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Effect of irrigation and FYM levels on yield, water use efficiency and oil content of European dill (*Anethum graveolens*)

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ABSTRACT

Among the various agro-techniques required to improve production and quality of essential oil, judicious water management and good nutrient supply play an important role. Therefore, a two years field and laboratory experiment was conducted to study the effect of irrigation and FYM on yield, oil content, and water use efficiency of European dill (*Anethum graveness* L.) at GBPUA and T, Pantnagar, Uttarakhand. For this, a factorial experiment based on randomized complete block design having three replications was carried out with treatments, viz irrigation scheduling at 4 CPE (cumulative pan evaporation) levels (50, 100, 150 and 200) with 6 cm of irrigation water and 3 FYM (farmyard manure) levels (0, 15 and 30 tonnes/ha). Various growth character, like no. of branches and dry matter accumulation as well as yield attributes with no. of fruit per umbell and 1000 seed weight were found to be significantly higher due to irrigation at 100 mm CPE and fertilized with 30 tonnes FYM/ha, this caused significant enhancement in the seed yield i e 1.32 and 1.43 t/ha during first and second year, respectively. Fresh seeds oil content and water use efficiency increased significantly with increase in irrigation and FYM levels and found to be highest with 200 mm CPE irrigation and 30 tonnes FYM/ha.

Key words: European dill, Farmyard Manure, Oil content, Water Use Efficiency

Since ancient times medicinal plants have been used in treating the human diseases nowadays, the no. of the plants use for medicinal pupose is about 35,000 species (Borrowand Groudh). Among these medicinal plants, European bill (Anethum grovelens) is one of an annual aromatic and medicinal plant belonging to the apic (Umbelliferae) family (Heamalatha *et al.* 2011). The genetic name "Anthum is derived from greek word 'anethon' and the common name bill comes from old norse word dylla or dilla this probably mean to soophe (Singh & Panda 2005). In India, it is commonly knwon as wilayati or videshi saunf.

The well known properties of European (*Anethum gravealens* L.) dill from the traditional medicine, such as carminative, stomachic, diuretic have been reported (Radulescu *et al.* 2010). The study by Jinesh *et al.* (2010) also supports that green leaves are traditionally used as vegetable and food flavoring agent. The seeds are common and very effective household remedy for a wide range of digestive problems (Kaur and Arora 2010) and infusion of seeds is especially efficacious in treating gripe in babies and flatulence in young children. The herb (0.5 to 1.2%) and seed (2.5 to 3.5%) contain essential oil known as dill oil.

In India, it grows chiefly in Punjab, Uttar Pradesh, Uttarakhand, Gujarat, Maharashtra, Assam and West Bengal. Because of its diversified uses and good source of foreign exchange, there is need to raise the productivity of dill crop by adopting scientific cultivation methods.

Under intensive cultivation, use of chemical fertilizers alone for longer period could deteriorate soil and produce quality. Use of organic manure benefits the soil nutritionally and improves soil health. Moreover effective utilization of organic sources for obtaining essential nutrients is possible from field with sufficient moisture. Even short-term water deficit at critical stages can reduce crop yield substantially. In northern India, it is grown under limited irrigation condition and almost without fertilizers, leading to reduced productivity and quality. Its productivity is controlled by many factors, of which judicious use of irrigation and nutrition by farmyard manure (FYM) are most important as they help to sustain the productivity of land as well as of crop. Therefore the present investigation was carried out to study the effect of irrigation and FYM on European dill.

MATERIALS AND METHODS

A two years field and laboratory experiment from 2005 to 2007 was conducted at Norman E. Borlaug Crop Research

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Centre and department of Agronomy of GBPUA & T., Pantnagar, Uttarakhand, India. The soil of the experimental field was sandy loam in 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. Post-sowing irrigations of 60 mm (6 cm) soil depth were applied as per treatments.

Different amounts of well decomposed and pulverized farmyard manure were broadcasted carefully in each plot two days before sowing of crop as per treatments. By hand, mixed uniformly and thoroughly by digging with the help of spade.

The crop was raised during winter season on December 14 of 2005–06 (first year) and 2006–07 (second year) by direct seeding using seed rate of 5 kg/ha and sown at 40 cm spacing. To maintain plant to plant distance of 30 cm extra seedlings were thinned out crop was harvested during summary in may.

For execution of irrigation treatments, irrigation channels were provided between the plots. One common irrigation was given in each plot for proper establishment of crop after 25 days of sowing. 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 in each plot 720 litres was provided at each irrigation. During growing period of 1st and second years amount of rainfall was 145.6 and 55.6 mm, respectively. 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. From net plot area umbels were picked up from the main shoots, primary, secondary and tertiary branches as and when they matured 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. Seed yield was expressed in t/ha.

