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ENHANCING FENNEL YIELD AND SOIL HEALTH THROUGH SHISHAM INTERCROPPING: EXPLORING QUALITY AND SOIL ATTRIBUTES

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ABSTRACT

The present investigation entitled "Enhancing Fennel Yield and Soil Health through Shisham Intercropping: Exploring Quality and Soil Attributes" was carried out in RBD with three replications from September, 2022 to April, 2023 at Herbal Garden, under the Department of Silviculture and Agroforestry, College of Horticulture and Forestry, Jhalawar (Agriculture University, Kota). Four years old Plantations of Shisham (*Dalbergia sissoo* Roxb.) spaced at 05 m × 05 m were used for intercropping of five varieties of Fennel (*Foeniculum vulgare* Mill.) *viz.* 'AF-1, AF-2, RF-125, RF-205 and RF-290' plant data spacing 50 cm × 20 cm were selected for the present study. The analysis of variance showed significant differences among intercropping fennel under Shisham based Agroforestry system as well as Sole cropping system. For the quality parameters under fennel sole and Shisham based agroforestry system, total chlorophyll content and germination percent was found non-significant in Fennel. In all varieties, the highest test weight was recorded with variety AF-1 (9.95 g) in intercropping followed by AF-1 (9.77 g) in sole and highest oil content was recorded with variety RF-125 (2.04%) in sole followed by RF-125 (2.01%) in intercropping.All the data regarding soil parameters (EC, pH, O.C, N, P and K) were found non-significant except soil moisture (%) (6.73), which was found maximum in T_1 (Shisham+ Fennel var. AF-1) var. AF-1 sole).

Key words : Agroforestry, Fennel, Intercropping, Organic carbon, Electrical conductivity, Shisham.

Introduction

The direct mixing of crops and trees in a spatial and temporal sequence on the same plot of land is referred to as agroforestry. Agroforestry is a broadly defined term that refers to the intentional cultivation of trees and shrubs alongside crops and/or animals in interdependent combinations for a range of purposes. These farming methods have been around for a while, but it wasn't until the late 1970s that they gained notoriety as a land-use technique due to scientific scrutiny.

The herb fennel (*Foeniculum vulgare* Mill.) is evergreen. The fruit is a dry schizocarp that is grooved and is 4–10 milli meters (3½16–3½8 inch) in length and half that width. The entire fruit is frequently mislabeled "seed" since the seed is affixed to the pericarp. There is variation in the variety and amount of vitamins present: folates (270 mg/kg); vitamin B3 (6.4 mg/kg); and vitamin C (8.7–340 mg/kg). Potassium (4.24–5.85 g/kg) is by far the most prevalent mineral in fennel; phosphorus (500 mg/kg), calcium (5.6–363 mg/kg), magnesium (8.2-389 mg/k) and sodium (7.7–512 mg/kg) are the least abundant minerals (Koudela and Petrikova, 2008). As per ministry of agriculture and farmers welfare (2021-22) 3rd advance estimate, the total area in India under Fennel cultivation is 0.79 lakh hectares and production is 1.28 lakh metric tonnes (Anonymous, 2021-22).

The Papilionaceae family includes the significant tree species known as shisham (*Dalbergia sissoo* Roxb.). About 25 meters tall, this medium-to-large tree has a grey-yellow trunk, a longitudinal fissure, and downcast twigs. Pinnately complex, leathery leaves have roughly

five alternating leaflets. Each leaflet is broadest at the base and has a leaf stalk (petiole) that is approximately 15 cm long and ends in a finely pointed tip that is 6 cm long (Bharath *et al.*, 2013). It is identified Shisham tree as a distinctive species of the principal seral type forest known as Khair– Sissoo (*Acacia catechu–Dalbergia sissoo* Roxb.).

Fennel (*Foeniculum vulgare* Mill.) intercropping within an agroforestry system based on Shisham (*Dalbergia sissoo* Roxb.) may prove to be an intriguing area of study with potential advantages for sustainable land use and agricultural productivity. Agroforestry system design, crop performance and interaction, soil health and nutrient cycling, microclimate alterations, sustainability and economic viability, and environmental effect are just a few of the many potential variables that might be taken into consideration when doing the research.

