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Role of Integrated Nutrient Management on Growth Attributes, Yield Attributes and Seed Yield of R*abi* Fennel (*Foeniculum vulgare* Mill.) in Middle Gujarat Condition

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A field experiment was conducted at Agronomy Farm, Department of Agronomy, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during *rabi* 2012 and 2013 to study the integrated nutrient management on *rabi* fennel *Foeniculum Vulgare* Mill.) in Middle Gujarat Condition. An experimental results revealed that application of 100 % RDN (Recommended Dose of Nitrogen) with *Azospirillum* + PSB + vermicompost @ 2 t ha^{-1} recorded significantly higher plant height at 60 DAS (41.80 cm), 90 DAS (109.20 cm), at harvest (148.00 cm), number of umbels plant^{-1} (20.57), number of umbellates umbel^{-1} (23.16), number of seeds umbel^{-1} (173.69), seed (2719 kg ha^{-1}) and stover (3084 kg ha^{-1}) yields as well as significantly the highest number of branches plant^{-1} (9.60) as compared to rest of the treatments. Hence, it can be concluded that the application of 100 % RDN with *Azospirillum* + PSB + vermicompost @ 2 t ha^{-1} would be useful to enhance the productivity of *rabi* fennel. The integrated use of fertilizers may be suggested for higher productivity along with overall betterment.

Keywords: Agronomy farm, *rabi* fennel, Nutrient management.

Fennel is one of the important seed spice cultivated throughout the temperate and sub-tropical regions of the world for its aromatic seeds which are used for culinary purpose. India occupies prime position in seed spices and plays very important role in earing foreign exchange through export of seed spices. India is the world's largest producer, consumer and exporter country of the spices. In India, Spices and seed spices occupies an area of 3.07 and 1.39 million ha, with production of 5.74 and 1.23 million tonnes, respectively (Directorate of Agriculture, Rajasthan, 2013). Gujarat occupies 14500 ha area with production of 21200 tonnes and productivity of 1462 kg ha^{-1}. Mehsana and Patan districts production more fennel as compared to other districts (DOA, 2014).

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Aromatic plants are traditionally employed for seasoning and prolongation of shelf life of food. Among the different aromatic plants, we consider the fennel, in which its seeds have several uses. Fennel is also highly recommended for diabetes, bronchitis and chronic caught, treatment of kidney stones and is considered to have diuretic, stomachic and galactogogue properties (Shivran and Jat, 2015).

Area under *rabi* fennel increase day by day, because of more profitable than other *rabi* crops like wheat gram, cumin, mustard etc. Fennel is mainly cultivated in Gujarat, Rajasthan and Uttar Pradesh. Gujarat and Rajasthan contributed more than 80% of the total seed spices production in country.

The plant is pleasantly aromatic and each of the plant part like leaves, stalks, bulbs and seeds are edible. The fennel seeds contain about 9.5 % protein, 10.0 % fat, 42.3 % carbohydrates, 18.5 %

fiber and 13.4 % minerals (Bhunia *et.al*., 2005).

Of late, there has been increasing recognition of the importance of organics, as the global consumers are showing inclination towards health cautiousness with their day to day diet. Organic manure are plant and animal wastes which can be used as sources of plant nutrients. Recently, there has been increasing importance of organic sources of plant nutrients due to growing ecological concern and depleting inherent soil fertility leading to multiple deficiencies of essential plant nutrients (Shivran and Jat, 2015). Addition of organic manures like FYM, vermicompost, neem cake, poultry manure etc. not only supplied most of the nutrients, but also improves physical, chemical and biological properties of soils.

Integrated Nutrient Management system required judicious use of nutrients from soil, mineral and biological resources to obtain maximum production with no deleterious effect on biological properties. Evolution of the effect of these resources may help in making necessary adjustment in use of chemical fertilizers, therefore the present investigation was taken to evaluate different organic inputs, nutrient sources and to compare the chemical and integrated treatments in fennel under middle Gujarat conditions.

