DISCUSSION

The results of the experiment entitled "Influence of Digested Sludge Application on Sesamum" as presented in the preceding chapter are being discussed, elucidated and interpreted in the light of established principles of crop science, Agricultural Chemistry and soil science and findings of research workers in the country and abroad.

5.1 Composition of Digested Sludge

The composition of the digested sludge used for the present investigation has been determined by standard procedures as described in the materials and methods and presented in the Table 1 in the preceding chapter. From perusal of the data, it is obvious that the sludge used for cultivation of the Sesamum crop had the potential to be used as fertilizer. According to Kanwar (1970) the sewage sludge is a rich source of plant nutrients and other organic wastes. He found that average content of N, P_2O_5 and K_2O in raw sewage was 66.2, 22.1 and 42.1 mg/L, respectively. King (1971)
reported that sludge applied on land caused an increase in the pH value from 7.4 to 7.8. Sludge application to neutral and acid soils decreased pH because of the acidity generated from the mineralization and nitrification of added sludge. Chaney et al. (1980) suggested that composted municipal sewage sludge is an acceptable organic amendment for blending potting media and a source of essential nutrients for plant growth and they found that it was a good source of organic matter which plays a vital role in soil fertility. Berglund (1982) reported that sludge improves soil texture, structure and water holding capacity. Studies carried out at NEERI by Juwarkar et al. (1991) showed that organic matter content and infiltration increased from 0.78 to 1.33\% and 5.88 to 7.80 cm/day respectively, whereas bulk density decreased from 1.68 to 1.48 at the sludge loading of 90t/ha. Kosobucki et al. (2000) reported that quantitative and qualitative composition of sewage sludge is very complicated, it is rich in organic matter, macroelements (N, P, K, Mg, S) and other microelements necessary for plants and soil fauna.
Dolgen et al. (2006) proposed that recycling of sludge for agricultural purposes seems to be an appealing solution that enables valuable components to be recycled. Kidd et al. (2007) found that Sewage sludge could be used as an amendment to agricultural soils and the application of sludge also increases soil organic matter content that contributes to the structural stability of the soil and to its resistance to erosion. The usage of sewage sludge has been encouraged in amendment of agricultural soils for many years, and this is a more economically attractive way than other methods used for sludge disposal including landfill and incineration because of the fact that using sewage sludge enables the waste materials to be recycled and at the same time, the natural resources and energy are saved effectively. In this study, significant levels of Nitrogen, phosphorus, potassium, sulphur and organic matter was detected in digested sewage sludge. These findings support the viewpoint that digested sewage sludge has the high potential agricultural benefits for land application and on account of it being a cheap source sewage sludge can be explored as an alternative source of
providing manure in the underdeveloped and developing countries.

5.2 Influence of digested sludge application on yield attributes of *Sesamum indicum*

(i) **Plant Height**: The plant height of the *Sesamum indicum* Type 13 demonstrated an increasing trend (table 2) with the increase in the doses of the digested sludge application during both the years of experimentation. Maximum plant height was obtained with the application of 10 tonnes of digested sludge per hectare during both the cropping seasons. This was significantly superior over all the other treatments and at par with the application of 8 tonnes of digested sludge per hectare. The increase in the plant height during both the years of the field trial might be due to the fact that the digested sludge is an excellent soil conditioner. It is not only a rich source of macro-elements (NPK) needed for normal plant growth but also provides the vital organic matter for the plants leading to a vibrant and healthy growth. The findings of the present investigation are in accordance with the findings of Singh *et al.* (2004) who reported that shoot length and number of leaves increased in the
plants of *Helianthus annuus* grown on soil amended with different amount of tannery sludge. The results obtained in the present investigation are in conformity with the results obtained by Kauthale *et al.* (2005) who found that minerals in organic matter in sewage sludge seem to have some benefits for growth and yield of crops: The results obtained are also accorded with the earlier research results reported by Wei and Liu (2005). They suggested that abundant nutrition in sewage sludge can increase the output and yield attributes of vegetables and other crops. Similar findings have also been reported by Pascual *et al.* (2008).

(ii) **Number of Branches per plant**: The application of sewage sludge had a positive and statistically significant impact on the number of branches per plant (Table 3) in the *Sesamum indicum* Type 13 variety during both the cropping seasons. Maximum numbers of branches per plant were recorded with the application of 8 tonnes of digested sludge per hectare during both the years of field experiment and it was statistically significant over all the other treatments but at par with the treatment receiving 10 tonnes of digested sludge per hectare.
The increase in the number of branches may be due to the enhanced availability of the essential nutrients for plant growth in the case of digested sludge. The significant amount of organic matter present in the digested sludge may have played a vital role in increasing the vigor of the crop which is evident from the increase in the number of branches. Snyman et al. (1998) and Delgado et al. (2002) confirmed that it is possible to use sewage sludge as fertilizer which led to increase in biomass and yield of plants. The results of the present investigation are in conformity with the findings of Seleiman et al. (2010). They reported that in oilseed rape, the maximum values of dry weight of plant, leaf area, photosynthesis, number of siliques per plant and number of seeds per plant were obtained from the 100% sludge treatment. However, the highest number of branches per plant, weight of siliques per plant, seed weight per plant and whole plant weight were obtained from the sludge-peat treatment.

