Indian Journal of Agricultural Sciences **83** (2): 193–7, February 2013/Article

Irrigation and FYM effect on seed, oil and carvone yield and economics of European dill (*Anethum graveolens*)

VINEETA[1], U C SHARMA[2], VANDANA[3], ATUL K GUPTA[4] and D S SRIVASTAVA[5]

Department of Agronomy, College of Agriculture, G B Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand 263 145

Received: 17 September 2012; Revised accepted: 6 January 2013

ABSTRACT

European dill (*Anethum graveolens* L.) has been used in ayurvedic medicines since ancient times and it is a popular herb widely used as a spice and also yields essential oil. A field cum laboratory experiment was conducted for three years from 2005–08 at Norman E Borlaug Crop Research Centre and in the Department of Agronomy of GBPUA & T, Pantnagar (Uttarakhand) to study the effect of irrigation and FYM on yield and oil quality of European dill. The treatments comprising 4 CPE levels of irrigation (50, 100, 150 and 200 mm) and 3 fertility levels (0, 15 and 30 tonnes FYM/ha) were laid out in factorial randomized block design with 3 replications. Various growth and yield attributes were found to be significantly higher due to irrigation at 100 mm CPE and fertilized with 30 tonnes FYM/ha ($I_{100}F_{30}$). This caused significant enhancement in the seed, oil and carvone yield and finally highest net return (₹ 36 145/ha) and B: C ratio (1.57).

Key words: Carvone, European dill, FYM, Irrigation, Oil yield, Yield

Essential oils and extracts of aromatic plants have long been used for a various medicinal and domestic purposes. European dill (*Anethum graveolens* L.) belongs to family *umbelliferae*, commonly known as *vilayati* or *bideshi saunf* in India and is used mainly as seed spice. The herb and seed contains essential oil known as dill herb/seed oil. The herb on hydro-steam distillation and seed on water distillation yields 0.5–1.2 and 2.5–3.5 per cent essential oil, respectively. The seed oil is considered to be of good quality due to presence of more carvone (>75%) and least dillapiole (<5%). As a medicinal plant, dill exhibits antispasmodic, carminative, digestive, laxative, narcotic, sedative, stimulant, galactogogue and stomachic properties. Dill is also useful in cough, cold, and flu remedies. In medicinal plants, the content of metabolite is economically more important than the yield of the plant part containing the metabolite, as it determines the cost of its extraction (Jaleel *et al*. 2008).

Among the various agro techniques, required for higher production and good quality essential oil, judicious water management and good nutrient supply play important role. Also, availability of adequate soil moisture is necessary for efficient use of other inputs. Therefore the present investigation was carried out to study the optimum irrigation scheduling and FYM nutrition to ascertain higher crop productivity, oil quality as well as net return.

MATERIALS AND METHODS

A field and laboratory experiment for three years from 2005-08 was conducted at N E Borlaug Crop Research Centre and in the Department of Agronomy, College of Agriculture, GBPUA & T, Pantnagar, U S Nagar, Uttarakhand. The soil of the experimental site was consisted of sandy loam texture, rich in organic carbon content (0.83%), low in available nitrogen (224.19 kg/ha), medium in available phosphorus (20.67 kg/ha) and potassium (146.74 kg/ha) and neutral in reaction (pH 7.78). The treatments comprising 4 levels of irrigation scheduled at 50 (I_{50}), 100 (I_{100}), 150 (I_{150}) and 200 (I_{200}) mm CPE and 3 levels of soil fertility, viz 0 (F_0), 15 (F_{15}) and 30 (F_{30}) tonnes FYM/ha, were evaluated in factorial randomized block design with three replications. The crop was sown two years from 2005–07 during winter (*rabi*) season in month of December using seed rate of 5 kg/ha and harvested during summer in May. Post-sowing irrigations of 60 mm depth and farmyard manure were applied as per treatments. Well decomposed and pulverized farmyard

