DISCUSSION

India is a vast country with over 10 billion inhabitants having diverse nutritional habits which includes consumption of edible oil in large quantity. However, the productivity of oil seed in India is very low vis-à-vis requirement of Indian population. Further it is a matter of great concern that demand for oil seed in India is growing at the rate of 6% per annum which is largely due to the increase in population and partly due to the change in eating habit. So in order to boost up the export potential and meet the International standard improvement in the oil seed quality and yield is a need of hour.

The global consumption of N fertilizers is expected to increase to 1225 million tone per year by the end of 21\textsuperscript{st} Century (Parkasha and Putanna, 2000; GIEWS, 2005 and USDA, 2006). A good amount of the fertilizers is used in oil crops even then the corresponding yield of the crops is alarmingly low. So improvements in seed quality and a better agronomic management is urgently needed to increase the yield potential and total yield of the oil crops.

The slow release fertilizers based on endogenous degradable non-toxic support matrix can be seen as better alternatives for enhancing the oil seed production. It has been demonstrated that the better management in sowing, irrigation, nutrient application and pest control measures have resulted in better yield (Subramaniam and Arulmozhi, 1999; Sarkar and Saha, 2005; Kavoos, 2007; Broschat and Moore, 2007; Wigena et al., 2007).

Slow (controlled) release fertilizers (SRFs) have a potential to manage a high crop productivity (See Saigusa, 1999; Singh et al., 2006; Kavoos, 2007; Broschat and Moore, 2007; Wigena et al., 2007). Unlike the rapidly available soluble fertilizers, SRFs are slow acting due to the delayed release of nutrients
Discussion

often available in bound/immobilized form in or into a non-torix, biodegradable and usually inert matrix. A good SRF should release the nutrient in rhizosphere at the rates and amounts that match the need of the growing plant (Fugaita et al., 1983; Hauck 1985; Saigusa 1999; Singh et al., 2006; Wigena et al., 2007 and Kavoos, 2007). The release rate of the nutrients from SRFs to soil can be controlled by immobilizing the nutrient salts onto or within the matrix which contain materials with impermeable or semipermeable coating through which the dissolved nutrients diffuse, molecular bonds causing low solubility, and small surface to volume ratio of granules for the delayed release of Nitrogen and other nutrients (Prasad, 1998, 1999, 2004; Dahiya et al., 2004; Singh et al., 2006). Broschat and Moore (2007) have recently reported release of ammonium, nitrate, P, K, Mg, Fe and Mn from seven controlled release fertilizers. Kavoos (2007) has found an increased yield of rice by zeolite application. Slow release fertilizers have also been applied in upland rice (Kondo, et al., 2005), in citrus nursery trees (Girarde et al., 2005) and in oil palm (Wigena et al., 2007).

The application of the sulphur and nitrogen at planting stage or during the vegetative stage does not meet the increased demand for fertilizer during later stages of crop growth because of heavy leaching losses and microbial immobilization of sulphate and nitrogenous derivatives (See Shaviv and Mikkelsen, 1993; Singh, 1995; Singh et al., 1998, 2006; Parasad 1998, 1999; Parkasha and Puttana, 2000). Application of slow release fertilizers can overcome the losses and can facilitate a sustained availability of the nutrients. Ideal timing of nutrient supplies at different growth stages of plants results in high crop production and increased growth (Kondo et al., 2005; Giradre et al., 2005; Singh et al., 2006; Wigena et al., 2007; Kavoos, 2007; Broschat and Moore, 2007; Chun et al., 2007).

Our formulation contained non toxic, biodegradable agrowaste from the local sources as cattle manure, nitrification inhibitor neem leaf powder, clay soil, rice bran and saresh as binder. Saresh has been used as binder for the preparation of slow release fertilizer and has a potential to bind with clay soil
particles. Saresh adheres strongly to the supporting matrix clay soil, cow dung, rice bran and neem leaf powder, which consequently form a big complex (supergranules) which may bind with the ammonium sulphate or urea.

