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Integrated Nutrient Management in Fenugreek (*Trigonellafoenumgraecum*L.)

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Abstract—*Fenugreek (TrigonellafoenumgraecumL.) occupies prime position among seed spices grown in India which has medicinal value with aromatic, carminative, tonic and galactagogue properties. In general, the grain yield and quality of fenugreek are influenced by different factors such as nutrition, cultural practices etc. Among these, nutrition is most important factor which has great influence on vegetative growth and grain yield and the crop is known to respond well to applied nutrients. Application of required quantities of chemical fertilizers is expensive as the cost of chemical fertilizers is ever increasing. The basic concept underlying Integrated Nutrient Management is the maintenance or adjustment of soil fertility and plant nutrient supply above optimum level to get the benefits from all possible sources of plant nutrients in an integrated manner. Fenugreek is an important medicinal plant with good export value. The information on effect of INM practices on yield and quality is lacking. Keeping this in view, the investigation entitled 'Effect of Integrated Nutrient Management on growth, yield and quality of fenugreek'was conducted for two rabi seasons (2008-09 and 2009-10) at Horticultural Research Station, Kovvur (A.P), India.Among different treatments, application of (T_2) 100 % RDF + Rhizobium + PSB recorded higher grain yield of 12.50 q ha^{-1} as compared to rest of the treatments. The above treatment recorded higher values for yield attributing characters also such as no. of seeds pod^{-1}, harvest index, straw yield and better pod length, test weight, number of pods plant^{-1}, seed yield plant^{-1} and grain shelling % . Further, the number of pods plant^{-1}, grain shelling % were reported to be highest with application of (T_7) 75 % RDF + PM + Rhizobium + PSB, whereas the pod length, test weight, seed yield plant^{-1} were found to highest with application of 75 % RDF + VC + Rhizobium + PSB (T_5). The above treatments (T_5 and T_7) recorded higher seed yield of 11.83 q ha^{-1} and 10.91 q ha^{-1} respectively. With respect to grain quality, highest crude protein % was noticed in T_2: 100 % RDF + Rhizobium + PSB and it was at par with T_5: 75 % RDF + VC + Rhizobium + PSB, T_7: 75 % RDF + PM + Rhizobium + PSB and T_3: 75 % RDF + FYM + Rhizobium + PSB %. Considering the higher seed yield and nutritional quality in view application of (T_5) 75 % RDF + vermicompost + Rhizobium + PSB and (T_7) 75 % RDF + poultry manure + Rhizobium + PSB was found promising and can be recommended to the farmers for reaping higher yield in fenugreek under agroclimatic conditions of Andhra Pradesh.*

Keywords*: Vermicompost, Rhizobium, PSB and rabi.*

1. INTRODUCTION

Fenugreek (*Trigonellafoenumgraecum*L.) belongs to the family Fabaceae. Fenugreek is cultivated over an area of 45,000 ha in India with an average production of 56,000 tons. During 2009-2010, India earned Rs. 6972 lakhs as foreign exchange by exporting 21,000 tonnes of fenugreek (Anonymous, 2010).The concept of integrated nutrient management was proved successful in many horticultural crops like vegetables and fruits in reducing the cost of cultivation and improving soil health and reducing chemical residues (Jain and Choudary, 2006). Fenugreek is an important spice crop with good export value and the information on the effect of various organic sources of nutrients and integrated nutrient management practices is lacking under agro climatic conditions of Andhra Pradesh. In Andhra Pradesh, fenugreek is grown in marginal lands under irrigated conditions during *rabi* season and hence, there is a need to reduce its cost of cultivation by using organic sources for its nutrition. Keeping the cost of production, INM concepts and importance of organic sources of manures in view, the present investigation was proposed to find out the effect of integrated nutrient management on growth, yield and quality of fenugreek.

2. MATERIALS AND METHODS

The investigation on "Integrated nutrient management in fenugreek" was carried out in randomized block design during *rabi*, 2008-09 at Horticultural Research Station, Kovvur (West Godavari District), Andhra Pradesh with three replications and ten treatments *viz*; T_1 : 100 % RDF (60 – 50 – 50 NPK kg ha^{-1})-control, T_2 : 100 % RDF (60 – 50 – 50 NPK kg ha^{-1}) + *Rhizobium* + PSB ,T_3 : 75 % RDF + Farm yard manure @ 2.8 t ha^{-1} + *Rhizobium* + PSB ,T_4 : 50 % RDF + Farm yard manure @ 2.8 t ha^{-1} + *Rhizobium* + PSB,T_5 : 75 % RDF + Vermicompost @ 3.3 t ha^{-1} + *Rhizobium* + PSB, T_6 : 50 % RDF + Vermicompost @ 3.3 t ha^{-1} + *Rhizobium* + PSB,T_7 : 75 % RDF + Poultrymanure @ 3.5 t ha^{-1} + *Rhizobium* + PSB,T_8 : 50 % RDF + Poultrymanure @ 3.5 t ha^{-1} + *Rhizobium* + PSB, T_9 : 75 % RDF + Neem cake @ 2.5 t ha^{-1} + *Rhizobium* + PSB

and T_{10}: 50 % RDF + Neem cake @ 2.5 t ha^{-1} + *Rhizobium* + PSB.