Materials and Methods

Study area

The present investigation was conducted at the Herbal Garden, College of Horticulture and Forestry, Jhalawar. Geographically, district Jhalawar present in Zone-V *i.e.*, Humid south eastern plains, which extends over 6.32 Lac hectare land area among 23°4' to 24°52' N (latitude) and 75°29' to 76°56' E (longitude). The experiment was carried outin RBD withthree replications during summer season (September, 2022 to April, 2023). All the quality and soil parameters were recorded at the termination of the experiment in the month of April.

Soil condition

In order to assess the physico-chemical properties of the soil at the experimental site, the soil samples were drawn randomly from different spots in the experimental site at a depth of 0-30 cm before the commencement of the experiment.

Plant material

Four years old plantations of Shisham (*Dalbergia sissoo* Roxb.) grown at 5 m ×5 m spacing was used for intercropping study. Five varieties of fennel (*Foeniculum vulgare* Mill.) crop *viz*. AF-1, AF-2, RF-125, RF-205 and RF-290 were selected for the present study. The Shisham plants of uniform size and growth were selected for experimentation. The gross plot area and net plot area of fennel was 5 m × 5 m and 4 m× 3 m, respectively.

Method analysis

Chlorophyll content (mg/g)

The chlorophyll content was assessed using the technique described by Sadasivam and Manickam (1997).

Table 1 : Treatment details.

	Treatment details
T_0	Shisham (*Dalbergia sissoo* Roxb.) alone
T_1	Shisham (*Dalbergia sissoo* Roxb.) + *Foeniculum vulgare* Mill. var. Ajmer fennel-1 (AF-1)
T_2	Shisham (*Dalbergia sissoo* Roxb.)+*Foeniculum vulgare* Mill. var. Ajmer fennel- 2 (AF-2)
T_3	Shisham (*Dalbergia sissoo* Roxb.)+*Foeniculum vulgare* Mill. var. Rajasthan fennel-125 (RF-125)
T_4	Shisham (*Dalbergia sissoo* Roxb.)+*Foeniculum vulgare* Mill. var. Rajasthan fennel- 205 (RF-205)
T_5	Shisham (*Dalbergia sissoo* Roxb.)+*Foeniculum vulgare* Mill. var. Rajasthan fennel- 290 (RF-290)
T_6	*Foeniculum vulgare* Mill. var. Ajmer fennel-1 (AF-1)
T_7	*Foeniculum vulgare* Mill. var. Ajmer fennel- 2 (AF-2)
T_8	*Foeniculum vulgare* Mill. var. Rajasthan fennel- 125 (RF-125)
T_9	*Foeniculum vulgare* Mill. var. Rajasthan fennel-205 (RF-205)
T_{10}	*Foeniculum vulgare* Mill. var. Rajasthan fennel- 290 (RF-290)

The volume of chlorophyll present in the extract was premeditated using the following equation:

Total chlorophyll (mg/g tissue) = 20.2 (A645) + 8.02 (A663) × V/1000 × W

where,

A = precise wavelength absorbance.

V = extraction of the final volume of chlorophyll in 80% acetone.

W = extracted tissue fresh weight

Germination percent (%)

Seed germination was tested using Top paper method. Number of seeds germinated was recorded in each treatment and percentage was calculated by the formulae given below:

$$\text{Seed Germination (\%)} = \frac{\text{Number of germinated}}{\text{Total number of seed}} \times 100$$

Oil content (%)

Fresh seeds of Fennel were placed in the plant chamber of the still and pressurized steam is generated in a separate chamber and circulated through the seeds.The thin layer of oil was recovered from hydrosols by using organic solvent (n-hexane) (Younis *et al.*, 2008).

pH

Using a glass electrode pH metre and 1:2 soil water

suspensions (Jackson, 1973).

Electrical conductivity (dS m^{-1})

Electrical conductivity of soil water suspensions (1:2.5) calculated using EC meter (Model Elico CL 180) as elaborated by Jackson (1973).

Organic carbon (%)

The chromic acid wet oxidation method developed by Walkley and Black (1934) serves as the foundation for the calculation of soil organic carbon.

$$\text{Organic carbon (\%)} = \frac{19(B-T)\times 0.003\times 100}{B\times \text{Weight of soil (g)}}$$

B = Volume (ml) of ferrous ammonium sulphate solution required for blank titration.

T = Volume of ferrous ammonium sulphate solution needed for titration of soil sample.

Available Nitrogen (kg ha^{-1})

Utilising the alkaline potassium permanganate method as recommended by Subbiah and Asija, available nitrogen was ascertained (1956).