(iii) Number of Pods per Plant: Perusal of data (Table 4) with respect to number of pods per plant in *sesamum* crop as influenced by digested sludge application clearly demonstrates a
statistically significant and positive impact of the increase in the doses of the digested sludge during both the years of field trial. Maximum number of pods was recorded with the application of 10 tonnes of digested sludge per hectare. The results obtained are similar to the findings of Pascual et al. (2008). They reported that ATAD (Autothermal Thermophilic Aerobic Digested) and mesophile sludge application increased the growth and yield of plants, and accelerated their phenological development as the sludge rate increased. The accelerated phonological development ultimately led to an increase in the number of pods per plant. Similar mechanism might be responsible for the increase in the number of pods during both the years of present investigation. The findings of the present investigation are also supported by the results obtained by Seleiman et.al. (2010).

(iv) **1000-Seed Weight**: The 1000-seed weight recorded an increasing trend with simultaneous increase in the doses of the digested sludge during both years (Table 5) of field experiment. Maximum 1000-seed weight was recorded with the application of 8 tonnes of digested sludge per hectare in both the cropping
seasons. The increase in the 1000-seed weight might be due to the fact that digested sludge is a good source of macroelements such as NPK. It is a well-established fact that phosphorus is an important constituent in the process of carbohydrate assimilation i.e., photosynthesis, its absorption thereby leads to its efficient accumulation in seeds leading to higher test weight. The role of phosphorus in starch biosynthesis in storage tissue of plant is well established. Phosphorus acts as an active ingredient and structural constituent of almost all the substrates of starch biosynthesis pathway in storage tissue of all the plants. This reason seems to play a major role in increasing test weight of the sesame seeds subjected to increasing doses of digested sludge. The findings are in agreement with the observation of Yadav et al. (1998), Sharma and Bhardwaj (1998). Similar results have also been reported by Seleiman et al. (2010) who proposed that increase in seed weight per plant and whole plant weight were obtained from the sludge-peat treatment in the case of oilseed rape.

(v) Grading for color: The application of digested sludge had a positive impact on the color of the Sesamum Type 13 variety
(Table 6). The treatments receiving increasing doses of the digested sludge had the most natural white color while the treatments receiving low doses of the digested sludge led to somewhat decrease in the whiteness of the seeds although it was statistically non significant. Natural white colour of seed might be due to the fact that sludge provide in addition to major nutrients and micronutrients too.

(vi) Grading for Vigor: The vigor of the sesamum crop was measured at 15, 30, 45 and 60 DAS. The data presented (Table 7) clearly indicated that the treatments receiving digested sludge with increasing doses led more profuse growth as compared to the treatment receiving no fertilizer. The increase in the vigor recorded with the increase in the doses of digested sludge was statistically non significant.

5.3 Influence of digested sludge on seed and straw yield

(i) Seed Yield (Kg ha⁻¹): The seed yield of the Sesamum indicum Type 13 varieties exhibited an increasing trend with the increase in the doses of the digested sludge application during both the years of experimentation. Maximum plant height was obtained with the application
of 8 tonnes of digested sludge per hectare during both the cropping seasons. This was significantly superior over all the other treatments and at par with the application of 10 tonnes of digested sludge per hectare. The increase in the seed yield during both the years of the field trial might be due to the fact that the digested sludge is an excellent soil conditioner having appreciable fertilizer qualities. It is a rich source of macro-elements (NPK) needed for normal plant growth and also provides the vital organic matter for the plants leading to a vibrant and healthy growth. The results obtained in the present investigation are in accordance to the results obtained by Kauthale et al. (2005) who found that minerals in organic matter in sewage sludge seem to have some benefits for growth and yield of crops. The results obtained are also supported with the earlier research results reported by Wei and Liu (2005). They suggested that abundant nutrition in sewage sludge can increase the output and yield attributes of vegetables and other crops. Similar findings have been reported by Pascual et al. (2008).
(ii) **Straw Yield (Kg ha⁻¹)**: A positive and statistically significant impact on the Straw yield in the *Sesamum indicum* Type 13 variety is evident with the application of digested sludge in increasing doses during both the cropping seasons. Maximum straw yield were recorded with the application of 8 tonnes of digested sludge per hectare during both the years of field experiment and it was statistically significant over all the other treatments but at par with the treatment receiving 10 tonnes of digested sludge per hectare. The increase in the straw yield may be due to the enhanced availability of the essential nutrients for plant growth in the case of digested sludge. The significant amount of organic matter present in the digested sludge may have played a vital role in increasing the vigor of the crop which is evident from the increase in the straw yield and also the number of branches per plant during both the cropping seasons. The results of the present investigation are in conformity with the findings of Snyman et al. (1998) and Delgado et al. (2002) who proposed that it is possible to use sewage sludge as fertilizer which
led to increase in biomass and yield of plants. The results of the present investigation are in accordance with the findings of Seleiman et al (2010). They reported that in oilseed rape, the maximum values of dry weight of plant, number of siliques per plant and number of seeds per plant were obtained from the 100% sludge treatment. However, the highest number of branches per plant, weight of siliques per plant, seed weight per plant and whole plant weight were obtained from the sludge – peat treatment. Thus the findings of the present investigation and previous research findings validate the fact that the increase in doses of digested sludge can have a positive and statistically significant impact on the straw yield of the Sesamum plants.