Newly developed slow release fertilizer granules make the availability of ammonium and sulphate to the plant consistently throughout the plant life even if the half of recommended dose of free-soluble chemical fertilizer is immobilized with matrix which could minimize the loss of chemical fertilizer and its contamination in air, water, soil and could save cost of cultivation and could enrich soil in terms of organic matter and microbial flora.

The newly developed slow release fertilizer granules containing clay soil, cow dung, neem leaf powder and rice bran immobilized with 10% saresh, were applied to Indian mustard (*Brassica juncea* L.), sesame (*Sesamum indicum* L.) and mentha (*Mentha piperita*) in experimental fields having multiple blocks in random design. The SRFs with 10% saresh (binder) showed better nutrient retention capacity and released the nutrients slowly almost throughout the plant growth phase (Fig. 4.3 & 4.5). Slow release or controlled release fertilizers are much more synchronized with the growth rate of plants and higher recoveries of the nutrients in comparison with conventional fertilizers. (Dahiya *et al.*, 2004; Singh *et al.*, 2006; Kavoos, 2007; Broschat and Moore, 2007 and Wigena *et al.*, 2007).

**Growth and productivity**

Application of these best selected slow release fertilizer granules (SRG-O and SRG-B) showed considerable increase in growth, total biomass and productivity in term of seed yield and oil yield in Indian mustard (Photoplate 4.2), in sesame (Photoplate 4.4) and in mentha (Photoplate 4.5), grown for two subsequent years in experimental fields. Increased growth and yield with the application of slow release fertilizers has also been reported by Allen, 1971, King Kelvin, 2000 (in forage, turf, and strawberries), Dumroese *et al.*, 2005 (in long leaf pine), Kondo *et al.*, 2005 and Kavoos, 2007 (in rice), Girardi *et al.*, 2005 (in citrus tree) and Wigena *et al.*, 2007 (in oil palm). Growth attributes are the primary requirement for development of yield component i.e. number of siliquae per
Discussion

plant, number of seeds per siliqua and low seed weight and yield component are positively correlated with the seed yield. These findings are in conformity with Kachroo et al., 1999; Biswas et al., 2004; Murthy, 2004; Chanda et al., 2005; Hamlin et al., 2006 and Garg et al., 2006). In the present study the number of seeds per siliqua and 1000 seed weight were enhanced significantly with the application of slow release fertilizer granules (SRGs) over the chemical soluble fertilizers of recommend dose. Earlier improvement in these growth and yield attributes led to a higher seed yield of Indian mustard (Table 4.10, Photoplate 4.2).

Best selected slow release fertilizer granules (SRG-O and SRG-B) application, increased growth, total biomass and productivity in terms of seed yield and oil yield in sesame (Photoplate 4.4). SRG-O and SRG-B, increased the number of capsules per plant and number of seeds per capsule very significantly. SRG-O applied plants increased number of capsules per plant and number of seeds per capsule by 65% and 29%. SRG-B applied plants increased number of capsules by 21% and 16%. A total yield of 24.99 q/ha was obtained in SRG-O and 15.91 q/ha in SRG-B applied plants (Table 4.22).

SRG-O and SRG-B applied plants showed significant increase in shoot length and total biomass in mentha (Photoplate 4.5). Oil contents were also found increased in SRG-O and SRG-B applied plants (Fig. 4.34). Ammonia assimilation

The higher productivity was also related to the increased ammonia assimilation by the plants which is evident by increase in L-glutamine synthetase (GS) (total and specific) activity and total soluble protein. In 45 days old mustard plants, increase in total soluble protein was recorded by 23% with recommended dose of chemical fertilizer and 33% with SRG-O over control with chemical fertilizer in one basal dose (Fig. 4.3). The application of SRG-O significantly increased the total and specific L-glutamine synthetase (GS) activities (Fig. 4.3). The mustard crop showed significantly higher sulphur content in leaf (33%) and seeds (28%) at maturity in SRG-O treated plants, followed by 22% and 14%
increase in recommended dose of chemical fertilizer applied plants over the control with no fertilizer (Table 4.9).

