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Performance of fennel varieties under organic production system

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Abstract

A field experiment was conducted to evaluate the fennel varieties tested for suitability under organic production system at ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan during the *Rabi* season 2015-16 to find out the varietal response under organic production system. Eight varieties *viz.,* AF-1, RF-101, CO-01, GF-12, Rajendra Saurabh, RF-281, RF-125 and GF-02 were tested under the organic system. The results revealed that, the variety GF-12 and AF-1 performed better in organic production system compared to other tested varieties. The maximum plant height at harvest (222.40 cm), number of primary branches plant^{-1} (11.53), number of secondary branches plant^{-1} (22.40), number of umbels plant^{-1} (45.73), number of umbelletes umbel^{-1} (39.67) and highest seed yield (2365.80 kg ha^{-1}) recorded in variety GF-12 followed by AF-1 (2354.10 kg ha^{-1}). AF-1 variety recorded highest plant nutrient status as compared to other varieties. Among eight varieties of fennel GF-12 and AF-1 were found better for organic production system in terms of growth and seed yield.

Key words : Fennel, organic production system, plant growth, varieties, yield.

Introduction

Foeniculum vulgare Mill commonly known as fennel is one of the most important medicinal and aromatic plants in the Mediterranean, Europe and Egypt (Kandil, 2002). It is a rustic perennial plant that can stand droughts and it is generally considered native to the Mediterranean shore (Rather *et al.,* 2012). However, it has become widely naturalized in many regions of the world, and it is often found on roadsides, in pastures and other cleared areas. The fennel by-products (biomass) in oasis environment are qualified to be used as fodder for livestock specifically for sheep breed named ‘‘D’Man”, known for its prolific and lactating qualities. The fennel promotes the secretion of milk due to its galactogogue properties (Agarwal *et al.,* 2008). In addition, biomass fennel can be used to extract natural dyes that can be applied in the textiles industry as an alternative to synthetic dyes (Haddar *et al.,* 2014). Moreover, Rao *et al.* (2010) the fennel residues, after the extraction of essential oil, can be used to sequester cadmium (Cd) ions from waste water. In fact, fennel domestication, which grows in a wild sate in oasis, would ensure a regular and sustainable supply of this plant and in a long-term would guarantee ex-situ conservation of this species which is threatened with extinction, under the combined effect of population pressure and climate aridity.

Organic fertilizers have been known to improve the biodiversity (Enwall *et al.,* 2005; Birkhofer *et al.,* 2008) and may prove a large depository for excess carbon dioxide (Lal, 2004). Organic fertilizers in comparison of the chemical fertilizers have lower nutrient content and are slow release but they are as effective as chemical fertilizers over longer periods of use (Naguib, 2011). Continuous usage of inorganic fertilizer affects soil structure. Hence, organic manures can serve as alternative to mineral fertilizers for improving soil structure (Dauda *et al.,* 2008) and microbial biomass (Suresh *et al*., 2004). Organic fertilizers are obtained from animal sources such as animal manure or plant sources like green manure. Organic manures and biofertilization are very important for spices and aromatic plants to produce the best product in both quantity and quality and it is safe for human, animal and the environment. The combination between compost and biofertilizers increased plant fresh and dry weights in the fourth cut compared to the other treatments of marjoram plants (Dewidar 2007). Active dry yeast, a natural biofertilizers is safe and causes various promoted effects on plants and is a natural source of cytokinins which simulates cell division and enlargement as well as the synthesis of protein, nucleic acid and B-vitamin (Ezz El-Din and Hendawy, 2010).

Organic farming involves holistic production management systems (for crops and livestock) emphasizing the use of management practices in preference to the use of off-farm inputs. This is accomplished by using, where ever possible, cultural, biological and mechanical methods in preference to synthetic materials. The European union

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regulations specify that an organic production system is designed to: Enhance biological diversity within the whole system, increase soil biological activity, maintain long-term soil fertility, recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimising the use of non-renewable resources, rely on renewable resources in locally organized agricultural systems, promote the healthy use of soil, water and air as well as minimise all forms of pollution there to that may result from agricultural practices, handle agricultural products with emphasis on careful processing methods in order to maintain the organic integrity and vital qualities of the product at all the stages. In the modern era of change in life pattern, the heath concern is increasing day by day therefore, the demands of organic products are very high in national and international market because, these are free from insecticides, pesticides and other harmful chemical compound residues. So this production system is human and environment friendly. Limited varieties information is available on fennel under organic cultivation system so far. Hence, the study on performance of fennel varieties under organic production system is very much needed. Therefore, this experiment was conducted to know the growth and yield performance of fennel varieties under organic production system.