MATERIALS AND METHODS

A field experiment was conducted at Agronomy Farm, Department of Agronomy, B.A.College of Agriculture, Anand Agricultural University, Anand (Gujarat, India) during *rabi* 2012 and 2013 to study the "Response of *rabi* Fennel to integrated nutrient management in middle Gujarat conditions". The soil of experimental field was loamy sand in texture. The soil is very deep and fairly moisture retentive. It is most suitable for all the crops of tropical and sub-tropical regions. The experimental field had an even topography with gentle slope having good drainage. The physic-chemical properties of experimental plot were determined by drawing soil sample. The experimental soil was slightly alkaline in nature (pH 7.90 and EC 0.16 dsm^{-1}, Jackson, 1973), low in available N (246.72 kg ha^{-1}), medium in available P_2O_5 (55.78 kg ha^{-1}, Olsen *et.al*., 1954) and high available K_2O (308.20 kg ha^{-1}, Jackson, 1973). The experiment comprised of twelve treatment of an integrated nutrient managements viz, $\mathbf{T_1}$- Recommended Dose of Nitrogen (RDN-90:30:00 NPK kg ha^{-1}), $\mathbf{T_2}$-100% RDN+ *Azospirillum* + Vermicompost @ 2 t ha^{-1}, $\mathbf{T_3}$-50% RDN + *Azospirillum* + Vermicompost @ 2 t ha^{-1}, $\mathbf{T_4}$-100% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{1}, $\mathbf{T_5}$-50% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{-}1,$\mathbf{T_6}$-100% RDN + Two spray of vermiwash @ 50 lit ha^{-1} at 45 and 75 DAS, $\mathbf{T_7}$-50 % RDN +Two spray of vermiwash @ 50 lit ha^{-1} at 45 and 75 DAS, $\mathbf{T_8}$- 100% RDN + 15 kg Humic acid ha^{-1}, $\mathbf{T_9}$-50% RDN + 15 kg Humic acid ha^{-1}, $\mathbf{T_{10}}$- 50 % RDN+ NADEP @ 5 t ha^{-1}+ 15 kg Humic acid ha^{-1}, $\mathbf{T_{11}}$-100% RDN + NADEP @ 5 t ha^{-1} and $\mathbf{T_{12}}$- 50 % RDN + NADEP @ 5 t ha^{-1} were laid out in Randomized Block design. The values of "F" was worked out and compared with the value of table F at 5 % level of significance. The values of S.Em., C.D and C.V. % were also calculated. The mean maximum and minimum temperature during growth and development period ranged between 25.3 to 40.9 °C and 8.6 to 28.2 °C, respectively. The Fennel variety Gujarat Fennel-2 (GF-2) was sown in second week of November at a spacing of 45 X 15 cm using seed rate 5 kg ha^{-1} and fertilized with 90-30-0 kg N-P-K ha^{-1} by applying half dose of N and full dose of P as basal application at sowing and remaining half dose of N was top dressed in two equal split at 30 DAS, The quantity of vermicompost, NADEP and humic acid were calculated as per their dose and they were applied uniformly to respective treatment plots at the time of sowing and crop was harvested at first week of April. All the standard package of practices including appropriate plant protection measure were followed through the cropping season. Data on growth and yield attributes were taken from 5 tagged plants. Biological and economic yields were taken from net plots. Economics of the study was determined by calculating parameters like cost of cultivation, gross returns, net returns and benefit cost ration using the prevailing price of inputs and output in the local market. Statistical analysis was performed as per methods suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Date presented in Table-1 indicated that application of integrated nutrient management treatments gave significant on growth attributes of fennel. Plant height at various stage was

observed at 60, 90 DAS and at harvest. Significantly higher plant height at 60 (41.80 cm), 90 (109.20 cm) DAS and at harvest (148.00 cm) and significantly the highest number of branches plant^{-1} (9.60) was recorded in treatment T_4 (100% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{1}) over rest of treatments. Increase in plant height and number of branches under treatment T4 was due to the fact that nitrogen is a constituent of protoplasm in plant cell and it plays vital role in plant metabolism like synthesis of chlorophyll; vermicompost contains appreciable amount of magnesium apart from other nutrients which helped in chlorophyll synthesis. Therefore application of nitrogen with vermicompost increased the available status of nutrients, which probably provided favorable physical environment and must be ensured for plant to grow taller and to have higher number of branches. The biological role of nitrogen as an essential constituent of chlorophyll in capturing solar energy and regulating cellular metabolism of protein, structural units and as biological catalyst is widely known. Phosphorus has been recognised as an essential constituent of all living organisms which plays an important role in the conservation and transfer of energy in the metabolic reactions of living cells including biological energy transformation. The positive effect of nitrogen and phosphorus supplied through combinations of fertilizers and manures on growth could be ascribed to its effectiveness in providing a balanced nutritional environment favourable both in soil *rhizosphere* and plant system. The overall improvement in crop growth under the influence of integrated nutrient management could possibly be attributed to better development of roots and increased microbial activities due to balanced nutritional environment. (Ashiwath *et al*., 2010).