5.4 Influence of digested sludge on oil content of Sesamum indicum

The oil content of the sesamum seeds as affected by increasing doses of digested sludge application has been numerically depicted in Table 9. It is obvious from the data presented in the table that digested sludge with increasing doses
was instrumental in increasing the oil content. Maximum oil content was recorded with the application of 8 tonnes of digested sludge per hectare during both the years of experiment. This was statistically significant over all the other treatments but at par with the treatment receiving 10 tonnes of digested sludge per hectare. The increase in the oil content may have been the direct outcome of the significant amount of sulphur content available in the digested sludge. Marschner (1986) reported that sulphur is the fourth major nutrient in crop production. Most crops require as much sulphur as phosphorus. The nitrogen and sulphur requirements of crops are closely related, because both nutrients are required for protein synthesis. Sulphur is involved in the synthesis of chlorophyll and is also required for the synthesis of oil. Chaudhry et. al. (1992) reported that sulphur increases the percentage of oil content of the seed. The increase in oil content was a result of increased availability of sulphur due to digested sludge application. Sulphur is known to enhance oil content by accelerating the process of oil biosynthesis in oil seed crops. Significant amount of sulphur in the digested sludge doses used in the present investigation may
have been instrumental in creating a favorable nutritional environment for production of metabolites responsible for oil synthesis in plants. Pasricha and Fox (1993) and Tomar et al. (1997) have stressed upon the fact that higher levels of sulphur and its increased availability favorably increases the transformation of carbohydrates into oil. This ultimately results in increased oil content by hydrolysing more glucosides due to increased availability and presence of sulphur. Mishra and Abidi (2002) have reported similar findings and acknowledged the role of sulphur in increasing oil content of the *Brassica juncea* L varieties. Jan et al. (2002), recorded significant increase in oil content by sulphur application (60 kg S ha\(^{-1}\)) compared to control.

5.5 Influence of digested sludge application on soil properties

Different properties of the soil as affected by the application of digested sludge have been presented in the preceding chapter (Table 10). It is evident from the data that digested sludge had a significant impact on some of the properties of the soil. The available N, P&K level in the soil was significantly increased with simultaneous increase in the doses of
the digested sludge. Maximum available N, P & K content was observed in the treatment receiving 10 tonnes of digested sludge per hectare. The findings of the present investigation are in accordance with the results obtained by Epstein et al. (1976). They reported that soil's nitrate nitrogen level, available phosphorus and CEC were increased with the application of sludge during a two year study and phosphorus level appeared to be in excess of that needed for normal plant growth. Naylor (1993) proposed that the organic matter in sludge also acts as a relatively long-term reserve for major nutrients like nitrogen, phosphorous, and potassium. It is estimated that 10 to 15 percent of nitrogen in this organic matter may be released during the first growing season through mineralization, with residual nitrogen released over the next 2 to 3 years.

Beck et al. (1996) reported that application of sewage sludge to agricultural land may be beneficial because it can improve the physical, chemical and biological properties of soils which may enhance crop growth: Rogers (1996) found that in sewage sludge major organic loading originates from human excreta, and is a complex mixture of fats, proteins,
carbohydrates, lignin amino acids, sugars, cellulosics, humic material and fatty acids.

The reduction of soil pH with increasing sludge application is evident from the data presented in the table 10. The decrease in the pH may be partly attributed to the lower pH of sludge, and also to microbial nitrification of ammonium contained in sludge. Similar findings were obtained by Patriquin et al., (1993); Smith and Doran (1996). This pH reduction toward more neutral values appears to improve soil fertility. However, long-term sludge application may lead to excessive soil acidification and reduction of crop yields in other soils of low buffering capacity.

The improvement in organic matter content of the soil amended with increasing doses of digested sludge is evident from the present investigation. The results obtained are in accordance with the findings of Hall and Cooker (1983). Similar observations were made by Kidd. et al. (2007). They found that sewage sludge application leads to an increase in the soil organic matter content that contributes to the structural stability of the soil and lowers the process of soil erosion.
Long term studies carried out by Nogwhi (2007) on the application of sludge as fertilizer in Yokohama city, Japan led to the conclusion that sludge fertilizer had the same nutrient value as organic fertilizer and due to minimal transfer of heavy metals from sludge to crop long term use of digested sludge could be used as an option to reduce the consumption of inorganic fertilizer.

Aggelidus and Londra (2000) found that application of different types of digested sludge improved that physical properties of the ammended soils. The results of the present investigation also suggest on marginal increase in the electrical conductivity and pH of the soil. Similar findings have been reported by Samaras et.al. (2008).