Available N (kg/ha) = R × 31.36, R = Volume of 0.02 N H_2SO_4 required for titration

Available Phosphorus in soil (kg ha^{-1})

Available phosphorus was determined with extraction by 0.5 M $NaHCO_3$ solution adjusted at pH 8.5 as suggested by Olsen *et al*. (1954).

$$Available\ P\left(kg\ ha^{-1}\right) = \frac{R\times Volume\ of\ extract\times 2.24\times 10^2}{Volume\ of\ aliquot\times Weight\ of\ soil\times 10^2}$$

$$\text{R = ppm P in the aliquot} = \frac{R\times 100}{5}\times\frac{2.24}{5}$$ (Obtained from standard curve) = (ppm P) R × 8.96 × 2.29

Available Potassium (kg ha^{-1})

Available potassium was determined by extracting the soil by shaking with 1 N neutral ammonium acetate solution by flame photometer as suggested by Metson (1956).

$$Available\ K\left(kg\ ha^{-1}\right) = \frac{R\times Volume\ of\ extract\times 2.24\times 10^2}{Weight\ of\ soil\ taken\times 10^2}$$

R = ppm of K in the extract (obtained from the standard curve)

Soil moisture (%)

The composite soil sample on monthly basis was collected from 0-15 cm depth and by gravi-metric.

$$\text{Soil moisture (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Dry weight}}\times 100$$

Statistical analysis

The data obtained from were subjected to statistical analysis (ANOVA) in MS Excel programme on computer system through the procedure of randomized block design (RBD) for various characters studied in present investigation. The treatment differences were tested by "F" test for significance based on null hypothesis. The appropriate standard error (S.Em.±) was calculated in each case and critical difference (CD) at 5 per cent level of probability was worked out to compare the treatment means, where the treatment effects were significant (Panse and Sukhatme, 1967).

Results and Discussion

Test weight

The test weight (g) of Fennel as a sole crop and under Shisham based agroforestry system was observed significant from analysis of variance. Highest test weight was found in the treatment T_1 (Shisham + *Foeniculum vulgare* Mill. var. AF-1) (9.95 g). However, lowest test weight was recorded in the treatment T_8 (*Foeniculum vulgare* Mill. var. RF -125 sole) (7.80 g), which exhibited at par performance with T_3 (7.88 g).

The superiority of AF-1 in test weight can be attributed on account of efficient translocation ofmetabolic toward grain development. These results are in close line to that of Bisht *et al*. (2017) in wheat under poplar, Singh *et al*. (2010) in Fennel.

Oil content

Among the evaluation of different treatments the result of oil content (%) of Fennel was found to be significant. The maximum percent of oil content was found in T_8 (*Foeniculum vulgare* Mill. var. Rajasthan Fennel-125 sole) (2.04%), which was found to be significantly superior over all other treatment sand minimum oil content (%) was found in T_7 (Shisham+ *Foeniculum vulgare* Mill. var. AF-1) (1.86%). The difference between the results of other researchers might be due to seed materials of different origin, different ecological conditions, different sowing time, fertilizer application, harvesting at different maturity stages and difference in agronomic practices conducted at growing stages. These results are in close line to that of Shivaprasad *et al*. (2018) in Fennel varieties.

Total chlorophyll content and germination test

The critical analysis of the data on total chlorophyll content and germination test of sole Fennel and with Shisham based agroforestry systems is mentioned in Table 2. Among the evaluation of different treatments the result of total chlorophyll content and germination

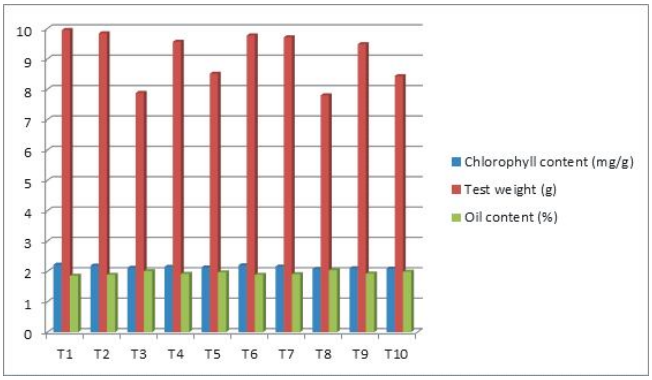

Fig. 1 : Graph representing the quality parameters of fennel.