In sesame, the increase in ammonium level was more pronounced on 30 days and 45 days old plants. The application of SRG-O and SRG-B significantly increased the total and specific L-glutamine synthetase activity and similarly increased total soluble protein, nitrogen content and sulphur content.

The higher sulphur content in plants applied with SRG-O may be attributed to its better vegetative growth which might have caused increase in its root proliferation and ultimately led to higher absorption of sulphur from the soil and significant increase in sulphur content of seed in SRG-O applied plants might be due to higher sulphur content of plant during its vegetative growth period, whereas plants applied with chemical fertilizer with one basal dose, in split dose and the dose conventionally applied by farmers showed non-significant differences in sulphur content during both the years. The sulphur content in plant was significantly influenced throughout the crop growth period with the application of SRG-O, as the plant got the nutrient almost throughout the plant life. The higher concentration of sulphur in both plant and seed may be due to increased availability of sulphur. High sulphur requirement for synthesis of oil as well as sulphur containing amino acids in Brassica species has also been reported by Arora et al., (1994); Dubey and Khan (1993 b); Buchner et al., (2004); Schnug et al., (2005); Sudeep and Bhuttar, (2006).

Nitrogen concentration in plants applied with SRG-O may be attributed to its better vegetative growth which might have caused increased in its root proliferation and ultimately led to higher absorption of nitrogen from the soil and caused significance increase in nitrogen contents. The mustard crop showed significantly higher nitrogen content in plant (45%) and seeds (48%) at maturity in SRG-O treated plants, followed by 27% and 35% increase in recommended dose of chemical fertilizer applied plants over the control with no fertilizer (Table 4.9). The nitrogen content in plants was significantly influenced throughout the crop growth period with the application of SRG-O, as the plant got the nutrient almost throughout the plant life. The higher concentration of
nitrogen in both plant and seed may be due to increased availability of nitrogen throughout the plant life (Buchner et al., 2004; Hogler et al., 2004 and Victoria et al., 2004).

Nutrient contents

Brassica juncea maintained its superiority in nitrogen, sulphur and protein content in SRG-O treatment. The results presented in Table 4.9 showed that total protein, sulphur and nitrogen content (%) in leaf and in seed at maturity was maximum in slow release fertilizer (SRG-O) applied plants.

In sesame, 19.3% (leaf) and 27.5% (seed) protein contents, 3.09% (leaf) and 4.46% (seed) nitrogen contents and 1.62% (leaf) and 0.24% (seed) sulphur contents were present in SRG-O applied plants (Table 4.21).

Their superiority in nitrogen, sulphur and protein content may be due to constant availability of nutrient to the plant throughout its life which increased their absorption and improve concentration of nutrients in plants. This might be explained with the fact that crop under regular supply of fertilizer accumulated more of these nutrients in seed and plants at one hand simultaneously improved their respective production remarkably on the other hand, which in combination resulted into higher total uptake of these nutrients by the crops. These results are in close conformity with the findings of many research workers (Singh et al., 1996; Dhaka, 1999; Shukla and Kumar, 2005; Singh et al., 2006).

Quality parameters

Regular fertilizer supply and plant nutrient management plays a vital role in quality parameters of mustard. Chemical fertilizer applied in bound form increased the protein content and oil yield in the seed. This may be due to the fact that more and long availability of nitrogen and sulphur increased the proportion of protein substances in the seed, (Singh and Kumar 1999; Annual Progress Report 2000; Ahmad et al., 2005; Osborne and Batten, 2006), and because of increase in efficiency of nitrogen uptake, utilization and long lasting supply of nitrogen in later growth stages. In present study, slow release fertilizer in bound form increased the oil content as well as the protein content. This
increase in oil content might be attributed to the constant availability of sulphur and boron. Tiwari et al., 2003, also found similar results with the application of sulphur and boron. The regular supply of these nutrients seems to be involved with an increased conversion of primary fatty acid metabolites to end products of fatty acid (Shukla et al., 2002). Since the oil yield and protein yield are the function of seed yield, their respective content in the seed increased with the regular supply of fertilizer throughout the plant life and nutrient management practices. These results are in close conformity with the results of Tomer et al., 1996; Singh and Kumar 1999; Ahmed et al., 2005; Osborne and Batten, 2006.