3. RESULTS AND DISCUSSION

Growth is also a phenotypic expression of the plant with respect to nutrient status provided all other conditions are favourable. In the present investigation, application of different organic sources of manures and their combinations at different levels and recommended dose of fertilizers (RDF) had exerted a significant influence on plant height, leaves $plant^{-1}$, leaf area and dry matter production at different stages of the crop growth.Significantly higher values for plant height, dry matter production at harvest stage and leaf production (75 DAS) was recorded with application of T_2: 100 % RDF + *Rhizobium* + PSB and it was on par with T_5: 75 % RDF + VC + *Rhizobium* + PSB and T_7: 75 % RDF + PM + *Rhizobium* + PSB. It was observed that T_2 recorded 19.7 % increase in dry matter over control (T_1). These results are in agreement with Jat*et al.,* (2006) who reported increase in growth parameters like plant height and dry matter in fenugreek with inorganic fertilizers.

From the observations made on vegetative characters, it can be inferred that the higher plant height and number of branches, leaves $plant^{-1}$ and leaf area and dry matter production recorded in inorganic fertilizers application in the present study (T_2) can be attributed to their readily soluble and easily available forms to the plant at root zone and rapid release of nutrients compared to organic manures. The increase in plant height and number of branches, leaves $plant^{-1}$ and LAI could be owing to higher uptake of nutrients by the plant particularly of nitrogen which has a prime role in the promotion of vegetative growth in plants. Rapid cell elongation occurs with adequate availability of nitrogen which favourably influences the plant growth. Application of vermicompost and poultry manure with 75 % RDF (T_5 and T_7) combined with *Rhizobium* and PSB also promoted the growth and recorded higher vegetative growth and were on par with inorganic treatment, 100 % RDF combined with *Rhizobium* and PSB (T_2). The higher values for vegetative characters recorded in case of T_7 and T_5 could be attributed to an increase in nitrogen availability consistently through organic manures and inorganic fertilizers. The application of organic manures and their mineralization in the soil can release significant amounts of nitrogen in a mineralized and available form and so may satisfy the needs of crops for nitrogen (Amlinger*et al*., 2003 and Bavec*et al*., 2006). Vermicompost is also rich in bacteria like *Azotobacter*, *Azotspirillum* besides number of actinomycetes which help in plant growth. This might have favoured the vegetative growth. Similarly, poultry manure in this study might have served as better substrate for PSB and might have favoured higher microbial activity. Increase in vegetative growth may be attributed to increased availability of phosphorous due to PSB.

The lower values for vegetative growth in plant height and dry matter production in treatments, T_4: 50 % RDF + FYM + *Rhizobium* + PSB and T_{10}: 50 % RDF + NC + *Rhizobium* + PSB may be attributed to the shortage/deficiency of nitrogen which might have increased the ABA levels in all parts of the shoot, root and xylem exudates (Krauss,1978) and dropping the gibberellic acid levels of the shoots and decreased in production and export of cytokinins from roots to shoot and leaves ultimately resulting in reduced growth (Krauss and Marchner, 1982). It could also be attributed to inadequate and untimely nitrogen supply that might have also resulted in shorter plants with a concomitant reduction in vegetative growth.

Effect of INM on seed yield

Treatments	Seed yield (q ha-1)		
	2008-09	2009-10	Pooled mean
T1	11.00	9.83	10.41
T2	12.58	12.41	12.50
T3	9.50	10.00	9.75
T4	8.75	8.58	8.66
T5	11.75	11.91	11.83
T6	8.50	8.33	8.41
T7	10.83	11.00	10.91
T8	9.25	9.08	9.16
T9	9.00	9.35	9.17
T10	8.25	8.41	8.33
Mean	9.94	9.89	9.91
SEm±	0.83	0.69	0.82
CD (P=0.05)	2.46	2.04	2.36

In the present experiment, the seed yield and yield attributes were significantly influenced by the integrated use of organic manures, inorganic fertilizers and biofertilizers in an INM combination. The results of seed yield on per hectare basis revealed that significantly highest seed yield in fenugreek was recorded by the application of T_2: 100 % RDF + *Rhizobium* + PSB followed by T_5: 75 % RDF + VC + *Rhizobium* + PSB, T7: 75 % RDF + PM + *Rhizobiun*+ PSB and T_1: 100 % RDF. The treatments *viz.*, T_2, T_5, T_7 recorded grain yield of 12.50, 11.83, 10.91 q ha^{-1} respectively. T_2, T_5, T_7 recorded 16.72 %, 12.00 % and 4.58 % increases in seed yield over control (T_1) respectively.

