JOURNAL OF PURE AND APPLIED MICROBIOLOGY, Sept. 2017. Vol. **11**(3), p. 1559-1565

# Influence of Integrated Nutrient Management on Yield, Quality and Nutrient Status of Drilled *rabi* fennel (*Foeniculum vulgare* Mill.)

**K.D. Mevada, Prakash Gamar, K.C. Ombase, R.S. Bhadane and P.D. Patel**

Department of Agronomy, B. A. College of Agriculture,
Anand Agricultural University, Anand (Gujarat)- 388110, India.

http://dx.doi.org/10.22207/JPAM.11.3.41

(Received: 20 July 2017; accepted: 12 September 2017)

**A field experiment was conducted to study the effects of integrated nutrient management practices on yield, quality and nutrient status of drilled *rabi* fennel (*Foeniculum vulgare* Mill) during the year 2016-17 at College Agronomy Farm, Anand Agricultural University, Anand. Twelve treatment combinations comprising of various integrated nutrient management practices were tested in randomized block design with four replications in sandy loam type of soil having slightly alkaline pH, low organic carbon and available nitrogen content, medium available phosphorus and high available potassium status. Results shown that treatment with 100 % N from vermi compost + bio NPK @ 1 lit ha$^{-1}$ produced significantly higher seed yield which was found comparable with all the treatments barring those applied with 50 % RDF along with 50% N from compost or vermi compost as well as 50 % RDF + 25% N from compost and vermi compost. Significantly highest microbial population was also found in the same treatment. Though available nitrogen and phosphorus were remained unaffected by IMN treatments, nitrogen content in seed and its uptake in seed as well as in stover had been affected significantly. Conversely, only phosphorus uptake in stover was found significantly vary due to different INM practices.**

**Keywords:** INM, fennel, Nutrient status, Bio NPK.

India is world's largest producer, consumer and exporter of the spices and among all the spices fennel is one of the most important spices. India occupies prime position in fennel and plays very important role in earning foreign exchange through export of the seed spice. Gujarat being the major fennel producing states in India along with Rajasthan, Karnataka, Andhra Pradesh, Punjab, Haryana, Madhya Pradesh and Uttar Pradesh, ranks first with respect to production and productivity in India and abroad. Gujarat produces 82% of total production of fennel in India with 14500 ha area under cultivation with production of 21200 t and productivity of 1462 kg ha$^{-1}$ in 2013-14 (Anon. 2016).

Fennel is raised profitably as a drilled crop in Gujarat. Area under *rabi* direct seeded fennel is increasing day by day, because it is more profitable as a winter direct seeded crop. In spite of this fact, the productivity of *rabi* fennel is low as compared to its potential yield of 2500 kg ha$^{-1}$. The reason for low productivity is lack of adoption of ideal agronomic practices including nutrient management for *rabi* drilled fennel. Integration of organic and inorganic sources of nutrient system not only augments yield, but also improves soil nutrient status by improving microbial activities.

* To whom all correspondence should be addressed.
Tel.: +91-9106042579;
E-mail: amt_kd@yahoo.com

As there is a dearth of such study under middle Gujarat conditions the experiment was conducted.

## MATERIALS AND METHODS

A field experiment was carried out at at College Agronomy Farm, Anand Agricultural University, Anand during rabi 2016-17 to study the influence of integrated nutrient management practices on yield, quality and nutrient status of drilled *rabi* fennel (*Foeniculum vulgare* Mill) on sandy loam type of soils having slightly alkaline pH (8.1), low organic carbon (0.49 %) and available nitrogen (230.50 kg N $ha^{-1}$) , medium available phosphorus (39.56 kg $P_2O_5$ $ha^{-1}$) and high available potash (315.40 kg $K_2O$ $ha^{-1}$). Total twelve treatment combinations comprising of integrated nutrient management *viz.,* $T_1$: 100 % RDF (90 kg N-45 kg $P_2O_5$-00 kg $K_2O$ $ha^{-1}$), $T_2$: 75% RDF+ 25% N from compost,$T_3$: 75% RDF + 25% N from vermi compost, $T_4$: 50% RDF + 50% N from compost , $T_5$: 50% RDF +50% N from vermi compost ,$T_6$: 50% RDF + 25% N from compost + 25% N from vermi compost, $T_7$: 50 % RDF + 50% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$ ,$T_8$: 50 % RDF + 50% N from vermi compost + Bio NPK @ 1.0 lit. $ha^{-1}$, $T_9$: 100% N from Compost + Bio NPK @ 1.0 lit. $ha^{-1}$, $T_{10}$: 100% N from vermi compost + Bio NPK @ 1.0 lit. $ha^{-1}$, $T_{11}$: 100% N from Compost and $T_{12}$: 100% N from Vermi compost were tested in randomized block design with four replications. Entire quantity of compost, vermi compost, bio NPK and phosphorus and 50 % nitrogen were applied at the time of sowing, whereas, 50 % of nitrogen was top dressed 30 DAS as per treatment. All other agronomic practices were followed as per schedule.

