils of middle Gujarat are light in texture and mostly in medium and deficient range in S availability; which results 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.

Combined application of available organic source along with optimal dose of inorganic fertilizers assure high and sustained productivity in oil seed-legume cropping system due to regulated nutrient supply and reduced losses, beside lowering costs. Such information is lacking for the sesame-chickpea cropping system. 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, present investigation was carried out to study the integrated nutrient management in sesame and its residual effect on succeeding chickpea under middle Gujarat condition.

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, low in organic carbon (0.33%), 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 (Recommended dose of nitrogen) from inorganic fertilizer, N_2: 50% RDN from inorganic fertilizer + 50% RDN from VC (Vermicompost), N_3: 50% RDN from inorganic fertilizer + 50% RDN from CC(Castor cake), 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 super imposed on the same lay out. The experiment was conducted on the same site during both the years without changing the randomization of treatments. The recommended dose of fertilizer (RDF) for *kharif* sesame 50: 25: 00 NPK kg ha^{-1}. 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 pure seeds of sesame variety Gujarat Till-2 were procured from Agricultural Research Station, Anand Agricultural University, Dhandhuka, District Ahmedabad and were used in the experiment. 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 14th July in 2012 and 20th 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 14th October in 2012 and 11th October in 2013. No irrigation was required for sesame crop since it was grown in *kharif* season. Six irrigation were applied to chickpea during crop growth period. Both the crops were kept free from major insect pests and diseases. In order to record various quantitative observations, five plants were randomly selected from each net plot. These plants were suitably labeled for easy demarcation. The observations on the growth and yield contributing characters were recorded from these plants. The gross realization ha^{-1} was worked out on the basis of seed and stover yields of sesame and chickpea for each treatment, considering the prices prevailing in the market. The cost of cultivation ha^{-1} for each treatment was calculated considering the current charges of agricultural operations and market prices of inputs involved. The benefit cost ratio of each treatment was calculated by dividing the gross realization by the cost of cultivation of respective treatments.

RESULT AND DISCUSSIONS

The data pooled analysis is presented and discussed here

3.1 EFFECT OF NITROGEN MANAGEMENT AND SULPHUR LEVELS ON GROWTH ATTRIBUTES OF *KHARIF* SESAME

3.1.1 Effects of nitrogen management (Table-1)

The nitrogen management treatments have significantly influenced the plant height, number of branches plant^{-1}, LAI and dry matter production. The plant height of N_1 treatment was at par with N_2only at 60 and 90 DAS, but not at 30 DAS. Significantly higher leaf area index (LAI) was recorded under treatment N_1 (100 % RDN from inorganic fertilizer) than the treatments N_4 and N_5 in the pooled results, but was remained at par with the treatments N_2 (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) and N_3 (50 % RDN from inorganic fertilizer + 50 % RDN from castor cake) at 30 DAS and 60 DAS. Significantly higher dry matter production was recorded under the treatment N_1 (100% RDN from inorganic fertilizers) than the treatments N_3, N_4 and N_5 but, remained at par with the treatment N_2 (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) at 30 DAS and 60 DAS. Higher dry matter production under application 100 % RDN from inorganic fertilizers can be attributed towards more availability of nitrogen resulting in enhanced vegetative growth and produce higher total dry matter of crop. Similar results were reported by Shashidhara (2007). Significantly higher number of branches plant^{-1}was recorded under the treatment N_2 (50% RDN from inorganic fertilizer + 50% RDN from vermicompost), while the treatment N_1 (100% RDN from inorganic fertilizers) was remained at par.

3.1.2 Effects of sulphur levels

Different sulphur levels have varied growth parameters of sesame. (Table-1)

Application of sulphur @ 20 kg ha^{-1} increased important growth characters of sesame over rest of the treatments. The plant height under 20 kg S ha^{-1}

treatment was higher as compared to other sulphur levels during both the years. This was probably due to better availability of sulphur, moisture, space and light. Similar results were observed by Mondal *et al.* (2013). The treatment S_1 (00 kg S ha^{-1}) and S_2 (20 kg S ha^{-1}) produced higher leaf area index at 30 DAS and at 60 DAS than the treatments and S_3 (40 kg S ha^{-1}). The results confirm the finding of Longkumer and Gohain (2012) and Mondal *et al.* (2013). The treatment S_2 (20 kg S ha^{-1}) produced highest values of dry matter production at 30 DAS and at 60 DAS in the pooled analysis. This 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 results confirm the finding of Mondal *et al.* (2013) and Thentu *et al.* (2014).Application of 20 kg S ha^{-1} recorded significantly higher number of branches plant^{-1}than the S_1 and S_3treatment. Increase in number of branches plant^{-1}by sulphur application is attributed to the stimulatory effect of sulphur in cell division. This was probably due to more activities of meristematic tissues of the plant producing more number of trifoliate, which ultimately increased total photosynthetic surface area of the plant contributing towards higher production of branches. The results confirm the findings of Chaudhari and Patel (2007), Longkumer and Gohain