The increase in the seed yield with application of (T_2) 100 % RDF + *Rhizobium* + PSB could be due to an increase in the values of growth and yield attributing characters such as plant height, branch number, dry matter production and LAI, number of seeds pod^{-1}, harvest index, pod length, test weight, number of pods $plant^{-1}$, seed yield $plant^{-1}$ and shelling %. Increased nutrient uptake resulted in initial vegetative growth of the plant in terms of the plant height (harvest stage), number of leaves, dry matter content, leaf area and leaf area index. The same was also evident from the positive correlation recorded between yield and yield attributing characters such as number of pods $plant^{-1}$, seed yield $plant^{-1}$, pod length and test weight. Also the higher nutrient availability through inorganic fertilizers and also due to direct role of biofertilizers in nitrogen fixation might have contributed positively for overall improvement in growth and development of the plant.

It was observed that next to T_2, the highest seed yield of 11.83 q ha^{-1} was recorded by T_5: 75 % RDF+ VC + *Rhizobium* +

PSB followed by T_7 and T_1. T_5 recorded 7.77 % and 12.00 % increase in seed yield over T_7 and T_1 (control) respectively. The increase in the seed yield with application of 75 % RDF along with vermicompost and biofertilizers (*Rhizobium* and PSB) (T_5) could be due to increase in growth characters and yield attributing characters such as pod length, test weight, seed yield plant^{-1} and better pod number, seeds pod^{-1} and harvest index. Further, the higher plant (harvest stage) and better leaf production, dry matter content, AGR and plant height, LA and LAI also positively contributed for initial vegetative growth of the plant. The same was also evident from positive and significant correlation registered between yield and number of leaves, dry matter content, pod number, number of seeds and test weight. Similar beneficial effect of vermicompost on grain yield of fenugreek was also reported by Kamalesh*et al*. (2006). The increase in yield with application of vermicompost in tomato was also reported by Prabhakaran (2003). Vermicompost is rich source of macro and micronutrients, growth hormones and microflora (Bhawalkar, 1991). The earthworm derived nitrogen could supply 30 % of the total crop requirements as it is potential source of readily available nutrients for plant growth (Curry and Byrne, 1992). The phosphorous content in vermicompost is higher than the phosphorus content in FYM (Shinde*et al*., 1992). Further, it also contains micronutrients like Fe (178 ppm), Mn (24.6 ppm), Zn (19.2 ppm) and Cu (7.6 ppm).

Similarly, application of (T_7) 75 % RDF along with poultry manure and biofertilizers (*Rhizobium* and PSB) resulted in higher seed yield of 10.91 q ha^{-1} as compared to other treatments except T_2 and T_5. The above treatment (T_7) registered 12 %, 17.2 %, 18.27 % and 4.5 % increase in number of pods plant^{-1}, number of seeds plant^{-1}, test weight and grain yields ha^{-1} respectively over control (100 % RDF). The better performance of T_7: 75 % RDF + PM + *Rhizobium* + PSB could be due to increased vegetative parameters such as AGR for plant height, leaf area, leaf area index, number of leaves and dry matter content and yield attributing characters like number of pods, pod length, number of seeds pod^{-1}, test weight and seed yield plant^{-1}. The same is also evident from positive and significant correlation between yield and number of leaves, dry matter content, pod number, number of seeds and test weight. Significant and positive correlation among yield and yield attributing characters was also reported by Kole and Mishra (2006) and Jat (2004 a). A similar increase in number of pods plant^{-1}, number of seeds plant^{-1}, test weight and grain yield in fenugreek with application of poultry manure was also reported by earlier authors (Anonymous, 2004).

The higher seed yield associated with application of vermicompost and poultry manure (T_5 and T_7) in combination with nitrogenous fertilizers may be attributed to higher mineralization of various essential elements due to increased microbial activity and organic colloids resulting in better availability and uptake of these elements ultimately resulting in increased photosynthetic activity. The increased photosynthetic activity in turn would have increased assimilation of photosynthates resulting in a higher C : N ratio (Smith, 1950). An increase in the higher C : N ratio might have helped in increasing number of pods, test weight and seed number pod^{-1} ultimately resulting in higher yields. Similar results were also reported by Deora and Jitendar Singh (2008) with application of vermicompost in fenugreek.

In this study, the treatment, T_1 (control) comprising of only 100 % recommended dose of fertilizers recorded seed yield of 10.41 q ha^{-1} and was found to be on par with T_2, T_5 and T_7. The increased seed yield in T_1 over other treatments *viz*., T_3, T_4, T_6, T_8, T_9, T_{10} may be attributed to increased initial vegetative growth and yield attributes due to higher nutrient availability through inorganic fertilizers.