## RESULTS AND DISCUSSION

### Seed and Stover yield

Data pertaining to seed and stover yields (table-1) exhibited substantial differences due to different integrated nutrient management practices. Results showed significant influence of INM treatments, wherein, treatment $T_{10}$ (100% N from vermi compost + Bio NPK @ 1.0 lit. $ha^{-1}$), being at par with all the treatments barring $T_4$ (50% RDF + 50% N from compost), $T_5$ (50% RDF +50% N from vermi compost) and $T_6$ (50% RDF + 25% N from compost + 25% N from vermi compost) produced significantly higher seed yield (2085 kg $ha^{-1}$).

The inference of data also indicated that 100% N from vermi compost + Bio NPK ($T_{10}$) and 100 % N from compost+ Bio NPK($T_9$) produced 5.89 % and 3.30% higher yield compared to 100% RDF($T_1$) through fertilizers, respectively. Further, it was also revealed that all the treatments with vermi compost gave higher seed yield over compost treatments. Treatment ($T_{10}$) reported 18.56 % higher seed yield over lowest producing treatment $T_5$.

Almost similar trend was observed for stover yield and treatment $T_{10}$ (100 % N from Vermi compost+ Bio NPK), being at par with $T_9$, $T_6$, $T_4$, $T_3$ and $T_8$, produced significantly higher stover yield (3085 kg $ha^{-1}$). Treatment $T_{10}$ secured 27.39 % higher yield compared to lowest stover producing treatment $T_6$.

The seed and stover yields being functions of growth and yield attributes improved significantly due to the cumulative effect of these attributes. The beneficial effect on yield attributes might be also due to increased supply of all the essential nutrients by vermi compost which might be resulted into improved assimilation of photosynthates, which subsequently partitioning to sink. The findings of present investigation are supported by those of Selvarajan and Chezhiyan (2001) and Khoja (2004). Application of vermi compost @ 2 t $ha^{-1}$ along with bio NPK significantly increased yield attributes and yield. Bio-fertilizers add nutrients through the natural processes of nitrogen fixation and stimulating plant growth through synthesis of growth promoting substances and might have positively influenced the crop yield. The beneficial role of supplemented organic manures and bio-fertilizers in improving soil physical, chemical and biological role is well known, which in turn helps in better nutrient absorption by plants and resulting higher yield. Similar results were published by Prabu *et al*., (2002) and Pariari *et al.* (2015). The significant enhancement in seed yield with the addition of vermi compost might be due to its positive impact on maintaining balanced source and sink relationship. Moreover, vermi compost might have increased the efficiency of added chemical fertilizer in soil, activities of N fixing bacteria and increased rate of humification. Humic acid in vermi compost might have enhanced

the availability of both native and added nutrients in soil and as a result improved growth and yield attributes and yield of the crop significantly. This might due to positive response of nitrogen and phosphorus increased availability of phosphorus in soil, being a major structural element of cell and helped in cell elongation, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures which ascribed to increased growth parameters and lead to higher yield attributes and yields of fennel crop. These findings are in agreement with those of Koyani *et al*. (2014).

Harvest index as influenced due to INM treatments (Table 1) demonstrated identical impact indicating equal proportion of seed and stalk yields under each treatment.

**Oil content (%)**

The data pertaining oil content (%) influenced by the integrated nutrient management practices presented in table 1 revealed that INM treatments exerted noticeable influence on oil content of fennel seed, wherein, treatment $T_{10}$ (100 % N from vermi compost + Bio NPK @ 1 lit $ha^{-1}$) produced significantly higher oil content (1.98 %) along with treatments $T_9$ (1.89 %), $T_{12}$ (1.85%) and $T_6$ (1.87 %).