Materials and methods

Investigation was carried at National Research Center on Seed Spices, Tabiji, Ajmer (Rajasthan) during 2015-16, to find out the fennel (*Foeniculum vulgare* Mill) varieties testing for suitability under organic farming system. Soil of experimental site is sandy loam in nature and the experimental block is maintained as per the organic production requirements from 2011. Soil fertility status of experimental site shows organic carbon (0.26%), available nitrogen (130.4 kg ha^{-1}), available phosphorus (12.06 kg ha^{-1}) and available potassium (359.07 kg ha^{-1}). The recommended dose of nutrients for fennel is 100:50:30 kg ha^{-1} and manures were applied on nitrogen equivalent basis through organic sources (50% by FYM, 25% by vermicompost and 25% by castor cake). Nitrogen content of farm yard manure, vermi compost and castor cake is 0.50 percent, 1.0 percent and 5.0 percent, respectively. Experiment was laid out in randomized block design with three replications with plot size of 12 m^2. Seeds were sown during second week of October by maintaining row to row spacing of 50 cm. Fennel seeds were sown at the rate of 10 kg ha^{-1} after treating seeds with *Trichoderma,* PSB and *Azotobacter* at rate of 10 g kg^{-1}. Irrigation and intercultural operations were done as and when required. The observations on growth and yield parameters of fennel were recorded periodically and the time of harvesting. Soil and plant samples were collected at time of harvest and analyzed for available nutrients in soil and nutrient content in plant samples. Randomly selected 5 plants were tagged/ labeled for recording observations on different growth and yield parameters. Data obtained were subjected to statistical analysis for F test as suggested by (Panse & Sukhatme, 1985).

Results and discussion

Effect on plant growth and growth attributing characters

The growth of different fennel varieties was significantly influenced by organic production system (Table-1). Maximum plant height at 45 days after sowing (DAS) (10.67 cm), 90 DAS (90.53 cm), at harvest (222.40 cm), primary branches $plant^{-1}$ (11.53), secondary branches $plant^{-1}$ (22.40) were recorded by the variety GF-12 followed by AF-1 where plant attained height 45 DAS (10.47 cm), 90 DAS (89.07 cm), at harvest (221.00 cm), primary branches $plant^{-1}$ (11.40), secondary branches $plant^{-1}$ (22.33). GF-2 and RF-125 was found to be statistically at par with GF-12. Flower initiation is one of the most important characters for seed production. It is evident from Table-1 that varieties GF-12 and AF-1 had early flower initiation and 50 percent flowering while variety GF-12 flower initiation (86.67 days), 50 percent flowering (97.00 days) followed by AF-1 then other varieties which was statistically significant. Nitrogen, phosphorus and potassium supply through FYM, vermicompost and castor cakes. Vermicompost is the builder of protein and is the main constituent of protoplasm in plants thus; the increase in nitrogen supply accelerates synthesis of amino acids which might have indirectly exhibited increase in plant height of fennel plant. Further, PSB also helpful in cell elongation and cell division in meristematic region of plant, this was due to the production of plant growth substances (IAA and GA) by PSB. Application of biofertilizers such as PSB helps to increase the biological nitrogen fixation and availability of phosphorus which is required for strong vegetative growth Deshmukh *et al*., (2014). Increase in plant growth might be due to the improvement in physio-chemical properties of soil; increase in enzymatic activity, microbial population and also increase in plant growth hormones by application of vermicompost Ekinci and Dursun (2009) in melon, Singh *et al.,* 2010 in cluster bean, Singh *et al.,* 2011 in brinjal. Herencia *et al.,* (2011) reported that composts contained nitrogen and phosphorus which enhanced vegetative growth and flower bud initiation. Singh

et al., (2008) found significant increase in fruit yield and flowering of strawberry with vermicompost based fertilizers. Subsequently, increase in plant height might be attributed to the effect of organic fertilizer that improves physiochemical, and biological properties of soil; that is, increasing soil organic matter, cation exchange capacity, and water holding capacity and availability of mineral nutrients and, this in turn, increases plant height (Al-Fraihat, 2011).

More number of primary and secondary branches might be attributed to the more balance C: N ratio, abundant supply of available nutrients from soil with comparatively lesser retention in roots and more translocation to arial parts for protoplasmic proteins and synthesis of other compounds. Similar results were also reported Vasmate *et al*., (2007) in coriander, Singh (2013) in fenugreek, Sahu *et al.,* (2014) and Lal *et al.,* (2017) in coriander.

Yield and yield attributing character

Findings of the present investigation: exhibited (Table-1) that the highest number of umbels (45.73 plant^{-1}), umbellets (39.67 umbel^{-1}) and seed yield kg ha^{-1} (2365.80 kg ha^{-1}) was in fennel variety GF-12 followed by AF-1 umbels (45.00 plant^{-1}), umbellets umbel^{-1} (39.40) and seed yield (2354.10 kg ha^{-1}). GF-02 and RF-125 was found to be statistically at par with GF-12. The lowest number of umbels plant^{-1} (33.93), umbellets umbel^{-1} (29.67) and seed yield (1804.70 kg ha^{-1}) was recorded in the variety CO-01. The increased yield in variety GF-12 and AF-1 might be due to more uptakes of N, P and K, which results in better vegetative growth, while phosphorus improves the root growth and productive ability. FYM had increased the soil organic matter and improved the soil structure and biological activity of soil. This would have reduced the loss of nitrogen by increased cation and anion exchange capacities in soil thereby enhancing the seed yield in umbel, umbellets and yield. Further, by improving the structure of the soil by more aggregation, water holding capacity and air permeability are increased. This comprehensive change in soil might have improved the vegetative growth and yield. Similar results were found in Vasmate *et al.,* (2008) in coriander, Abdou *et al.,* (2004), Azzaz *et al.,* (2009), Singh (2012) in fennel, Singh (2013) in fenugreek and Sahu *et al.,* (2014) in coriander.