The result of present study illustrated the prominent role of regular availability of fertilizer for enhancing productivity and quality of seed. The decline in oil content may be due to higher protein content in seed when the flowering is delayed. Moreover shorter reproductive phase under delayed sowing also caused poor development of seed and resulted into its lower oil content. The application of slow release fertilizer not only increases the yields but improves the product quality also. Slow release fertilizer increased the oil content by 26% in mustard (Table 4.11). Due to combined influence of yield increase and oil content, the oil yield of mustard increased significantly. Oil contents and oil yield were found increased significantly in SRG-O and SRG-B applied plants over chemical fertilizer and biofertilizer used in free form in sesame (Fig. 4.25). The oil content of crop decreased with the application of fertilizer in free form as compare to bound form. The decrease in oil content with the application of chemical fertilizer in free form might have caused due to increase in protein content in seed that led to an inverse effect on oil synthesis as reported by Dubey et al., 1994 and Ahmad et al., 2005. Data obtained show that oil yield was significantly influenced by the mode of fertilizer application, SRG-O, significantly increased the oil yield of the crop. This increase in oil yield could be ascribed to combined effect of higher oil content and seed yield. Comparative effect of different treatments on growth, yield parameters and oil yield in mustard, sesame and mentha is shown in Fig. 5.1, describing clearly the best
effects of chemical fertilizer and biofertilizer in immobilized form, on overall performance of plants.

Quality of seed measured in terms of seed protein was also improved with the newly developed slow release fertilizer granules. As discussed earlier, the nitrogen and Sulphur assimilation is linked at metabolic level and therefore, their adequate and balanced supply is essential to optimize uptake and assimilation of these nutrients by the crop and their subsequent conversion into the nitrogenous and sulphur amino acids needed for protein synthesis (Buchner et al., 2004; Hogler et al., 2004; Victoria et al., 2004; Osborne and Batten, 2006 and Patra et al., 2006). Consequently, the adequate and balanced supply of S and N through slow release fertilizer in our study had led to the increased protein content in the seeds.

The most important component of vegetable oil is its fatty acid spectrum, which determines its suitability for human consumption. The physical properties and nutritional value of oils is determined by the types and the proportions of different fatty acids present in their triglycerides. These fatty acids may be saturated or unsaturated. High ratio of unsaturated : saturated fatty acids is desirable for human consumption of oil. Lower amount of linolenic acid (polyunsaturated) improve the stability of oil (self life of oil), while lower proportion of erucic acid will make the oil more palatable, nutritive and less vulnerable to metabolic disorders. On the other hand increased proportion of two major fatty acids, oleic and linolenic improve the nutritional value of oil. The oleic acid (monounsaturated) being thermostable, is desirable for cooking oil and linolenic acid is important because it is basis for the formation of prostaglandin and other essential body regulators (Downey and Rakow, 1987). The best selected treatment is therefore, is the one which possess high amount of oleic acid and linolenic acid and low amounts of erucic acid (Singh, 1995). In present study, newly developed slow release fertilizer (SRG-O) possess this type of desirable fatty acid composition except a little bit high value of linolenic acid. However, the free chemical fertilizer applied crop was found to have relatively
Fig. 5.1. Comparative effect of different treatments on growth, yield parameter and oil yield in Brassica juncea, Sesamum indicum and Mentha piperita

**Brassica juncea**

- Dry weight at 45 days
- GS specific activity at 45 days
- Total soluble protein at 45 days
- Seed yield q/ha
- Oil yield q/ha

**Sesamum indicum**

- Dry weight at 45 days
- GS specific activity at 45 days
- Total soluble protein at 45 days
- Seed yield q/ha
- Oil yield q/ha