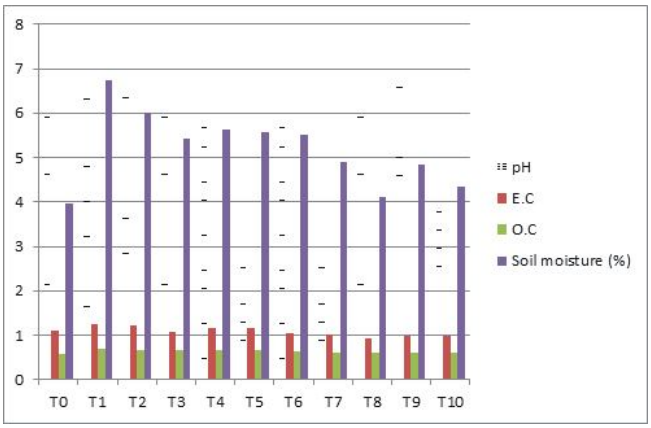

Fig. 2 : Graphical representation of different soil parameters (%).

test of Fennelwasfoundtobenon-significant. These results are in confirmation with the findings of Meena *et al*. (2014) in Fennel and Deswal *et al*. (2017) in Fennel.

Soil parameters

Soil pH, E.C. (ds / m) and O.C. (%)

The data obtained with regard to the pH, E.C. and O.C. of soil at harvesting stage of Fennel intercrop under

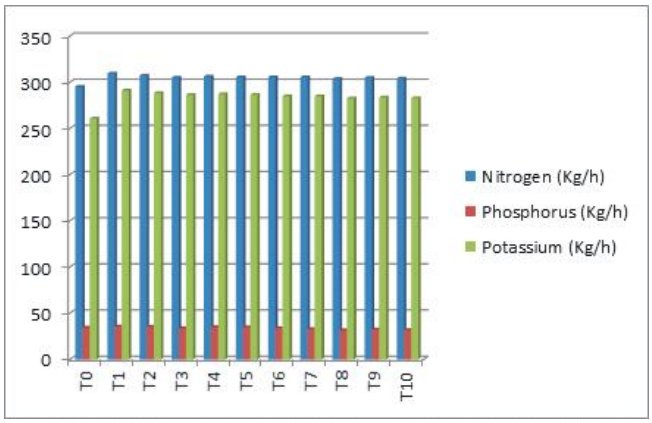

Fig. 3 : Graph representing the N, P and K contents in soil.

Plate 1 : Field view of Fennel at flowering stage.

Shisham based agroforestry system and their sole crops are mentioned in Table 3. The results were found non-significant which are supported by Lal *et al*. (2019) in Fennel, Chander *et al*. (1998) in Wheat and Cowpea

Table 2 : Mean performance of quality attributes of Fennel sole and under Shisham based intercropping.

S. no.	Treatments	Chlorophyll content (mg/g)	Test weight (g)	Germination percentage(%)	Oil content (%)
1.	T_1 Shisham+Fennel var. AF – 1	2.22	9.95	98.33	1.86
2.	T_2 Shisham+Fennel var. AF – 2	2.19	9.84	97.67	1.89
3.	T_3 Shisham+Fennel. var. RF-125	2.12	7.88	98.00	2.01
4.	T_4 Shisham+ Fennel. var. RF – 205	2.15	9.56	98.01	1.92
5.	T_5 Shisham+Fennel var. RF- 290	2.13	8.51	98.00	1.97
6.	T_6 Fennel var. AF – 1 Sole	2.20	9.77	99.33	1.89
7.	T_7 Fennel var. AF – 2 Sole	2.16	9.71	98.33	1.91
8.	T_8 Fennel. var. RF -125 Sole	2.08	7.80	97.33	2.04
9.	T_9 Fennel. var. RF - 205 Sole	2.10	9.48	98.00	1.93
10.	T_{10} Fennel var. RF- 290 Sole	2.09	8.43	97.67	1.99
	C.D. at 5%	**NS**	**0.29**	**NS**	**0.06**
	SE(m)	**0.03**	**0.1**	**0.36**	**0.02**

Table 3 : Mean performance of soil attributes of Fennel sole and under Shisham based intercropping.