Yield attributes of fennel was significantly influenced by combine application of nitrogen (organic+inorganic). Significantly higher number of umbels plant^{-1} (20.57), number of umbellates umbel $^{-1}$ (23.16) and number of seeds umbel^{-1}(173.69) was recorded in treatment T_4 (T_4 (100% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{1}) over rest of treatments. The important reason responsible for better production of yield components and yield could be the supply of nutrients in balanced amount and available form. The increased growth in term of plant height, branches per plant, expansion of leaf lamina and chlorophyll content provided greater sites for photosynthesis and diversion of photosynthates towards sink (umbels and seed). The beneficial effect on yield attributes might be also due to increased supply of all the essential nutrients by vermicompost which might have resulted in higher manufacture of food and its subsequent partitioning to sink. The combined inoculation with *Azospirillum* and PSB shows synthetic effect and increased the nitrogen and phosphorus availability in soil rhzosphere to plant. It is well known that addition of vermicompost and biofertilizer along with RDN could increase the micronutrient concentration in the soil and increase the adsorption power of soil for cations and anions, particularly phosphates and nitrated and they were released slowly for the benefit of the crop during entire growth period. Opined that humic acid in vermicompost enhanced the availability of both native and added micronutrients in soil and thus yield attributes and yield were increased. Similar results due to combination of organic, inorganic and bio fertilizers were also obtained by Shirkhodaei *et al.,* (2014), Akhani *et al*., (2011).

Results presented in the (Table-2) revealed that effect of integrated nutrient management on seed and stover yields of fennel was found significant. Treatment T_4 (100% RDN + *Azospirillum* + PSB+ Vermicompost @ 2 t ha^{-1}) recorded significantly higher seed (2719 kg ha^{-1}) and stover (3084 kg ha^{-1}) yields over rest of the treatment except treatment T_2 (100 % RDN + *Azospirillum* + Vermicompost @ 2 t ha^{-1}) and T_{11} (100 RDN + NADEP @ 5 t ha^{-1} in pooled basis. This might be due to the fact that *Azospirillum* helps in increasing nitrogen availability because it is an associative micro-*acrophillic* nitrogen fixer. It colonizes the root mass and fixes N in loose association with plants and these bacteria induce the plant roots to secrete mucilage which creates low oxygen environment and helps to fix atmospheric nitrogen. On the other hand, PSB might have helped in reducing the fixation by its chelating effect and possibly solubilized the unavailable form leading to better uptake of nutrients which is well reflected in better growth, yield attributes and finally yield. The increased growth in term of plant height, branches per plant, expansion of leaf lamina

Table 1. Effect of integrated nutrient management on growth attributes of fennel (pooled of Two years)