Table:1 Growth components of sesame as influenced by various treatments

Treatments	Plant height (cm)			LAI		Dry matter production (g plant-1)		No. of branches plant-1
	At 30 DAS	At 60 DAS	At harvest	At 30 DAS	At 60 DAS	At 30 DAS	At 60 DAS	
Nitrogen management (N)								
N^1: 100% RDN from inorganic fertilizer	56.08	129.16	138.90	2.15	2.58	5.96	15.54	3.51
N^2: 50% RDN from inorganic fertilizer + 50% RDN from vermicompost	52.87	125.27	134.15	2.09	2.50	5.39	14.98	3.57
N^3:50% RDN from inorganic fertilizer + 50 % RDN from castor cake	51.21	123.84	132.95	2.07	2.47	5.16	14.60	3.35
N^4:25% RDN from inorganic fertilizer+37.5% RDN from vermicompost+ 37.5 % RDN from castor cake	49.88	121.34	131.53	2.03	2.44	4.97	14.12	3.18
N^5: 50 % RDN from vermicompost + 50% RDN from castor cake	48.09	117.85	126.75	1.99	2.38	4.72	13.65	3.12
S.Em. ±	0.84	1.75	1.82	0.03	0.03	0.13	0.28	0.05
C.D. at 5 %	2.36	5.00	5.20	0.07	0.10	0.37	0.81	0.14
Sulphur levels (S)								
S^1: 00 kg ha^{-1}	51.63	123.26	133.00	2.07	2.48	5.26	14.56	3.16
S^2: 20 kg ha^{-1}	52.09	123.97	133.48	2.07	2.48	5.33	14.63	3.96
S^3: 40 kg ha^{-1}	51.17	123.19	132.08	2.06	2.46	5.14	14.55	3.31
S.Em. ±	0.64	1.36	1.41	0.02	0.03	0.10	0.22	0.08
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	0.34
Significant Interaction (N × S)		-	-	-	-	-	-	--
C.V. %	7.26	6.94	6.71	6.04	6.74	12.05	9.52	7.22

(2012) and Mondal *et al.* (2013).

3.2 EFFECT OF NITROGEN MANAGEMENT AND SULPHUR LEVELS ON YIELD ATTRIBUTES AND YIELD OF *KHARIF* SESAME

3.2.1 Effects of nitrogen management (Table-2)

The treatment N_1 (100% RDN from inorganic fertilizer) produced significantly higher number of capsules plant^{-1} as compared to the treatment N_3 , N_4 and N_5, while the treatment N_2 (50 % RDN from inorganic fertilizer + 50 % RDN from VC), remained at par. Application 100 % RDN from inorganic fertilizers attributed towards more availability of nitrogen resulting in enhanced vegetative growth, leading to improved fruiting and thereby more number of capsules plant^{-1}. These results are in close agreement with those reported by Ghosh *et al.* (2013). Significantly higher number of seeds capsule^{-1} were found under treatment N_2 (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) followed by treatments N_3 (50 % RDN from inorganic fertilizer + 50 % RDN from castor cake) and N_4 (25 % RDN from inorganic fertilizer + 37.5 % RDN from vermicompost + 37.5 % RDN from castor cake) Application of 50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost enhancedthe uptake of nutrient at flowering and resulted in improvement in the size of the sink to receive the source i.e., increased number of seeds capsule^{-1}. The present findings are in close agreement with those reported by Shashidhara (2007),Jaishankar and Wahab (2005) and Ghosh *et al.* (2013). Higher value of 1000- seeds weight was recorded under the treatment N_2 (50 % RDN from inorganic fertilizer + 50% RDN from vermicompost) followed by treatments N_1 and N_3. 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). The treatments N_2, N1 and N_3 gave17.79,15.61 and 9.83 per cent higher seed 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 provided vital microbes and also increased the availability of both the native and applied nitrogen in the soil and substantially enhance their uptake by the plant. This led 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) andVerma *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. 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) remained at par.