It has been reported by Singh and Ramesh (2002) that fennel oil content increased by organic and inorganic fertilizers. Moradi *et al*., (2011) demonstrated that organic matters such as vermi compost can improve soil structure, improving root development, providing plant nutrients and enhancing nutrient uptake by plants. Furthermore, Mahfouz and Sharaf-Eldin (2007) reported that free-living nitrogen fixing bacteria viz; *Azospirillum lipoferum* have not only the ability to fix nitrogen but also release phyto-hormones similar to gibberellic acid and indole acetic acid, which could stimulate plant growth, absorption of nutrients and photosynthesis with subsequent improvement of yield and essential oil components of sweet fennel. Darzi *et al*., (2013) reported that essential oil yield of fennel seeds increased significantly by increasing the vermi compost. It was demonstrated that vermi compost supplied phosphate and nitrogen to the soil, giving a more balanced nutritional status than mineral fertilizers.

**Microbial population**

Data presented in table-1 revealed significant impact of integrated nutrient

**Table 1.** Fennel yield and other characters as influenced by integrated nutrient management of drilled *rabi* fennel

| Treatment | Seed yield (kg $ha^{-1}$) | Stover yield (kg $ha^{-1}$) | Harvest index (%) | Oil content (%) | Microbial population (cfu×$10^6$) |
|---|---|---|---|---|---|
| $T_1$ : 100 % RDF (90 kg N-45 kg $P_2O_5$-00 kg $K_2O$ $ha^{-1}$) | 1962 | 2947 | 40.13 | 1.74 | 46 |
| $T_2$ : 75% RDF+ 25% N from compost | 1925 | 2755 | 40.92 | 1.83 | 62 |
| $T_3$ : 75% RDF + 25% N from vermi compost | 1935 | 2768 | 40.96 | 1.74 | 81 |
| $T_4$ : 50% RDF + 50% N from compost | 1698 | 2247 | 43.06 | 1.83 | 72 |
| $T_5$ : 50% RDF +50% N from vermi compost | 1786 | 2555 | 41.04 | 1.63 | 139 |
| $T_6$ : 50 % RDF + 25% N from compost + 25% N from vermi compost | 1470 | 2240 | 39.58 | 1.87 | 182 |
| $T_7$ : 50 % RDF + 50% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 1861 | 2575 | 42.39 | 1.79 | 65 |
| $T_8$ : 50 % RDF + 50% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 1884 | 2643 | 41.68 | 1.79 | 67 |
| $T_9$ : 100% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 2029 | 2983 | 40.37 | 1.89 | 189 |
| $T_{10}$ :100% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 2085 | 3085 | 40.38 | 1.98 | 206 |
| $T_{11}$: 100% N from compost | 1937 | 2806 | 40.79 | 1.72 | 43 |
| $T_{12}$ :100% N from vermi compost | 1955 | 2933 | 40.28 | 1.85 | 45 |
| S. Em ± | 98 | 143 | 1.84 | 0.05 | 2.35 |
| C. D. at 5% | 281 | 412 | NS | 0.14 | 6.77 |
| C. V. % | 10.41 | 10.56 | 9.01 | 5.38 | 4.73 |

management on microbial population and treatment $T_{10}$ (100 % N from vermi compost+ Bio NPK 1.0 lit. $ha^{-1}$) recorded significantly the highest micro-organism status ($206 \times 10^6$) over rest of the treatments.

The higher soil microbial population and the consequent better availability of nutrients attributed to the production of higher seed yield of fennel in plots treated with combination of organic, inorganic and microbial inoculants (Vyas *et al.,* 2016).

**Nutrient status**

**Nitrogen and phosphorus content in seed and stover**

Nitrogen content in seed of fennel was found noticeably influenced due to different INM

**Table 2.** Nitrogen and phosphorus content as influenced by integrated nutrient management of drilled *rabi* fennel

| Treatment | N Content(%) | | P Content(%) | |
|---|---|---|---|---|
| | Seed | Stover | Seed | Stover |
| $T_1$ : 100 % RDF (90 kg N-45 kg $P_2O_5$-00 kg $K_2O$ $ha^{-1}$) | 1.47 | 0.25 | 0.25 | 0.22 |
| $T_2$ : 75% RDF+ 25% N from compost | 1.43 | 0.26 | 0.25 | 0.22 |
| $T_3$ : 75% RDF + 25% N from vermi compost | 1.42 | 0.26 | 0.26 | 0.22 |
| $T_4$ : 50% RDF + 50% N from compost | 1.24 | 0.26 | 0.26 | 0.23 |
| $T_5$ : 50% RDF +50% N from vermi compost | 1.35 | 0.26 | 0.26 | 0.22 |
| $T_6$ : 50 % RDF + 25% N from compost + 25% N from vermi compost | 1.37 | 0.26 | 0.26 | 0.23 |
| $T_7$ : 50 % RDF + 50% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 1.39 | 0.26 | 0.26 | 0.22 |
| $T_8$ : 50 % RDF + 50% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 1.39 | 0.26 | 0.26 | 0.22 |
| $T_9$ : 100% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 1.41 | 0.27 | 0.27 | 0.23 |
| $T_{10}$ :100% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 1.48 | 0.25 | 0.28 | 0.22 |
| $T_{11}$: 100% N from compost | 1.44 | 0.25 | 0.25 | 0.21 |
| $T_{12}$ :100% N from vermi compost | 1.42 | 0.24 | 0.24 | 0.21 |
| S. Em ± | 0.03 | 0.02 | 0.01 | 0.01 |
| C. D. at 5% | 0.07 | NS | NS | NS |
| C. V. % | 3.96 | 3.91 | 4.80 | 4.59 |