Based on part of Ph D thesis submitted to GBPUA&T, Pantnagar in 2007

[1] SPO (e mail: vineetaagron@gmail.com), UKS&TDC, Pantnagar, Uttarakhand 263 145; [2]Assistant Professor, Department of Agronomy, RVSKVV, Gwalior, Madhya Pradesh; [3]MSc Student, Department of Foods & Nutrition; [4]SPO, UKS&TDC, Pantnagar, Uttarakhand 263 145; [5]SMS, Plant Protection, KVK, Sitapur–II, Uttar Pradesh

manure (FYM) broadcasted carefully in different amounts in each plot as per treatments two days before sowing and mixed uniformly and thoroughly by digging with the help of spade. Irrigation treatments were executed by providing irrigation channels between the plots. One common irrigation was given in each plot after 25 days of sowing for proper crop establishment. Subsequent irrigation treatments were scheduled based on cumulative pan evaporation (CPE) data. Irrigation water was measured with the help of *Parshall* flume under free flow conditions fixed in the irrigation channel to provide water up to 6 cm depth of soil at each irrigation. Depending upon rainfall, number of irrigation needed in I_{50}, I_{100}, I_{150}, I_{200} treatments during first and second year were 4, 2, 1, 1 and 7, 3, 2, 1, respectively. For the observations on growth and yield attributes five plants were randomly selected from net plot area and tagged before starting observation. Umbels from the main shoots, primary, secondary and tertiary branches were picked up as and when they matured from net plot area then umbels were collected in separate cloth bags and sun dried. After proper sun drying, the umbels were threshed manually. Thereafter, the seeds were collected, cleaned and weighed.

The crop quality was judged by extracting oil from seeds and active principles present in oil. For obtaining seed oil, water distillation method using Clevenger's type glass distillation apparatus was used. Immediate after crop harvesting, essential oil was distilled from seeds after threshing. Distillation process for each sample continued for 3 hours during the year 2005–06 (first year) and 2006–07 (second year). The essential oil content was calculated using formula:

$$\text{Essential oil content (\% volume/weight basis)} = \frac{\text{Quantity of essential oil (ml)}}{\text{Weight seeds (g)}} \times 100$$

For obtaining oil yield, the following formula was used:

$$\text{Oil yield (kg/ha)} = \frac{\text{Seed yield (kg/ha)} \times \text{Oil content in seed (\%)} \times \text{Specific gravity of seed oil}}{100}$$

Essential oil samples were analyzed for determination of active principles in oil, i e carvone using Gas-liquid chromatography. The filtered dehydrated oil was used for analysis. The carvone yield was obtained by using following formula:

$$\text{Carvone yield (kg/ha)} = \frac{\text{Oil yield (kg/ha)} \times \text{Carvone content in seed oil (\%)}}{100}$$

The statistical analysis of the data was done by following the procedure for analyzing factorial randomized block design (Cochron and Cox 1966) and by using statistical software programme, STPR 3 (Developed by Department of Mathmatics & Statistics, College of CBSH, GBPUA&T, Pantnagar). The critical difference for comparing the treatment means at 5% level of probability was computed wherever the F-test was significant.

RESULTS AND DISCUSSION

Effect of irrigation levels

Irrigation levels influenced the growth characters, yield attributes, oil yield, seed yield and carvone yield of European dill significantly.

During first year, scheduling irrigation at 100 mm CPE caused similar dry matter accumulation and test weight to that of 50 mm CPE and dry matter accumulation also being at par with 150 mm CPE but significantly more compared to 200 mm CPE level of irrigation because increased sensitivity of water stress has progressively depressing effect on practically all the growth parameters due to decreased osmotic potential of cell sap. During second year, scheduling irrigation at 100 mm CPE caused significantly more leaf volume, dry matter accumulation and 1 000 seed weight except leaf volume which was also being at par with 50 mm CPE, was found to be significantly higher compared to remaining CPE levels. However, these differences disappeared in leaf volume during first year (Table 1).

The optimum water supply speed up the organo-genesis and stimulated growth characters thereby enhanced dry matter production (Salah *et al.* 2010). The higher dry matter accumulation leads to enhanced yield attributes by providing reserve food for reproductive phase. Comparatively less dry matter accumulation by the crop irrigated frequently at 50 mm CPE may be because of excessive water supply.