**Mentha piperita**

- Shoot length at 60 days
- No. of side branches per plant
- Dry weight at 60 days
- Oil content (%)
higher amount of oleic, linolenic and erucic acid. Results obtained illustrate that quality of oil deteriorated slightly in the treatments where chemical fertilizer was applied in two split dose, recommended dose and chemical fertilizer in one basal dose respectively as compare to SRF formulations, because erucic acid increased and that of linoleic and oleic acid decreased. This is in agreement with the findings of Yadav et al., 1995; Singh et al., 1996; Tomar et al., 1997; Sharma et al., 1997; Ahmad, 2001 and Gupta et al., 2002 on their commercial interest in the development of high erucic acid and targeted towards industrial use.

Data on growth parameters indicate that mustard and sesame did not differ significantly in various parameters observed but biofertilizer (Azotobacter) significantly increased the plant height, branch number, siliquae/capsule number and seed weight per plant. The effect of biofertilizer (Azotobacter) is found more prominent and significantly increased the growth and yield parameter (Chauhan et al., 1996; Gudadhe et al, 2005; Nisar Ahmad et al., 2005 and Arya et al., 2007), over no fertilizer. These findings are similar to the findings of other workers (Laxminarayan, 1995; Ram et al, 1999; Vyas, 2003; Baldev and Pareek, 1990; Kundu and Gaur, 1984; Gudadhe et al., 2005; Nisar Ahmad et al., 2005 and Arya et al., 2007). It is further observed that increased assimilate partitioning capacity of biofertilizer treated plants towards seed and increase in shoot and root length has more pronounced effect on seed yield. This indicate that seed yield may be closely associated with the characters relating to assimilate synthesis and their transport towards seed due to interminate growth habit of the plant where vegetative and reproductive growth continues simultaneously.

The best performance supergranules (SRG-B) containing cow dung, clay soil, rice bran and neem leaf powder as matrix alongwith Azotobacter (non-symbiotic N\textsubscript{2} fixing rhizobacteria) immobilized with 10% saresh was applied to Indian mustard (Brassica juncea L), sesame (Sesamum indicum L) and mentha (Mentha piperita).
Biofertilizers are seen as a potential eco-friendly nutrient system for sustainable plant productivity (Sindu and Dadarwal, 1995; Prasad, 1998, 1999; Mishra et al., 1999; Sellstedt, 1999; Sinha et al., 2002a,b; Sindhu et al., 2003; Nisar Ahmad et al., 2005 and Arya et al. 2007). The popularity of biofertilizers are limited, however, due to their lower responsiveness to the plant productivity and the lack of awareness and technical know-how to the conventional farmers. The share occupied by the various kinds of biofertilizers is still meger in crop productivity in context of the chemical fertilizer use. With biofertilizer application it is further observed increase assimilate partitioning capacity of immobilized biofertilizer treated plants towards seed and large developed biomass has more pronounced effect on seed yield. The future of agriculture, thus depends on the use of biofertilizers as a potential source of nutrients (Chauhan et al., 1996, Gudadhe et al., 2005; Arya et al. 2007). This indicate that seed yield may be closely associated with the characters relating to assimilate synthesis and their transport towards seed due to indeterminate growth habit of the plant where vegetative and reproductive growth continues simultaneously. The findings indicated that immobilized Azotobacter have positive effects on growth and yield of Indian mustard, sesame and mentha as compare to the biofertilizer applied in free form without any matrix.