3.2.2 Effects of sulphur levels (Table-2)

Significantly higher number of capsules plant^{-1} was recorded under treatment S_2 (20 kg S ha^{-1}) than treatments S_3 (40 kg S ha^{-1}) and S_1 (00 kg S ha^{-1}). Increase in number of capsules plant^{-1} with treatment 20 kg S ha^{-1} was probably due to stimulatory effect of sulphur on tillering through cytokines synthesis and rapid conversion of synthesized carbohydrates into protein, consequent to increase in the number and size of growing cells, resulting into more number of branches thereby increase in number of capsules plant^{-1}. These results are in accordance with those reported by Mathew *et al.* (2011),Longkumer and Gohain (2012),Mondal *et al.* (2013) and Verma *et al.* (2014).The differences in number of seeds capsules^{-1} due to sulphur levels were not found significant. The highest number of seeds capsules^{-1} was recorded under the treatment S_2 (20 kg S ha^{-1}) as compared to treatments S_1 (00 kg S ha^{-1}) and S_3 (40 kg S ha^{-1}). Significantly higher values of 1000- seeds weight were 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}). These findings are in close agreement with those reported by Patel *et al.* (2009), Mathew *et al.* (2011), Longkumer and Gohain (2012), Mondal *et al.* (2013) and Verma *et al.* (2014). Significantly the higher seed yield (493 kg ha^{-1}) 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 6.25 per cent, respectively. Similarly, decline in yield at 40 kg S ha^{-1} might be ascribed to greater increase in sulphur

Table: 2 Yield components of sesame and succeeding chickpea as influenced by various treatments

Treatments	Sesame						Chickpea	
	Number of capsules plant^{-1}	Number of seeds capsule^{-1}	1000-seeds weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
Nitrogen management (N)								
N^1: 100% RDN from inorganic fertilizer	32.79	39.54	3.10	494	1170	29.68	1422	4289
N^2: 50% RDN from inorganic fertilizer + 50% RDN from vermicompost	31.83	47.75	3.15	503	1192	30.16	1674	5052
N^3:50% RDN from inorganic fertilizer + 50% RDN from castor cake	30.50	45.46	3.08	469	1148	28.93	1615	4908
N^4:25% RDN from inorganic fertilizer + 37.5 % RDN from vermicompost + 37.5 % RDN from castor cake	29.00	43.13	3.04	443	1118	28.27	1726	5200
N^5: 50 % RDN from vermicompost + 50 % RDN from castor cake	27.21	41.21	3.03	427	1104	27.90	1881	5667
S.Em. ±	0.50	0.84	0.04	13	24	0.40	30	81
C.D. at 5 %	1.44	2.36	NS	37	67	1.10	81	230
Sulphur levels (S)								
S^1: 00 kg ha^{-1}	29.43	42.90	3.01	445	1126	28.42	1607	4863
S^2: 20 kg ha^{-1}	31.33	44.38	3.19	493	1178	29.59	1726	5237
S^3: 40 kg ha^{-1}	30.05	42.98	3.06	464	1140	28.95	1652	4974
S.Em. ±	0.39	0.65	0.04	10	19	0.30	22	59
C.D. at 5 %	1.10	NS	0.10	30	NS	0.90	59	178
Significant Interaction (N × S)	-	-	-	-	-	-	-	-
C.V. %	8.15	9.32	6.85	10.27	10.21	6.81	8.70	8.71

uptake. 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. They might be increase in nitrate reductase activity and chlorophyll content due to sulphur application 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 reduced 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 Chaudhari 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}). 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 increased dry matter production. 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 harvest index (28.42 per cent) was recorded under the treatment S_1 (00 kg S ha^{-1}).

3.3 RESIDUAL EFFECTS ON SUCCEEDING CHICKPEA

3.3.1 Residual effect on seed and haulm yields (Table2)

3.3.1.1 Residual effect of nitrogen management

It was observed that the increase in seeds yield of chickpea under treatment N_5 (50 % RDN from vermicompost + 50 % RDN from castor cake) by 8.98 percent over treatment N_4, 16.47 per cent over N_3, 12.36 per cent over $N_2$and 32.27 per cent over N_1.

Likewise, the increase in haulm yield 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 15.46 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.

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 Thiruppathi*et al.* (2001), Purushottam(2005), Jat and Ahlawat (2006), Malligawada (2010), and Ghosh*et al.* (2013).

3.3.1.2 Residual effect of sulphur levels

Significantly higher seed and haulm yields were recorded under treatment S_2(20 kg S ha^{-1}) and the increase was 7.40 and 7.69 per cent respectively over treatment S_1 (00 kg S ha^{-1}). Moreover, increase under treatment S_2 was might be ascribed to comparatively more addition of nitrogen also left over residual phosphorus applied to sesame which enhanced 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).

3.4 ECONOMICS (Table 3)

3.4.1 Economics of sesame

3.4.1.1 Effect of nitrogen management

The highest net return of Rs. 52,730 ha^{-1} was secured from treatment N_1 (100 % RDN from inorganic fertilizers) with the maximum B:C RATIO of 4.48. The treatments N_3 and N_2 also recorded higher net return of Rs. 46,967 ha^{-1} and Rs. 49,830 ha^{-1} with B:C RATIO of 3.68 and 3.59, respectively. Similar results were also reported by Deshmukh *et al.* (2002),Jaishankar and Wahab (2005) and Tripathy and Bastia (2012).