Seed, oil and carvone yield during both the years was found to be highest due to 100 mm CPE level and being at par with 50 mm CPE level during second year, caused

Table 1 Effect of irrigation and FYM levels on growth and yield attributes of European dill

Treatments	Leaf volume (cc/m^{-2}) at harvest		Dry matter accumulation (g/m^2) at harvest		1 000 seed weight (g)	
	I year	II year	I year	II year	I year	II year
Irrigation level (mm CPE)						
50	188.72	162.87	653.33	524.17	1.84	1.80
100	204.33	167.68	658.33	546.97	1.87	1.83
150	192.73	156.60	646.67	509.37	1.79	1.77
200	185.10	147.43	640.52	498.63	1.74	1.72
CD (P=0.05)	NS	8.42	12.56	16.19	0.07	0.03
FYM levels (tonnes/ha)						
0	178.92	150.63	641.84	500.60	1.76	1.73
15	198.20	161.45	652.08	523.45	1.83	1.80
30	201.05	163.86	655.23	535.30	1.85	1.81
CD (P=0.05)	18.06	7.29	10.88	14.20	0.06	0.03

Table 2 Effect of irrigation and FYM levels on seed, oil and carvone yield

Treatments	Oil content (%)		Seed yield (q/ha)		Oil yield (kg/ha)		Carvone yield (kg/ha)	
	I year	II year	I year	II year	I year	II year	I year	II year
Irrigation level (mm CPE)								
50	2.05	2.64	10.88	9.75	22.70	26.72	18.91	19.73
100	2.13	2.71	11.71	11.44	25.87	31.17	21.66	23.15
150	2.08	2.85	9.95	7.45	21.07	21.30	17.58	15.68
200	2.26	2.82	9.12	8.02	20.67	22.95	17.37	17.11
CD (P = 0.05)	0.12	NS	0.63	2.08	1.74	6.61	1.45	4.90
FYM levels (tonnes/ha)								
0	1.69	2.55	9.32	8.42	15.77	21.55	12.96	15.69
15	2.19	2.73	10.66	8.14	23.19	22.37	19.52	16.71
30	2.55	2.98	11.26	10.95	28.78	32.69	24.16	24.34
CD (P = 0.05)	0.11	0.19	0.54	1.80	1.51	5.72	1.26	4.24

significantly more seed yield compared to 150 and 200 m CPE levels for scheduling irrigation (Table 2). Yield is a function of growth parameters and yield attributes. The high values of growth parameters and yield attributes at 100 mm CPE irrigation level reflected into significantly higher yield

Essential oil containing plants have been found much more abundant in dry than in humid habitats (Cosge *et al*. 2008). This fact has to be evaluated from the point of view that essential oil plays an important role in mechanism of drought resistance via reduction in transpiration (Kaur and Arora 2010) because of that oil content in fresh seeds was found to be significantly higher when crop was irrigated at 200 mm CPE compared to remaining levels during first year.

These differences disappear during second year, where irrigating the crop at 150 mm CPE level caused highest oil content (Table 2). Water stress imposed by restricting the number of irrigations increased the percentages of volatile oils in parsley and fennel (Petropoulos *et al*. 2008). In other words, the stress conditions accelerated the biosynthesis of essential oils (Ezz *et al*. 2009).

Effect of farmyard manure (FYM)

Organic manures, like farmyard manure, are good sources of nutrients and also improve the physical conditions of soil which make plant roots to proliferate, resulting in better utilization of nutrients (Okorogbona *et al*. 2011). Application of FYM at 15 to 30 tonnes/ha caused similar but significantly higher leaf volume, dry matter accumulation and 1 000 seed weight compared to no FYM application at during both the years (Table 1). The 30 tonnes/ha FYM application caused significantly more oil content in seeds compared to 0 and 15 tonnes/ha FYM levels during both the years.

All increase in growth and yield attributes and oil content in the seeds leads to higher seed and oil yield. Increasing levels of FYM caused significant increase in seed, oil and carvone yield during first year while during second year application of 30 tonnes FYM/ha caused significantly more yield compared to 0 and 15 tonnes FYM/ha (Table 2).

Farmyard manure at its higher levels (15 to 30 tonnes/ha) is expected to provide about 75, 37.5 and 75 kg NPK/ha (15 tonnes FYM/ha) and 150, 75 and 150 kg NPK/ha (30 tonnes FYM/ha), thus meeting the total nutrients requirement of the crop. In addition, it provides micronutrients which are essential for plant growth and secondary metabolites synthesis and also activates the microbial growth which helps in making nutrients available (Zhou *et al*. 2009). Thus addition of FYM may have enhanced the growth parameters, dry matter accumulation and yield of crop by making complete nutrition available to plants (Azeez *et al*. 2010).

Interaction effect between irrigation and FYM

Interaction between irrigation and FYM levels was found to be significant when oil was obtained from fresh seeds during first year (Fig 1).