Our data indicate that the growth rate of the crop studied are affected significantly due to the salt stress during the early vegetative phase. Several studies are available which report variable decrease in length, fresh and dry weight of plant at various stages under the salt stress due to the adverse effects of the salinity on their metabolic processes (Sharma et al., 1996; Kent and Lauchli, 1985; Khuhad and Sheoran, 1987; Datta and Dayal, 1987; Abdel et al., 1994; Kader et al., 2003 and Chauhan et al., 2005). The reduction in biomass is an important cause of reduction in growth (Frechilla et al., 2001 and Chauhan et al., 2005). Almost out of the 1.5 billion hectare land that cultivated, about 5% i.e. 77 million hectare is salt affected. The problem of salinization of land is increasing primarily due to the bad agricultural practices. Land salinity problem in India is
noless. About 17.5 million hectare out of total land area of 32.9 million hectare in India is waste land out of which more than 12 million hectare land area is salt affected. This saline land result in low yield of crops with the present way of using chemical fertilizers. This result is compounding the problem of available chemical fertilizer and also further increase of the salinity of land.

From the present investigation it is clear that saline stress decrease the plant and root growth, primary nitrogen metabolism by varying magnitude whereas it caused the ionic imbalance in plants by modifying the nutrient and ionic uptake. Salinity stress caused a significant reduction in yield due to delay in flowering, number of siliquae/capsule number per plant, number of seeds per siliqua/capsule and seed weight in salt stress plants. In conformity, reduction in seed yield and its attributing character have been reported in *Cicer arientum* (Manchanda *et al.*, 1991). The decrease in yield could be attributed to greater accumulation of Na+ and Cl− in tissues, which proved detrimental to plant growth (Manchanda *et al.*, 1991), low photosynthetic activity of leaves and lower rate of translocation of photosynthates (Soussi *et al.*, 1999). Soil salinity leads to a decrease in yield and its attributes in crop plants depending upon their sensitivity (Promila and Kumar, 1982; Sharma and Gill, 1994; Chauhan *et al.*, 2005). Soil salinity is reported to cause a decline in seed yield of legumes and this reduction was described to different factors such as reduction in number of pods, number of seed pod−1 and seed size.

Salt stress conditions has been found to affect uptake, assimilation, mobilization and transport of nitrogen in various plant species which vary with different modes of fertilizers and other agro-climatic conditions (see Srivastava, 1992; Dubey *et al.*, 1995; Lips, 1999; Burmen *et al.*, 2003).

Our data showed significant effect on L-glutamine activities with different SRGs. The enzyme glutamine synthetase (GS) involved in ammonia assimilation in plants are known to be affected markedly under the saline conditions in many plants, (Mishra and Dwivedi, 1990; Chaillou and Guerrier, 1992; Sadale and Karadge, 1993; Silveira *et al.*, 1999). Growth and yield reduction occur as a result
of shortening of lifetime of individual leaf thus reducing net productivity and yield (Munns, 2002; Chauhan et al., 2005). The salinity stress make fast growing plants to slow growing to survive with low ion and water uptake, nitrite assimilation capacity, photosynthesis and transpiration etc.

Nitrogen fertilization is a technique to alleviate salinity effects on crop plants has been recommended (Lips et al., 1990) as large amount of nitrogen is needed for plant growth as well as for the maintaining high levels of nitrogenous osmoprotectant molecules under the stress (Veen and Kleinendorst, 1985; Sagi et al., 1998; Shankhdhar et al., 2004). Within the each salinity level applied, NR activity in leaves of tomato and cucumber increased with NO$_3^-$ fertilization levels (Martinez and Cerda, 1989).

Although protein biosynthesis generally declines under the stress conditions, cells preferentially synthesize specific stress proteins. Several proteins induced in response to saline environment have been identified from many plant species (See Pareek et al., 1997). The protein content decreased in leaves of mustard and sesame slightly at low salinity. The salinity induced decline in protein has been observed in many cases (Ramanjulu et al., 1994; Mishra et al., 1994,1996; Chauhan et al., 2005).

**Cost Analysis**

Economics of cultivation was determined by detailed economic analysis of the input cost and the income obtained.

The total cost of cultivation was sum of common and variable costs of different treatments.

The economics of various treatments have been worked out of the prevailing market rate during both the years of the experimentation.

Chemical fertilizer application to the crop needed an additional expenditure over no fertilizer application. Use of matrix and binder also needed and additional expenditure in the purpose of immobilization.