3.4.1.2 Effect of sulphur levels

The highest net returns of Rs. 49,053 ha^{-1} was incurred by treatment S_2 (20 kg S ha^{-1}), with maximum B:C RATIO value of 3.69. Similar results were also reported by Wadile *et al.* (2005), Mathew *et al.* (2011),De *et al.* (2013) and Verma *et al.* (2014).

3.4.2 Economics of chickpea

3.4.2.1 Effect of nitrogen management

Application of treatment (N_5) (50 % RDN from vermicompost + 50% RDN from castor cake) to preceding sesame gave highest net realization (Rs.

Table : 3 Economics of sesame, succeeding chickpea and sesame-chickpea cropping sequence as influenced by various treatments

Treatments	Economics of sesame				Economics of succeeding chickpea				Economics of sesame-chickpea cropping sequence			
	Gross realization Rs. ha-1	Cost of cultivation Rs. ha-1	Net realization Rs. ha-1	B:C ratio	Gross realization Rs. ha-1	Cost of cultivation Rs. ha-1	Net realization Rs. ha-1	B:C ratio	Gross realization Rs. ha-1	Cost of cultivation Rs. ha-1	Net realization Rs. ha-1	B:C ratio
Nitrogen management (N)												
N^1: 100% RDN from inorganic fertilizer	67919	15189	52730	4.47	49756	18337	31419	2.71	117675	33526	84149	3.51
N^2: 50% RDN from inorganic fertilizer + 50% RDN from VC	69069	19234	49830	3.59	58620	18337	40283	3.20	127690	37577	90113	3.40
N^3:50% RDN from inorganic fertilizer + 50 % RDN from CC	64523	17555	46967	3.68	56674	18337	38337	3.09	121198	35893	85305	3.38
N^4:25% RDN from inorganic fertilizer + 37.5% RDN from VC + 37.5 % RDN from CC	60908	20005	40903	3.05	60393	18337	42056	3.29	12130	13834	28295	93.16
N^5: 50 % RDN from VC + 50% RDN from CC	58769	21607	37162	2.72	65849	18337	47512	3.59	124618	39945	84673	3.12
Sulphur levels (S)												
S^1: 00 kg ha^{-1}	61251	17765	43486	3.45	56394	18337	38057	3.08	117645	36102	81543	3.26
S^2: 20 kg ha^{-1}	67772	18719	49053	3.62	60530	18337	42193	3.30	128302	37057	91246	3.46
S^3: 40 kg ha^{-1}	63690	19673	44016	3.24	57852	18337	39515	3.15	121541	38011	83531	3.20

47,512 ha^{-1}) and B:C RATIO (3.59) from succeeding chickpea crop over rest of the nitrogen management treatments given in preceding sesame crop in average of two years. Similar results were also reported by Gudadhe *et al.* (2011) and Ghosh*et al.* (2013).

3.4.2.2 Residual effect of sulphur levels

Treatment S_2 (20 kg S ha^{-1}) recorded the maximum net realization Rs. 42,193ha^{-1}with maximum B:C RATIO of 3.30 in average of two years. The lowest monetary net return (Rs. 38,057 ha^{-1}) and B:C RATIO (3.08) was obtained under treatment S_1(00 kg S ha^{1}) Similar results were also reported by Srinivasrao *et al.* (2010).

3.4.3 Economics of sesame-chickpea crop sequence (Table-3)

3.4.3.1 Effect of nitrogen management

The highest net return of Rs. 90,113 ha^{-1} was secured with treatment N_2 (50 % RDN from inorganic fertilizer + 50 % RDN from vermicompost) followed by treatment N_3 (50 % RDN from inorganic fertilizer + 50 % RDN from castor cake) in average of two years. The highest B:C RATIO of 3.51 was secured from sesame-chickpea sequence with the treatment N_1 (100 % RDN from inorganic fertilizer), followed by 3.40 with treatment N_2 in average of two years.

3.4.3.2 Effect of sulphur levels

The highest net realization of Rs. 91,246 ha^{-1} in average of two years) was recorded under treatment S_2(20 kg S ha^{-1}) with the B:C RATIO values of 3.47 in average of two years.

CONCLUSION

From the results of two years experimentation, it can be concluded that application of 50 % RDN (25 kg ha^{1}) from inorganic fertilizer + 50 % RDN (25 kg ha^{-1}) from vermicompost and 20 kg S ha^{-1} applied to sesame crop produced higher yield and net realization of sesame-chickpea cropping sequence, followed by application of 50 % RDN (25 kg ha^{-1}) from inorganic fertilizer + 50 % RDN (25 kg ha^{-1}) from castor cake and 20 kg S ha^{-1} under middle Gujarat condition.

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