In organic system, use of different organic sources of plant nutrients, increased the yield and related attributes of fennel. This is possible due to balanced C:N ratio and more decomposition, mineralization, availability of native and applied macro and micro-nutrients. All these might have accelerated the synthesis of carbohydrate and its better translocation from sink to source, which probably have led to an improvement in yield and yield related attributes. Similar observations were also in conformity with, Salem and Awad (2005) in coriander, Bardan and Safwat (2004), Godara *et al*., (2014) in fennel, Valadabadi and Farahani (2011) in nigella and Lal *et al.,* (2017) in coriander.

Table 1. Growth and yield attributing characters of fennel varieties under organic production system.

Treatment	Plant height (cm)			Primary branches Plant^{-1}	Secondary branches plant^{-1}	Days to flower initiation	Days to 50% flowering	Umbel plant^{-1}	Umbellate umbel^{-1}	Seed yield (kg ha^{-1})
	45 DAS	90 DAS	At harvest							
AF-1	10.47	89.07	221.00	11.40	22.33	87.67	97.33	45.00	39.40	2354
RF-101	8.10	82.13	208.73	7.57	15.63	91.67	100.67	35.03	30.03	1829
Co-1	7.53	80.13	204.77	7.00	14.43	91.67	101.00	33.93	29.67	1804
R. Saurabha	8.40	85.27	212.43	8.10	17.67	91.00	100.33	38.17	32.07	1951
GF-12	10.67	90.53	222.40	11.53	22.40	86.67	97.00	45.73	39.67	2365
RF-281	8.90	86.27	214.40	8.83	18.97	90.00	99.67	39.50	35.53	2099
RF-125	9.93	88.37	220.00	10.47	21.67	88.67	98.67	42.50	37.53	2276
GF-2	9.80	88.13	218.17	10.33	21.07	89.00	99.00	42.17	37.37	2278
S Em±	0.40	1.12	3.44	0.44	0.75	0.71	0.71	1.95	1.47	118
CD(P=0.05)	1.22	3.41	10.44	1.34	2.26	2.16	2.14	5.92	4.45	358
CV %	7.53	2.26	2.77	8.11	6.70	1.38	1.23	8.40	7.23	9.65

Soil fertility status of fennel varieties

Soil fertility and nutrient status of fennel crop after harvest was influenced significantly under organic management (Table 2). High yielding varieties such as GF-12, AF-1, GF-2 and RF-125 removed higher amount of nutrients as compared to low yielding group *i.e*., Co-01, RF-101, Rajendra Saurabha and RF-281. In the plots of Co-01 (158.47 kg ha^{-1}), RF-101 (156.80 kg ha^{-1}), Rajendra Saurabha (154.29 kg ha^{-1}) and RF-281 (153.45 kg ha^{-1}) highest residual nitrogen was found. This is mainly due to the fad that early maturity of crop leads to more residual soil fertility in the respective plots which is attributed by less removal of nutrients. Similar trend was observed in phosphorus and potassium fertility of the soil also. Nutrient use efficiency will vary with the efficiency of variety to utilize the applied nutrients. High yielding varieties are always efficient enough to absorb more nutrients since these are metabolically more active. The results are in confirmation with Chhibba *et. al.,* (2000), Basu *et.al.,* (2008) in fenugreek, Azarmi *et al*., (2008) in tomato, Patel *et al., (*2013) in cumin, Malik *et al*., (2013), Singh *et al.,* (2013), Lal *et al.,* (2017) in coriander and Malav *et al.,* (2018) in fenugreek.

Conclusions

Selection of proper and responsive variety in any crop under organic production system plays a vital role. From the study it can be concluded that suitable variety is very important for organic farming which is able to perform in organic system. GF-12 and AF-1 are most suitable varieties under organic management system as these are high yielding and produced more biomass which can be recycled to produce compost. Application of 50 percent FYM, 25 percent vermi compost and 25 percent castor cake on nitrogen equivalent basis along with *Trichoderma and PSB* seed treatment is sufficient to meet the demand of fennel varieties for achieving higher seed yield and biomass.

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Table 2. Soil nutrient status after harvest of fennel varieties under organic production system.

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	O.C (%)
AF-1	148.02	13.63	365.64	0.28
RF-101	156.80	16.00	375.01	0.29
Co-01	158.47	16.65	377.93	0.29
Rajendra Saurabha	154.29	15.66	374.42	0.29
GF-12	147.60	13.78	365.57	0.27
RF-281	153.45	12.70	373.22	0.28
RF-125	150.11	13.47	369.04	0.28
GF-02	149.69	12.93	367.77	0.27
S Em±	1.02	0.68	2.47	0.02
CD(P=0.05)	3.09	2.08	7.50	NS
CV %	1.16	8.26	1.15	10.01

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