**Table 3.** Nitrogen and phosphorus uptake as influenced by integrated nutrient management of drilled *rabi* fennel

| Treatment | N uptake (kg $ha^{-1}$) | | P uptake (kg $ha^{-1}$) | |
|---|---|---|---|---|
| | Seed | Stover | Seed | Stover |
| T1 : 100 % RDF (90 kg N-45 kg P2O5-00 kg K2O ha-1) | 28.91 | 24.57 | 4.33 | 6.33 |
| T2 : 75% RDF+ 25% N from compost | 27.63 | 23.73 | 4.30 | 6.82 |
| T3 : 75% RDF + 25% N from vermi compost | 27.45 | 23.47 | 4.28 | 5.95 |
| T4 : 50% RDF + 50% N from compost | 21.14 | 19.40 | 3.86 | 5.68 |
| T5 : 50% RDF +50% N from vermi compost | 24.13 | 21.89 | 4.01 | 5.94 |
| T6 : 50 % RDF + 25% N from compost + 25% N from vermi compost | 20.21 | 19.72 | 3.35 | 5.88 |
| T7 : 50 % RDF + 50% N from compost + Bio NPK @ 1.0 lit ha-1 | 25.94 | 22.00 | 4.16 | 5.80 |
| T8 : 50 % RDF + 50% N from vermi compost + Bio NPK @ 1.0 lit ha-1 | 26.18 | 22.47 | 4.18 | 5.92 |
| T9 : 100% N from compost + Bio NPK @ 1.0 lit ha-1 | 28.56 | 26.16 | 4.67 | 8.59 |
| T10 :100% N from vermi compost + Bio NPK @ 1.0 lit ha-1 | 31.22 | 25.60 | 4.63 | 6.54 |
| T11: 100% N from compost | 27.85 | 23.21 | 4.04 | 4.97 |
| T12 :100% N from vermi compost | 27.93 | 23.39 | 4.06 | 5.07 |
| S. Em ± | 1.45 | 1.24 | 0.26 | 0.35 |
| C. D. at 5% | 4.16 | 3.56 | NS | 0.99 |
| C. V. % | 10.95 | 10.76 | 12.38 | 11.27 |

**Table 4.** Available nitrogen and phosphorus status in soil as influenced by integrated nutrient management of drilled *rabi* fennel

| Treatment | Available N(kg $ha^{-1}$) | Available $P_2O_5$(kg $ha^{-1}$) |
|---|---|---|
| $T_1$ : 100 % RDF (90 kg N-45 kg $P_2O_5$-00 kg $K_2O$ $ha^{-1}$) | 256.67 | 49.45 |
| $T_2$ : 75% RDF+ 25% N from compost | 248.18 | 53.14 |
| $T_3$ : 75% RDF + 25% N from vermi compost | 259.37 | 49.89 |
| $T_4$ : 50% RDF + 50% N from compost | 258.93 | 53.11 |
| $T_5$ : 50% RDF +50% N from vermi compost | 254.90 | 52.09 |
| $T_6$ : 50 % RDF + 25% N from compost + 25% N from vermi compost | 255.78 | 53.32 |
| $T_7$ : 50 % RDF + 50% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 248.83 | 51.61 |
| $T_8$ : 50 % RDF + 50% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 252.12 | 52.08 |
| $T_9$ : 100% N from compost + Bio NPK @ 1.0 lit | $ha^{-1}$ | 248.05 |
| 53.72 | | |
| $T_{10}$ :100% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$ | 246.18 | 49.32 |
| $T_{11}$: 100% N from compost | 263.50 | 49.14 |
| $T_{12}$ :100% N from vermi compost | 262.00 | 48.86 |
| S. Em ± | 6.77 | 1.29 |
| C. D. at 5% | NS | NS |
| C. V. % | 5.32 | 5.01 |

treatments (Table 2) and treatment $T_{10}$ (100% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$) which being at par with all treatments except $T_4$ (50% RDF + 50% N from compost), $T_5$ (50% RDF +50% N from vermi compost),$T_6$ (50% RDF + 25% N from compost + 25% N from vermi compost),$T_7$ (50 % RDF + 50% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$) and $T_8$ (50 % RDF + 50% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$) contained significantly higher nitrogen content (1.48%). However, the N content in stover was found non- significant. Phosphorus content (%) in seed and stover was found identical in different INM treatments (Table 2).