Oil content due to irrigation at 100 and 150 mm CPE and fertilized with 30 tonnes FYM/ha was found to be similar but significantly more compared to remaining treatment combinations. Ghassemi-Golezani *et al.* (2008) reported that the essential oil percentage of dill significantly improved,

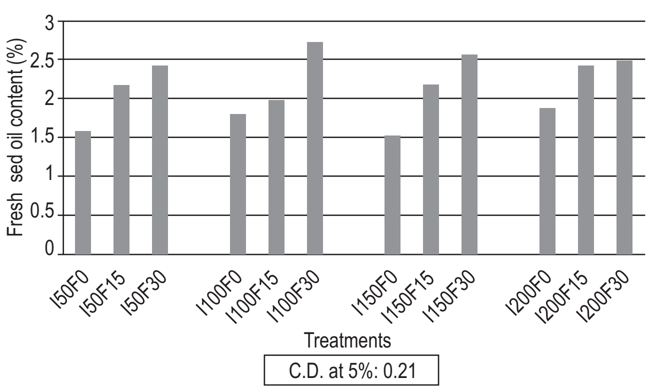

Fig 1 Interaction between irrigation and FYM levels with respect to fresh seeds oil content (%) during first year

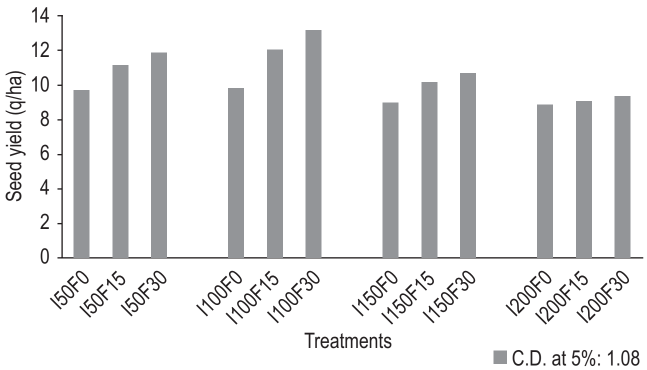

Fig 2 Interaction between irrigation and FYM levels on seed yield (q/ha) during first year

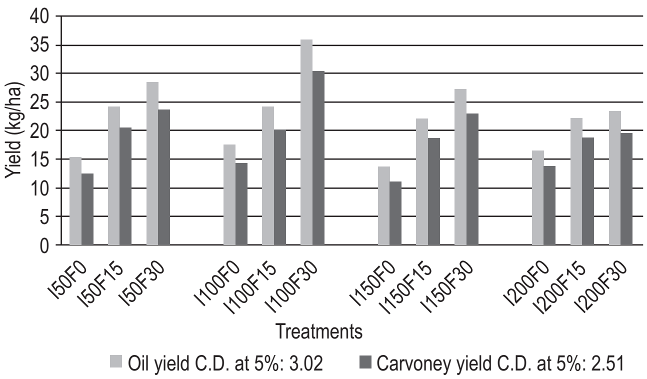

Fig 3 Interaction between irrigation and FYM levels on oil and carvone yield (kg/ha) during first year

when plants were subjected to water stress during reproductive stages. This may be attributed to the function of secondary metabolites as self-defense components against stress conditions.

Interaction between irrigation and FYM levels in respect of yield was found to be significant during first year (Fig. 2 and 3). Significant increase in seed, oil and carvone yield was observed where crop was irrigated at 100 mm CPE and fertilized with 30 tonnes FYM/ha compared with remaining treatment combinations except 100 mm CPE and with 15 tonnes FYM/ha treatment combination in seed yield. Over all increase in growth and yield attributes and oil content in the seeds leads to higher seed and oil yield.

Economics

The net return in terms of ₹/ha was highest due to $I_{100}F_{30}$ treatment combination (Table 3).

This was probably because of higher oil yield which gave more gross return, however, the increase in cost of cultivation in these treatments could not decrease the net return as it was compensated by enhanced gross return. Among FYM treatments, relatively more B: C ratio was obtained with no FYM application compared to FYM applied treatments. The possible reason for this is cost of farmyard manure which resulted in lower-net returns.