S. no.	Treatments	pH	E.C	O.C	Soil moisture content (%)	Nitrogen (Kg/ha)	Phosphorus (Kg/ha)	Potassium (Kg/ha)
1.	T_0 Shisham Sole	7.41	1.09	0.57	3.95	295.21	34.56	260.78
2.	T_1 Shisham+ Fennel var. AF – 1	7.06	1.25	0.68	6.73	309.347	35.66	291.21
3.	T_2 Shisham+Fennel var. AF – 2	7.10	1.22	0.67	6.01	307.26	35.52	288.32
4.	T_3 Shisham+Fennel. var. RF-125	7.40	1.06	0.65	5.42	305.12	33.96	286.36
5.	T_4 Shisham+ Fennel. var. RF – 205	7.11	1.17	0.66	5.62	306.32	34.98	287.24
6.	T_5 Shisham+Fennel var. RF- 290	7.30	1.15	0.66	5.56	305.43	34.87	286.62
7.	T_6 Fennel var. AF – 1 Sole	7.11	1.04	0.63	5.52	305.517	33.82	284.96
8.	T_7 Fennel var. AF – 2 Sole	7.30	1.02	0.62	4.91	305.39	32.86	284.92
9.	T_8 Fennel. var. RF -125 Sole	7.41	0.92	0.6	4.12	303.58	31.78	282.62
10.	T_9 Fennel. var. RF - 205 Sole	7.35	0.99	0.62	4.83	304.89	32.48	283.54
11.	T_{10} Fennel var. RF- 290 Sole	7.37	0.98	0.61	4.34	303.99	31.96	282.86
	C.D.at 5%	**NS**	**NS**	**NS**	**1.01**	**NS**	**NS**	**NS**
	SE(m)	**0.10**	**0.07**	**0.04**	**0.34**	**4.36**	**0.92**	**7.17**

under Shisham, Gupta and Pandey (2008) in Shisham, Teak, Eucalyptus and Poplar.

Major nutrients (N, P, K)

At the harvesting stage of Fennel, the results obtained with respect to major nutrients (N, P and K) in soil under Shisham based agroforestry system and their sole cropping were found non-significant, which are supported by Bertin *et al*. (2003) and Devi *et al*. (2020) in Wheat under Kinnow and Eucalyptus.

Soil moisture (%)

The maximum soil moisture was found in T_1 (Shisham+ Fennel var. AF-1) (6.73%) and minimum Soil moisture was found in T_8 Fennel var. RF-125 (Sole) (4.12%). The data pertaining to the variation in soil moisture recorded on monthly basis in Fennel intercropped under Shisham based agroforestry system in an intercropping system; the presence of taller crop Shisham can provide shade and reduce direct sun light exposure on the soil surface. Further, this shade helps toreduce evaporation and waterloss from the soil, leading to highersoil moisture content. Similar results were also observed by Salim *et al*. (2018), Das and Mondal (2016) and Sundarpandian *et al*. (2016) from Uttara khand, West Bengal and Pondicherry, respectively.

Conclusion

From the present investigation, it can be concluded that the analysis of variance showed non-significant differences for Chlorophyll content; Germination percentage parameters collected from intercropping of Fennel under Shisham based Agroforestry system as well as sole cropping system. Significantly maximum test weight was found in the treatment T_1 (Shisham + *Foeniculum vulgare* Mill. var. AF-1) and maximum oil content was found in the treatment T_8 (*Foeniculum vulgare* Mill. var. RF-125 sole). Similarly, the analysis of variance showed non-significant differences among all soil parameters except for soil moisture collected from intercropping of Fennel under Shisham based agroforestry system as well as sole cropping system. Significantly maximum soil moisture (%) T_1(Shisham + *Foeniculum vulgare* Mill. var. AF -1). Therefore AF-1 among five varieties of Fennel is recommended as an intercrop at the spacing 50 cm × 20 cm in Shisham plantation at the spacing of 5 m × 5 m.

Declaration

The authors do not have any conflict of interest.

References

Anonymous (2021-22). Area and Production of Horticulture crops (third advance estimate). *Ministry of Agriculture and Farmers' Welfare*, New Delhi, p. 1.

Bertin, C., Yang X. and Weston L.A. (2003). The role of root exudates and allelochemicals in the rhizosphere. *Int. J. Plant Soil Sci.*, **256(1)**, 67-83.

Bharath, M., Tulasi E.L.R., Sudhakar K. and Eswaraiah M.C. (2013). *Dalbergia sissoo* DC–An important medicinal plant. *Int. J. Res. Pharma. Chem.*, **3(2)**, 384-388.

Bisht, N., Sah V.K., Satyawali K. and Tiwari S. (2017). Comparison of wheat yield and soil properties under open and poplar based agroforestry system. *J. Appl. Nat. Sci.*, **9(3)**, 1540-1543.