In this experiment, the treatments, T_3, T_8 and T_9 recorded intermediate values for seed yield. Similarly, the treatments; T_{10}, T_6 and T_4 recorded lower grain yield of 8.33, 8.41 and 8.66 q ha^{-1} respectively. The reduction of yield in the above treatments may be due to poor initial vegetative growth and dry matter accumulation leading to reduction in yield attributing characters like lower per plant yield, test weight and number of pods particularly in treatments T_{10} and T_4 and lower nutrient uptake Similarly, the decreased yield in T_6 may be due to reduction in leaf area leading to reduction in number of pods.

Further, it was observed that T_7: 75 % RDF + PM + *Rhizobium* + PSB registered higher grain shelling % (42.58 %) over other treatments and it was on par withT_2: 100 % RDF + *Rhizobium* + PSB. The treatments, T_7 and T_2 recorded 7.44 % & 5.40 % increase in grain shelling % over control (T_1) respectively. It was noticed that the treatments; T_5, T_7 and T_2 registered higher values of 12.88 g, 12.43 g and 11.70 g test weight respectively. Further it was observed that T_5 recorded 18.20 % increase in test weight over control (T_1). The increased test weight might have lead to higher grain shelling % in T_7 and T_2. The higher test weight in T_5, T_7 and T_2 may be attributed to the accumulation of stored food material in endosperm of seed as influenced by the combination of organic manures and nitrogen application in split doses resulting in better translocation and accumulation of stored food material in the endosperm. The present findings are in accordance with Abusaleha (1992 b) who reported increased seed weight in okra with poultry manure and nitrogen fertiliser combination.

The biological yield was found to be significantly highest in T_2 and it was at par with T_1, T_3, T_5 and T_7. There were no significant differences among treatments with respect to straw yield. Similarly, the highest value for harvest index (HI) was also noticed in T_2: 100 % RDF + *Rhizobium* + PSB (27.46) followed by T_5 (27.25). The efficient partitioning of dry matter to reproductive structures and economic sink might have led to higher test weight resulting in increased harvest index.

In this study the effect of various INM treatments on grain quality was assessed in terms of crude protein content in the seed.The higher protein content in the seed can be considered beneficial for human consumption since the seed is used as condiment. It is evident from the data that the highest protein content was observed in T_2: 100 % RDF with biofertilizers (*Rhizobium* + PSB) but it was at par with 75 % RDF with poultry manure + biofertilizers (T_7), 75 % RDF with vermicompost + biofertilizers (T_5) and 75 % RDF + FYM + biofertilizers (T_3). The treatments with 50 % RDF + FYM + *Rhizobium* + PSB (T_4), 75 % RDF + NC + *Rhizobium* + PSB (T_9) and 100 % RDF (T_1) were also at par with each other. The improvement in nitrogen content in seed may be attributed to higher uptake due to increased availability of nitrogen from *Rhizobium* and 75 % recommended dose of nitrogenous fertilizer. The results are in agreement with the findings of Sharma *et al*. (2006) in fenugreek. However, further study is required to confirm these trends.A perusal of the results in this study indicate that the quality in fenuegreek in terms of protein content in seed can be improved by certain INM treatments *viz*., T_2, T_7 and T_5 (crude protein). Fenugreek is of use as spice and condiment in cooking and the results do have profound practical significance in the light of human nutrition. However, further research is required to confirm the above trends.

It was observed that highest benefit cost ratio (1.54) was recorded by application of 100 % RDF + *Rhizobium* + PSB (T_2) followed by 100 % RDF: T_1 (1.19 B:C ratio) and 75 % RDF + PM + *Rhizobium* + PSB : T_7 (1.12 B:C ratio). Though, the application of 75 % RDF + VC + *Rhizobium* + PSB (T_5) recorded higher grain yield than 75 % RDF + PM + *Rhizobium* + PSB (T_7), the B : C ratio was found to be lower due to high cost of vermicompost. Similarly, the lowest B : C ratio was observed in T_6.

4. CONCLUSION

Keeping the seed yield and B : C ratio and nutritional values of seed and straw in view, it can be concluded from the results of this experiment that an application of (T_5) 75 % RDF + VC + *Rhizobium* + PSB followed by T_7 *i.e*., 75 % RDF + PM + *Rhizobium* + PSB can be recommended to the farmers of fenugreek for the agroclimate of Andhra Pradesh. Therefore, an integrated approach with specific emphasis on organic manures and biofertilizer components along with chemical fertilizers may be encouraged keeping quality of produce and soil health in view for popularising the cultivation of fenugreek under agroclimate of Andhra Pradesh.

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