Data regarding to economics of mustard crop cultivation (Table 5.1) indicated that SRF formulation, SRG-O gave maximum net return of
Table 5.1. Net loss/gain in terms of economic return for Indian mustard cultivated using various kinds of fertilizers

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Labour + Field preparation (Rs.)</th>
<th>Input cost (Rs.)</th>
<th>Income (Rs.) ha⁻¹</th>
<th>Net seed yield</th>
<th>Approx. rate q¹</th>
<th>Cost of product</th>
<th>Net loss/gain (+/-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fertilizer</td>
<td>7,032</td>
<td>52</td>
<td>7,084</td>
<td>15.8</td>
<td>2,800</td>
<td>44,240</td>
<td>(+) 37,156</td>
</tr>
<tr>
<td>DAP</td>
<td>7,232</td>
<td>52</td>
<td>8,244</td>
<td>36.75</td>
<td>2,800</td>
<td>1,02,900</td>
<td>(+) 94,656</td>
</tr>
<tr>
<td>Gyp+Urea+Boron (basal dose)</td>
<td>7,232</td>
<td>52</td>
<td>7,467</td>
<td>37.5</td>
<td>2,800</td>
<td>1,05,000</td>
<td>(+) 97,533</td>
</tr>
<tr>
<td>Gyp+Urea+Boron (split dose)</td>
<td>7,432</td>
<td>52</td>
<td>7,867</td>
<td>39.4</td>
<td>2,800</td>
<td>1,10,320</td>
<td>(+) 1,02,453</td>
</tr>
<tr>
<td>Recommended dose</td>
<td>7,232</td>
<td>52</td>
<td>8,211</td>
<td>54.6</td>
<td>2,800</td>
<td>1,52,880</td>
<td>(+) 1,44,669</td>
</tr>
<tr>
<td>SRG-O</td>
<td>7,232</td>
<td>52</td>
<td>21,747</td>
<td>67.3</td>
<td>2,800</td>
<td>1,88,440</td>
<td>(+) 1,66,693</td>
</tr>
<tr>
<td>Azotobacter (free form)</td>
<td>7,232</td>
<td>52</td>
<td>7,354</td>
<td>44.4</td>
<td>2,800</td>
<td>1,24,320</td>
<td>(+) 1,16,966</td>
</tr>
<tr>
<td>SRG-B</td>
<td>7,232</td>
<td>52</td>
<td>21,354</td>
<td>58.1</td>
<td>2,800</td>
<td>1,62,680</td>
<td>(+) 1,41,326</td>
</tr>
</tbody>
</table>

Approx. input cost and cost of the produce has been calculated on the available rates for 2003-04 when crops were cultivated in the experimental fields during this study.
<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Labour + Field preparation (Rs.)</th>
<th>Fertilizer seed (Rs.)</th>
<th>Others (Rs.)</th>
<th>Net seed yield (kg)</th>
<th>Total cost (Rs.)</th>
<th>Income (Rs.) ha(^{-1})</th>
<th>Cost of product rate ha(^{-1})</th>
<th>Net loss/gain ((+/-) Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fertilizer</td>
<td>7,032</td>
<td>40</td>
<td>14,000</td>
<td>7,808</td>
<td>21,640</td>
<td>24,480</td>
<td>2,000</td>
<td>(+) 12,808</td>
</tr>
<tr>
<td>Recommended dose</td>
<td>7,322</td>
<td>40</td>
<td>736</td>
<td>1,595</td>
<td>6,031</td>
<td>9,994</td>
<td>3,000</td>
<td>(+) 23,372</td>
</tr>
<tr>
<td>SRG-O Azotobacter (unbound)</td>
<td>7,322</td>
<td>40</td>
<td>368</td>
<td>24,99</td>
<td>7,491</td>
<td>24,480</td>
<td>2,000</td>
<td>(+) 28,340</td>
</tr>
<tr>
<td>SRG-B</td>
<td>7,322</td>
<td>40</td>
<td>70</td>
<td>15,91</td>
<td>21,342</td>
<td>24,480</td>
<td>2,000</td>
<td>(+) 17,138</td>
</tr>
</tbody>
</table>