For seed oil, water distillation method using Clevenger's type glass distillation apparatus was used for obtaining essential oil. Distillation process for each sample continued for 3 hours. The essential oil content was calculated using formula:

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

The soil moisture content data were utilized to find out water use efficiency and water use efficiency (kg seed/ha/cm of water use) was calculated by formula:

$$\text{WUE} = \frac{Y}{U}$$

where, Y = seed yield (kg/ha), and U = seasonal consumptive use of water (cm)

The statistical analysis of the data was done by following the procedure for analyzing factorial randomized block design (Cochran 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

Increase in irrigation frequency improved the values of all the growth and yield attributes as well as seed yield, the highest being recorded with irrigation applied at 100 mm CPE during both the years. Moisture stress under 200 mm CPE irrigation treatment resulted in adverse effect.

During first year, irrigating crop at 100 mm cumulative pan evaporation (CPE) caused significant enhancement in plant height, tertiary branches per plant and dry matter accumulation though tertiary branches and dry matter accumulation were also found to at par with irrigation at 50 and 150 mm CPE levels. During second year, irrigating crop at 100 mm CPE level caused significant enhancement in growth characters and dry matter accumulation though growth characters, viz. plant height, number of primary, secondary and tertiary branches being at par with 50 and 150 mm CPE (Table 1).

This enhancement in dry matter accumulation was due to enhancement in plant height, and number of branches per plant as the crop was not exposed to any perceptible moisture stress during the growth period also, optimum water supply speed up the organo-genesis, stimulated the number of branches thereby enhanced dry matter production. Comparatively less dry matter accumulation by the crop irrigated frequently at 50 mm CPE may be because of excessive water supply. Poor dry matter accumulation due to irrigating the crop at 200 mm CPE because water stress reduced the relative leaf expansion rate, leaf number, plant height and shoot: root ratio (Vurayai *et al.* 2011).

Fruits per umbel on main shoot and primary branches during second year and secondary branches during both the years increased non-significantly with increase in CPE levels up to 100 mm CPE and then a significant decrease was noticed (Table 2).

Fruits per umbel on main shoot (1749.93) and primary branches (1325.77) in first year and on secondary (866.17 and 797.30) and tertiary branches (9643.03 & 512.47) during

Table 1 Effect of irrigation and FYM levels on growth characters and dry matter accumulation of European dill crop at harvest

Treatment	Plant height (cm)		Number of branches						Dry matter accumulation (g m^{-2})	
			Primary branches		Secondary branches		Tertiary branches			
	I year	II year	I year	II year	I year	II year	I year	II year	I year	II year
Irrigation level (mm CPE)										
50	130.23	125.23	5.7	5.9	17.9	17.9	36.7	35.6	653.33	524.17
100	131.77	126.53	5.9	5.8	19.0	18.5	38.2	36.7	658.33	546.97
150	127.63	122.20	5.6	5.6	17.1	17.2	35.6	33.7	646.67	509.37
200	125.87	118.33	5.3	5.4	16.7	16.0	33.5	32.4	640.52	498.63
CD = (P = 0.05)	0.94	2.87	NS	0.3	NS	0.8	3.1	2.5	12.56	16.19
FYM levels (tonnes ha)										
0	126.40	119.30	5.4	5.5	16.7	16.3	33.9	32.7	641.84	500.06
15	129.40	124.45	5.7	5.8	17.9	17.7	36.6	35.1	652.08	523.45
30	130.83	125.48	5.8	5.9	18.5	18.3	37.5	36.0	655.23	535.30
CD (P = 0.05)	0.81	2.49	NS	0.2	NS	0.7	2.7	2.1	10.88	14.20

Table 2 Number of fruits per umbel influenced by the treatments

Treatment	Number of fruits per umbel							
	Main shoot		Primary branches		Secondary branches		Tertiary branches	
	I year	II year	I year	II year	I year	II year	I year	II year
Irrigation levels (mm CPE)								
50	1671.90	1647.39	1254.31	1189.57	820.77	758.23	588.03	445.20
100	1749.93	1702.07	1325.77	1254.67	866.17	797.30	643.03	512.47
150	1562.32	1557.67	1157.86	1119.57	750.84	691.90	517.10	382.27
200	1476.51	1467.83	1027.02	1002.13	674.50	586.87	433.89	311.10
CD at (P = 0.5)	67.30	83.25	66.07	81.59	47.47	40.05	42.91	20.56
FYM (tonnes/ha)								
0	1469.43	1498.43	1080.02	1037.88	701.40	619.05	461.18	329.10
15	1652.69	1626.62	1228.60	1176.75	802.63	738.15	572.00	441.20
30	1723.38	1656.18	1265.10	1209.83	830.18	768.53	603.37	467.98
CD at (P = 0.05)	58.29	72.09	57.22	70.66	41.11	34.69	37.16	17.81

both the years increased significantly with increase in CPE levels up to 100 mm CPE. Weight of 1000 seeds increased significantly by irrigating crop at 100 mm CPE compared to remaining irrigation scheduling during both years (1.87 & 1.83 g) though in first year it was also, at par with 50 mm CPE (1.80 g). Increasing CPE levels for scheduling irrigation caused significant increase in seed yield (1.17 & 1.14 t/ha) due to 100 mm CPE level compared to remaining CPE levels during both the years and also being at par with 50 mm CPE level (0.98 t/ha) in second year (Table 3).