Chander, K., Goyal S., Nandal D.P. and Kapoor K.K. (1998). Soil organic matter, microbial biomass and enzyme activities in a tropical agroforestry system. *Biol. Fert. Soils*, **27(2)**, 168-172.

Das, C. and Mondal N.K. (2016). Litterfall, decomposition and

nutrient release of *Shorea robusta* and *Tectona grandis* in a sub-tropical forest of West Bengal, Eastern India. *J. Forestry Res.*, **27(1)**, 1055-1065.

Deswal, S., Mor V.S., Malik T.P., Tehlan S.K. and Mekala S. (2017). Seed quality and vigour assessment of fennel (*Foeniculum vulgare*) genotypes. *Int. J. Curr. Microbioliol. Appl. Sci.*, **6(10)**, 4970-4980.

Devi, S., Bhardwaj K.K., Dahiya G., Sharma M.K., Verma A.K. and Louhar G. (2020). Effect of agri-silvi-horticultural system on soil chemical properties and available nutrients at different depths in Haryana. *Range Manage. Agroforest.*, **41(2)**, 267-275.

Gupta, M.K. and Pandey R. (2008). Soil organic carbon pool under different plantations in some districts of Uttarakhand and Haryana. *Indian J. Forestry*, **31(3)**, 369-374.

Jackson, M.L. (1967). *Soil chemical analysis* (Indian edition). Prentice hall of India Pvt. Ltd., New Delhi.

Kang, B.T. and Akinnifesi F.K. (2000). Agroforestry as alternative land use production systems for the tropics. In: *Natural Resources Forum*, **24(2)**, 137-151. Oxford, UK: Blackwell Publishing Ltd.

Koudela, M. and Petøíková K. (2008). Nutritional compositions and yield of sweet fennel cultivars-*Foeniculum vulgare* Mill. ssp. *vulgare* var. azoricum (Mill.) Thell. *Hort. Sci.*, **35(1)**, 1-6.

Lal, G., Meena N.K., Chaudhary N. and Choudhary M.K. (2019). Performance of fennel varieties under organic production system. *Int. J. Seed Spices*, **9(1)**, 21- 26.

Meena, M., Yadav L.R., Yadav S.S., Sharma O.P., Choudhary G.L. and Choudhary P. (2014). Response of fennel (*Foeniculum vulgare* Mill) to irrigation and mulching. *J. Spices Aromatic Crops*, **23(1)**, 106-109.

Meston, A.J. (1956). *Methods of chemical analysis for soil survey samples*. Department of Science and Research Soil Buro, pp. 12.

Olsen, S.R., Cole C.V., Watanabe F.S. and Dean L.A. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate*. U.S. Department of Agriculture Circular .p. 939.

Panse, V.G. and Sukhatme P.V. (1967). Statistical methods for agricultural workers, Indian edition. ICAR, New Delhi, p. 58-62.

Salim, M., Kumar S., Kumar P. and Gupta M.K. (2018). A comparative study of soil physicochemical properties between eucalyptus, teak, acacia and mixed plantation of Jhilmil Jheel wetland, Haridwar-Uttrakhand. *Int. J. Scientif. Res. Public.*, **8(1)**, 378-385.

Shivaprasad, S., Umesha K., Gowda A.M., Shivapriya M., Ramegowda G.K. and Mohankumar S. (2018). Performance of fennel varieties for quality attributes under eastern dry zone of Karnataka. *J. Pharmacog. Phytochem.*, **7(3)**, 147-149.

Singh, B., Gill R.I.S. and Gill P.S. (2010). Soil fertility under various tree species and poplar-based agroforestry system. *J. Res., Punjab Agricult. Univ.*, **47(3-4)**, 160-164.

Subbiah, B.V. and Asija G.L. (1956). A rapid method for estimation of nitrogen in soil. *Curr. Sci.*, **26**, 259-260.

Sundarapandian, S.M., Amritha S., Gowsalya L., Kayathri P., Thamizharasi M., Dar J.A. and Subashree K. (2016). Soil organic carbon stocks in different land uses in Pondicherry university campus, Puducherry, India. *Trop. Plant Res.*, 3(1): 10-17.

Walkley, A. and Black I.A. (1934). An examination of method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.*, **37**, 29-37.

Younis, M. and Akkaya K. (2008). Strategies and techniques for node placement in wireless sensor networks: A survey. *Ad Hoc Networks*, **6(4)**, 621-655.