CHAPTER I
INTRODUCTION

Seed spices constitute an important group of agricultural commodities and play an important role in our national economy. Historically, India has always been recognized as a land of spices. Out of the 109 spices listed by the International Organization for Standardization (ISO), India produces as many as 63 owing to its varied agro climatic regions. Out of the total 63 spices grown in India, 20 are classified as seed spices with 36 per cent share in area and 17 per cent share in production of total spices in India. Rajasthan and Gujarat has been emerged as “seed spice bowl” and together contributes more than 80 per cent of total seed spices produced in the country. Main seed spices of India are Coriander, Cumin, Fennel, Fenugreek, Dill, Ajowain, Celery, Anise, Nigella and Caraway.

Fenugreek (Trigonella foenum-graecum L.) generally known as methi, occupies an important position amongst leafy vegetables and condiment crop largely grown in northern India during rabi season. Fenugreek (Trigonella foenum-graecum L.) is an annual herb belongs to the family Leguminosae. In India, 2015-16, area reported 1.31 lakh ha of total cultivated area with production of 1.38 lakh tons and productivity (yield) is 950 kg ha$^{-1}$. In Gujarat state, it is cultivated an area of about 0.06 lakh ha with production of 0.13 lakh tons and productivity (yield) is 2001 kg ha$^{-1}$ (Anon. 2016). Major producing states are Rajasthan, Madhya Pradesh, Gujarat, Uttar Pradesh, Maharashtra, Punjab, and Tamil Nadu. Out of these, Rajasthan stands out as the single largest producer, contributing 87% of the total production of Indian fenugreek. Besides, Madhya Pradesh, Gujarat, Uttar Pradesh and Chhattisgarh for its dry seeds are used as condiment. Fresh leaves, tender pods and stem are used after boiling.

Fenugreek (Trigonella foenum-graecum L.) is an annual, self pollinating, legume crop, believed to be native to the Mediterranean region but now, is widely cultivated in India and other parts of the world (Acharya et al., 2006). Fenugreek (Trigonella foenum graecum L.), like other legumes, is a good source of dietary protein for consumption by man and animals. From ancient times, Greeks and the Romans used it as medicine, spice and cattle fodder and so it was and still known as
Greek hay. Seeds of fenugreek are used as a yellow dye, in cosmetics and for medicinal purposes. Fenugreek is a good soil renovator and widely used as a green manure. The response of fenugreek to fertilization has been reported to vary from no response to highly significant depending upon the fertilizer, cultivar and soil type (Saeed and Elsheikh, 1995). Inoculation of legumes is widely practiced with the objective of increasing production of the legume in question. *Rhizobium* inoculation of fenugreek has been reported to increase the biomass of plant and seed production (Poi *et al.*, 1991). Fenugreek was reported to fix 48% of its total nitrogen during the growing season (Desperrier *et al.*, 1985). Although it is well known fact that Fenugreek is a good source of atmospheric nitrogen fixation by *Rhizobium* present in its root nodules, effort was not made to study the indigenous *Rhizobia* present in nodules of this plant.

Fenugreek is a multipurpose spices crops, every part of the plant is being used as leafy vegetable, fodder and condiment (Khiriya *et al.*, 2003). Fenugreek plants are weak and spreading moderately attaining a height of 30 to 50 cm. It comes to flowering 30 to 50 days after sowing and matures in 110-140 days.

The spice is exported in its whole and powdered forms as well as in the form of extracted oil which is extensively used as herbal supplements, therapeutic applications, culinary, tea, perfumery and dye. The major importers of Indian fenugreek are Saudi Arabia, Japan, Malaysia, USA, the UK, Singapore and Sri Lanka. Introduction of high yielding varieties can boost the yield levels in the adopted areas. The seeds are mainly used as flavoring agent in many vegetable preparations and having high medicinal and nutraceutical value. It has also got medicinal importance, therefore used for cure of flatulence, dysentery, diarrhoea, enlargement of liver and spleen, rickets, diabetes, and many others. It is assumed that the class of flavonoids which fenugreek contains may play a substantial role in the prevention of cancer. The biological and pharmacological actions of fenugreek are attributed to the variety of its constituents, viz., steroids, nitrogen compounds, polyphenolic substances, volatile constituents and amino acids *etc.* (Mehrafarin *et al.*, 2010).

Chemical analysis of fenugreek seed revealed that it contains 13.7 per cent water, 26.2 per cent protein, 5.8 per cent fat, 3.0 per cent mineral matter, 7.2 per cent fibre, 4.41 per cent carbohydrate, 0.16 per cent calcium, 0.37 per cent phosphorus, 14.1 mg iron, 333 calories and 160 IU carotene per 100 g (Agrawal, 2001).
Agronomic research conducted in different agro-climatic zones in India suggest that optimum productivity can be obtained when fenugreek seed is spaced 20 to 30 cms apart and planted in early October or November to optimize crop productivity (Korla and Saini, 2003). Well-drained loam soils (Rosengarten, 1969) with a pH of 8 - 8.5 are favored by the crop. According to Petropoulos (1973) heavy and wet soils limit crop growth. Potash has been used to adjust soil pH to increase nutrient uptake of fenugreek (Yadav and Kumawat, 2003). Use of organic and inorganic fertilizers, farmyard manure, nitrogen and phosphorus has been found to be effective in increasing fenugreek yield (Khiriya et al., 2003).

The basic concept of integrated nutrient management (INM) or integrated plant nutrition management (IPNM) is the adjustment of soil fertility/productivity and of optimum plant nutrient supply for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients including locally available ones in an integrated manner. In practical term, a system of crop nutrition in which plant nutritional needs are met through a pre-planned integrated use of mineral fertilizers, organic manures (e.g. green manures, recyclable wastes, crop residues, farm yard manure, oil cakes, vermicompost, poultry manure etc.) and bio-fertilizers (Davari and Mirzakhani, 2009).