Approx. input cost and cost of the produce has been calculated on the available rates for 2003-04 when crops were cultivated in the experimental fields during this study.
Table 5.3. Net loss/gain in terms of economic return for Mentha cultivated using various kinds of fertilizers

| Fertilizer          | Labour + Field preparation | Fertilizer ha⁻¹ seed | Fertilizer | Others | Total | Net seed yield | Approx. rate q⁻¹ | Cost of product | Net loss/gain (-/+)
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No fertilizer</td>
<td>7,032</td>
<td>22,500</td>
<td>-</td>
<td>-</td>
<td>29,532</td>
<td>41.4</td>
<td>750</td>
<td>31,050</td>
<td>(+) 1,518</td>
</tr>
<tr>
<td>Recommended dose</td>
<td>7,232</td>
<td>22,500</td>
<td>1,530</td>
<td>-</td>
<td>31,262</td>
<td>72.7</td>
<td>750</td>
<td>54,525</td>
<td>(+) 23,263</td>
</tr>
<tr>
<td>SRG-O</td>
<td>7,232</td>
<td>22,500</td>
<td>765</td>
<td>14,000</td>
<td>44,497</td>
<td>104.8</td>
<td>750</td>
<td>78,600</td>
<td>(+) 34,103</td>
</tr>
<tr>
<td>Azotobacter (unbound)</td>
<td>7,232</td>
<td>22,500</td>
<td>-</td>
<td>70</td>
<td>29,802</td>
<td>54.2</td>
<td>750</td>
<td>40,650</td>
<td>(+) 10,848</td>
</tr>
<tr>
<td>SRG-B</td>
<td>7,232</td>
<td>22,500</td>
<td>-</td>
<td>14,070</td>
<td>43,802</td>
<td>72.0</td>
<td>750</td>
<td>54,000</td>
<td>(+) 10,198</td>
</tr>
</tbody>
</table>

Approx. input cost and cost of the produce has been calculated on the available rates for 2003-04 when crops were cultivated in the experimental fields during this study.
(Rs. 1,66,693) followed by recommended dose (Rs. 1,44,669). Biofertilizer (Azotobacter) application in immobilized form increased the net return appreciably. An extra income of Rs. 24,360 under SRG-B was recorded over the control (Azotobacter in free form).

Data regarding to economics of sesame crop cultivation (Table 5.2) indicate that SRF formulation, SRG-O gave maximum net return of (Rs. 28,340) followed by recommended dose (Rs. 23,372). Biofertilizer (Azotobacter) application in immobilized form increased the net return appreciably. An extra income of Rs. 18,478 under SRG-B was recorded over the control (Azotobacter in free form).

Data regarding to economics of mentha crop cultivation (Table 5.3) indicate the SRF formulation, SRG-O gave maximum net return of (Rs. 34,103) followed by recommended dose (Rs. 23,263). Biofertilizer (Azotobacter) application in immobilized form increased the net return appreciably. An extra income of Rs. 12,973 under SRG-B was recorded over the control (Azotobacter in free form).

Application of chemical fertilizer even in half of the recommended dose, immobilized with matrix (SRG-O) resulted appreciable increase in net return. It might be owing to favorable effect of SRGs on the yield attributes and thereby increasing the seed yield and net return compared to control. Applying fertilizer nutrients at the correct rate, time and place could increase both crop yield and farmer’s needs and society’s expectations for wise use of our environment.

Confronted with the global problem of shortage of oil seeds, chemical fertilizers and ever increasing salinity of agricultural land, this study has been conducted with an aim of finding ways to increase the productivity of oil seed crops to improve the quality of vegetable oil, to get better yield of oil crops from non saline and saline land and to minimize the use of chemical fertilizers yet getting the better yield of oil seed in the most eco-friendly ways and to reduce the cost of the produce.