Treatments	Plant height (cm)			Number of branches plant^{-1}	Number of Umbels plant^{-1}
	60 DAS	90 DAS	At harvest		
T_1- Recommended Dose of Fertilizer (RDN-90:30:00 NPK kg ha^{-1})	32.60	91.90	133.47	7.20	14.96
T_2-100% RDN+ *Azospirillum* + Vermicompost @ 2 t ha^{-1}	40.60	108.50	145.16	9.00	20.03
T_3-50% RDN + *Azospirillum* + Vermicompost @ 2 t ha^{-1}	38.60	103.20	141.14	8.30	17.76
T_4-100% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{1}	41.80	109.20	148.00	9.60	20.57
T_5-50% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{-1}	39.10	104.00	140.26	8.50	18.38
T_6-100% RDN + Two spray of vermiwash @ 50 lit ha^{-1} at 45 and 75 DAS	34.00	96.50	135.31	7.40	15.68
T_7-50 % RDN +Two spray of vermiwash @ 50 lit ha^{-1} at 45 and 75 DAS	30.50	90.70	131.55	7.00	14.76
T_8- 100% RDN + 15 kg Humic acid ha^{-1}	36.00	100.80	138.24	7.70	16.87
T_9-50% RDN + 15 kg Humic acid ha^{-1}	35.10	96.50	136.03	7.50	15.93
T_{10}- 50 % RDN+ NADEP @ 5 t ha^{-1}+ 15 kg Humic acid ha^{-1}	37.40	101.30	138.71	8.00	17.26
T_{11}-100% RDN + NADEP @ 5 t ha^{-1}	39.70	106.20	141.28	8.80	19.17
T_{12}- 50 % RDN + NADEP @ 5 t ha^{-1}	35.30	99.20	136.77	7.60	15.93
S.Em.+	1.00	2.80	1.76	0.20	0.47
C.D. (P=0.05)	3.00	8.10	4.96	0.50	1.31
C.V. %	8.30	8.00	3.58	6.80	7.63

Table 2. Effect of integrated nutrient management on yield attributes and yield of fennel (pooled of Two years)

Treatments	Number of umbellates umbel^{-1}	Number of seeds Umbel^{-1}	Seed yield (kg ha-^{1})	Stover yield (kg ha-^{1})
T_1- Recommended Dose of Fertilizer (RDN-90:30:00 NPK kg ha^{-1})	17.57	144.89	1676	2205
T_2-100% RDN+ *Azospirillum* + Vermicompost @ 2 t ha^{-1}	22.29	167.70	2601	2914
T_3-50% RDN + *Azospirillum* + Vermicompost @ 2 t ha^{-1}	19.91	156.86	2291	2738
T_4-100% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{1}	23.16	173.69	2719	3084
T_5-50% RDN + *Azospirillum* + PSB + Vermicompost @ 2 t ha^{-1}	21.07	159.13	2339	2785
T_6-100% RDN + Two spray of vermiwash @ 50 lit ha^{-1} at 45 and 75 DAS	18.15	145.83	1889	2229
T_7-50 % RDN +Two spray of vermiwash @ 50 lit ha^{-1} at 45 and 75 DAS	16.46	141.97	1619	2085
T_8- 100% RDN + 15 kg Humic acid ha^{-1}	19.26	151.84	2082	2542
T_9-50% RDN + 15 kg Humic acid ha^{-1}	18.50	146.86	1952	2417
T_{10}- 50 % RDN+ NADEP @ 5 t ha^{-1}+ 15 kg Humic acid ha^{-1}	19.56	154.32	2263	2672
T_{11}-100% RDN + NADEP @ 5 t ha^{-1}	21.66	161.41	2516	2860
T_{12}- 50 % RDN + NADEP @ 5 t ha^{-1}	18.81	149.31	1983	2535
S.Em.+	0.72	1.56	73	87
C.D. (P=0.05)	2.04	4.39	207	247
C.V. %	10.38	2.85	9.60	9.56

and chlorophyll content provided greater sites for photosynthesis and diversion of photosynthates towards sink (umbels and seed). The beneficial effect of vermicompost by supplying an essential nutrients by vermicompost which might have resulted in higher manufacture of food and its subsequent partitioning to sink. The findings of present investigation are supported by those of Selvarajan and Chezhiyan (2001) and Khoja (2004).

CONCLUSION

The experimental results showed (Table-1 and 2) beneficial effect of integrated nutrient management on *rabi* fennel. Application of 100 % RDN (Recommended Dose of Nitrogen) with *Azospirillum* + PSB + vermicompost @ 2 t ha^{-1} recorded significantly higher growth, yield attributes and yield of *rabi* fennel. Integration of inorganic fertilizers along with bio-fertilizer and vermicompost results in higher growth and yield attributes as well as yield compared to use of inorganic ones only. This may due to the fact that the balanced and combined used of various plant nutrient sources results in proper absorption, translocation and assimilation of those nutrients, ultimately increase the growth, yield attributes and yield. It is also facts that improvement of physiological efficiency of different macro and trace elements resulted from the combined application of organic and inorganic sources of nutrients produces crop with superior quality under investigation.

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