Table 3 Average economic analysis as influenced by the treatment

Treatment combi-nations	Oil yield (kg/ha)	Gross return* (₹/ha)	Cost of cultivation (₹/ha)	Net return (₹/ha)	Benefit: Cost ratio
$I_{50}F_0$	16.92	25 380.00	8 016.00	17 364.00	2.16
$I_{50}F_{15}$	23.98	35 970.00	15 869.00	20 101.00	1.27
$I_{50}F_{30}$	33.24	49 852.50	23 831.75	26 020.75	1.08
$I_{100}F_0$	22.76	34 140.00	7 108.00	27 032.00	3.75
$I_{100}F_{15}$	23.41	35 107.50	14 640.25	20 467.25	1.40
$I_{100}F_{30}$	39.39	59 085.00	22 939.50	36 145.50	1.57
$I_{150}F_0$	17.47	26 205.00	6 443.50	19 761.50	3.03
$I_{150}F_{15}$	20.75	31 132.50	14 107.75	17 024.75	1.21
$I_{150}F_{30}$	25.32	37 987.50	21 836.25	16 151.25	0.74
$I_{200}F_0$	17.48	26 220.00	6 244.00	19 976.00	3.20
$I_{200}F_{15}$	22.99	34 477.50	14 019.25	20 458.25	1.46
$I_{200}F_{30}$	24.97	37 455.00	21 618.50	15 836.50	0.73

* Oil price, ₹ 1 500/ha; I, cumulative pan evaporation; F, farmyard manure (tonnes/ha)

It can be concluded that 6 cm irrigation at 100 mm CPE (IW: CPE ratio of 0.6) is optimum to obtain maximum dry matter accumulation and yield of European dill though the frequency of irrigation depends on rainfall. Also application of 15-30 tonnes FYM/ha has been found optimum for yield maximization. So, judicious application of irrigation water and organic manures not only increase the yield but also enhance the content of oil and provide higher net return.

REFERENCES

Azeez J O, Averbeke Van W and Okoronbonga A O M. 2010. Differential responses in yield of pumpkin (*Cucurbita maxima* L.) and nightshade (*Solanum retroflexum*) to the application of three animal manures. *Bioresource Technology* **101**: 2 499–505.

Cochron W G and Cox G M. 1966. *Experimental Design*, 2nd edn. John Wiley and Sons, Inc., New York.

Cosge B, Kiralan M and Gurbuz B. 2008. Characteristics of fatty acids and essential oil from sweet fennel (*Foeniculum vulgare* Mill. var. dulce) and bitter fennel fruits (*F. vulgare* Mill. var. *vulgare*) growing in Turkey. *Natural Products Research* **22**: 1 011–6.

Ezz Edaa, Aziz E E, Hendawy S F and Omer E A. 2009. Response of *Thymus vulgaris* L. to salt stress and alar (B9) in newly reclaimed soil. *Journal of Applied Science Research* **5**: 2 165–70.

Ghassemi Golezani K, Andalibi B, Zehtab S S and Saba J. 2008. Effects of water stress during vegetative and reproductive stages on seed yield and essential oil content of dill (*Anethum graveolens* L.). *J. Food Agric. Environ* 6: 282–4.

Jaleel C A, Sankara B, Sridharan R and Panneerselvam R. 2008. Soil salinity alters growth, chlorophyll content, and secondary metabolite accumulation in *Catharanthus roseus*. *Turkish Journal of Biology* **32**: 79–83.

Kaur G J and Arora D S. 2010. Bioactive potential of *Anethum graveolens*, *Foeniculum vulgare* and *Trachyspermum ammi* belonging to the family *Umbelliferae* - Current status. *Journal* *of Medicinal Plants Research* **4**: 87–94.

Okorogbona A O M, Averbeke W Van and Ramusandiwa T D. 2011. Growth and yield response of chinese cabbage (*Brassica rapa* L. subsp. *chinensis*) as affected by nutrient availability in air dried and pulverized different types of animal manure using low biological activity soil. *World Journal of Agricultural Sciences* **7**(11): 1–12.

Petropoulos S A, Daferera D, Polissiou M G and Passam H C. 2008. The effect of the water deficit stress on the growth, yield and composition of essential oils of parsley. *Scientia Horticulturae* **115**: 393–7.

Salah E, Hendawy E and Schmidhalter U. 2010. Optimal coupling combinations between irrigation frequency and rate for drip-irrigated maize grown on sandy soil. *Agri. Water Manage* **97**: 439–48.

Zhou Q Li K, Jun X and Bo L. 2009. Role and function of beneficial microorganisms in sustainable aquaculture. *Bioresource Technology* **100**: 3 780–6.