Integrated nutrient management holds great promise in meeting the growing nutrient demands of intensive agriculture. Normally, intensive agriculture is characterised by raising of more crops per unit time and space involving heavy dependence on fertilizers, progressively depleted soil of their macro/micro nutrient reserves and soil micro organisms. This low soil fertility is the main cause of low productivity of most of the cultivated lands. According to soil test analysis in our country, nitrogen deficiency is universal, phosphorus status is low in 50% and medium in 48% soils. Further, 48% soils are low to medium in available potassium and its deficiency is rapidly increasing due to intensive cropping and imbalanced use of fertilizers. The long term fertilizer experiments under different agro-climatic regions of the country have shown that potassium deficiency in future will become a limiting factor for crop production. It will also reduce the efficiency of other fertilizer nutrients (Singh et al., 2000).

On account of continuing world energy crisis and spiraling price of chemical fertilizer, the use of organic manure as a renewable source of plant nutrients is
assuming importance. In this endeavor proper blend of organic manure and inorganic fertilizer is important not only for increasing yield but also for sustaining soil health (Kumar et al., 2009).

The seed yield and quality of fenugreek are known to be influenced by different factors such as nutrition, cultural practices etc. Among these, nutrition plays an important role and which has great influence on vegetative growth as well as seed yield (Sharma et al., 2006). However, fertilizer application generally remained much below as compared to its removal. This gap can be attained by application of both organic and inorganic form of fertilizers through integrated nutrient management, is more efficient than application of chemical fertilizers alone. The efforts should have to be made for proper utilization of costly chemical fertilizers with their efficient use. The reduction in NPK fertilizers can be fulfilled through supplementation with organic manure and bio fertilizer.

Amongst different factors known to augment crop production, adequate fertilization is considered essential for exploiting yield potential of any crop. Plant nutrients play special and important role in growth and development of plants. Adequate mineral fertilization is considered to be one of the most prerequisites in this respect. Fenugreek, being legume crop, does not require much nitrogen for its growth. However, intensive agriculture and adoption of exhaustive high yielding varieties of crop have led to heavy withdrawal of nutrients from the soil during past few years and fertilizer use remained much below as compared to removal. The gap between the nutrient removal and supply cannot be bridge up by the application of any single nutrient but this has to be achieved with balanced use of fertilization. Nitrogen is an indispensable constituent of protein and nucleic acid molecules. It is an integral part of chlorophyll molecules which are responsible for photosynthesis. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs, finally leading to higher productivity.

Similarly, phosphorus is an essential major plant nutrient required for growth, quality and inducing disease and pest resistance property in crops. The phosphorus has fixation problems; therefore it may become unavailable to plants. Therefore, it is necessary to rationalize the economic dose of the fertilizer.
Vermicompost application to the soil drastically improves the soil fertility, increase the yield, improve soil pH, releases more available nutrient, increase pest resistance, enhances water infiltration and water holding capacity of soil, reduces irrigation requirement, improves soil microbial activities and produces yield with better taste, laster keeping quality and low pesticide residues enhancing its export ability (Bhawalkar and Bhawalkar, 1991). Vermicompost is potential source due to presence of readily available plant nutrient, growth enhancing substance and number of benificial microorganism like nitrogen fixing, P solubilising and cellulose decomposing organism. Vermicompost is a rich source of N, P, K, beside major nutrient, it contain nearly all the micronutrient hormones like auxin, cytokinins, enzymes, vitamins and several useful bacteria, actinomycetes, fungi etc. (Reddy, 2011).

Farm yard manure (FYM) is the principle source of organic matter in our country. The organic carbon in the organic matter acts a source of energy for soil microorganisms and upon mineralization release essential elements during crop growth. In addition to supply available plant nutrients directly (Cooke, 1967), the use of FYM also mobilizes the unavailable nutrients present in the soil system.

Bio-fertilizers also play an important role in integrated system. Further, they are low cost and eco-friendly with tremendous potential for supplying nutrients and can replace the use of synthetic nitrogenous fertilizers by 25-50%, through biological nitrogen fixation. Phosphate-solubilizing bacteria (PSB) species like *Pseudomonas striata* and *Bacillus polymyxa* are also reported to be beneficial in increasing the phosphorus availability in soil and thereby seed yield of pulses (Gupta, 2006). Fenugreek, being a legume crop, responds to inoculation with *Rhizobium* to meet the partial requirement of nitrogen. *Rhizobium* inoculation of fenugreek has been reported to intensification the biomass of plant and seed production. Many studies have shown that simultaneous infection with rhizobia and rhizosphere bacteria increases nodulation and growth in a extensive variety of legumes. Introduction of an efficient strain of bio-fertilizers in such soils may help in boosting up the production of legume crops. Inoculation of seeds with *Rhizobium* as well as PSB culture is a very low cost method of nitrogen and phosphorus fertilization in legumes and is beneficial for succeeding crops through residual effects.
In view of the paucity of adequate research on integrated nutrient management in fenugreek crop, the present investigation was carried out at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during rabi season of 2016-17.

The specific objectives envisaged to be achieved from this study are as follows:

1. To study the effect of different INM treatments on yield attributes, quality parameters and yield of fenugreek.
2. To study the effect of different INM treatments on content and uptake of nutrients by fenugreek.
3. To study the effect of different INM treatments on soil available nutrients after harvest of crop.
4. To find out an economical viability of the treatments.