Since content of a nutrient is a function of concentration and yield, the increase in seed and stover yield coupled with increased nutrient concentration resulted in higher total content of nitrogen and phosphorus with the supply of 100 % N from vermi compost+ Bio NPK and 100% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$. The increased fennel seed and stover nutrients content resulted in higher yield recorded with these combinations as compared to other treatment combinations. Higher photosynthetic activity in plant as evident from increase in biomass accumulation at successive duration and plant height reveals higher availability of metabolites from shoot to root. This might have promoted growth of root as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial parts.

The results might be due to the influence of N on the ribosome structure and the biosynthesis of some hormones viz; gibberellines, auxins and cytokinins, involved in protein synthesis. Increase in N uptake at higher levels and also nitrogen as a part of amino acid, which constitutes building blocks of protein and that might have resulted in higher protein content. Similar increasing with N application was also reported by Bhardwaj (2014) in fennel.

**Nitrogen and phosphorus uptake in seed and stover**

Results presented in table-3 revealed that nitrogen uptake by fennel seed and stover was found appreciably influenced due to INM treatments, wherein, treatment $T_{10}$ (100 % N from vermi compost+ Bio NPK) being at par with all treatments barring $T_4$ (50% RDF + 50% N from compost), $T_5$(50% RDF +50% N from vermi compost), $T_6$(50% RDF + 25% N from compost + 25% N from vermi compost), $T_7$ (50 % RDF + 50% N from compost + Bio NPK @ 1.0 lit $ha^{-1}$) and $T_8$ (50 % RDF + 50% N from vermi compost + Bio NPK @ 1.0 lit $ha^{-1}$), had higher nitrogen uptake in seed (31.29 kg $ha^{-1}$). Nitrogen uptake in stover

was found significantly maximum (26.16 kg ha$^{-1}$) in treatment $T_9$ (100% N from compost + Bio NPK @ 1.0 lit ha$^{-1}$), however, it was found at par with all the treatments except $T_4$, $T_5$, $T_6$ and $T_7$.

It was further revealed that though INM treatments did not exert any influential impact on phosphorus uptake by fennel seed, however, it was found noticeably affected for uptake by stover and treatment $T_{10}$ (100 % N from vermi compost+ Bio NPK lit. ha$^{-1}$) had significantly the highest P uptake (8.59 kg ha$^{-1}$).

The nutrient uptake is a function of yield and nutrient concentration in plant. Thus, significant improvement in uptake of nitrogen and phosphorus might be attributed to their concentration in seed and stover and associated with higher seed and stover yield. This might also be attributed to better availability of nutrients in the soil under these treatments. The results of present investigation are in close agreement with the findings of Shivanna *et al.,* (2009), Uttam (2013) and Patel *et al.*(2013).

**Nitrogen and phosphorus status**

The data on available nitrogen and phosphorus in the soil just after harvest of the fennel as influenced by the integrated nutrient management practices presented in Table 4 indicated non-significant effect of integrated nutrient management practices. This might be due to reduced nutrient loss when inorganic and organic fertilizers were applied in combinations which improved the availability of soil nutrients. Shivran and Jat (2015) reported progressive rise in available N through organic sources alone.

## CONCLUSION

In light of the above investigation it can be concluded that recommended dose of fertilizer (RDF: 90 kg N- 45 kg $P_2O_5$ – 45 kg $K_2O$ kg ha$^{-1}$) was found analogous with 75 % + 25 % N from either compost or vermi compost. For organic sources, 100 % N with either compost or vermi compost with or without bio NPK were also found comparable with RDF. As far as content and uptake of nitrogen and phosphorus are concerned, 100 % N from compost or vermi compost with or without Bio NPK @ 1 lit ha$^{-1}$ was found comparable with 100% RDF i.e. 90-45-00 kg N-$P_2O_5$-$K_2O$ ha$^{-1}$.

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