Higher yield at 100 mm CPE level may be because of more growth and 1000 seed weight. The higher dry matter accumulation leads to enhanced yield attributes by providing reserve food for reproductive phase thus the number of fruits and seed weight were found to be higher. More number of branches resulted in more number of umbels, fruits per umbel and test weight. Seed yield reduced due to irrigation the crop at 200 mm CPE as water stress decrease plant height, leaf area and thus reduce photosynthesis (Srivastava and Srivastava 2007).

Oil content in fresh seeds was found to be significantly higher when crop was irrigated at 200 mm CPE (under moisture stress condition) compared to remaining levels in first year while during second year irrigating the crop at 150 mm CPE level caused highest oil content (Table 3). 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. Ghassemi-Golezani *et al.* (2008) also reported that the essential oil percentage of dill significantly improved, 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. Water stress imposed by restricting the number of irrigations increased the

Table 3 Effect of irrigation and FYM levels on 1000 seed weight, seed yield and oil content

Treatment	1000 seed weight (g)		Seed yield (t/ha)		Oil content (%)	
	I year	II year	I year	II year	I year	II year
Irrigation level (mm CPE)						
50	1.84	1.80	1.09	0.98	2.05	2.64
100	1.87	1.83	1.17	1.14	2.13	2.71
150	1.79	1.77	0.99	0.75	2.08	2.85
200	1.74	1.72	0.91	0.80	2.26	2.82
CD (P = 0.05)	0.07	0.03	0.06	0.21	0.12	NS
FYM levels (tonnes/ha)						
0	1.76	1.73	0.93	0.84	1.69	2.55
15	1.83	1.80	1.07	0.81	2.19	2.73
30	1.85	1.81	1.13	1.09	2.55	2.98
CD (P = 0.05)	0.06	0.03	0.05	0.18	0.11	0.19

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)

The values of plant height increased significantly with increase in levels of FYM up to 30 tonnes/ha during both the years but in second year 15 tonnes/ha FYM also caused similar plant height. The number of primary and secondary branches increased with increase in FYM levels however, during first this increase was non-significant, though application of 30 tonnes FYM/ha being at par with 15 tonnes FYM/ha, caused significant increase in tertiary branches in first year and all branches in second year compared to no FYM application (Table 1). Dry matter accumulation, yield attributes, viz number of fruits and test weight were found to be highest with 30 tonnes/ha FYM application during both the years however, difference due to 15 to 30 tonnes FYM/hawere found non-significant except number of fruits/umbel on main shoot in first and on tertiary shoot in second year which were significantly highest with 30 tonnes/ha FYM application (Table 2). Increasing levels of farmyard manure has been found to enhance growth parameters led to significant increase in dry matter accumulation. 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.

In the present investigation, increasing levels of farmyard manure caused the significant enhancements in seed yield, however, 30 tonnes FYM/ha out yielded over 0 and 15 tonnes FYM/ha (Table 3). The phenomenal response of dill to FYM levels is understood as FYM is a balanced nutrient provider which resulted in optimum growth and development of crop, resulting in higher seed yield. No FYM application led to poor fertility status of soil, thereby drastic reduction in growth and development and ultimately seed yield.

Application of 30 tonnes/ha/FYM caused significantly more oil content in seeds compared to 0 and 15 tonnes/ha FYM levels during both the years (Table 3) may be because farmyard manure could provide definite nutrients for synthesis of essential oil in the seeds.

Interaction effect of Irrigation and farmyard manure on seed yield

Interaction between irrigation and FYM levels in respect of seed yield was found to be significant during first year (Table 4).

Significant increase in seed 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. Increase in yield due to adequate amount of irrigation and FYM application may be ascribed to good availability and better utilization of nutrients, increase in synthesis of carbohydrates leading to good vegetative and

Table 4 Interaction between irrigation & FYM level with respect to seed yield (t/ha) of fresh seeds during first year

FYM levels	Irrigation levels (mm CPE)				For comparing irrigation
(t/ha)	50	100	150	200	FYM combination on CD at 5%
0	0.968	0.977	0.902	0.882	0.108
15	1.116	1.215	1.020	0.912	
30	1.180	1.320	1.063	0.942	

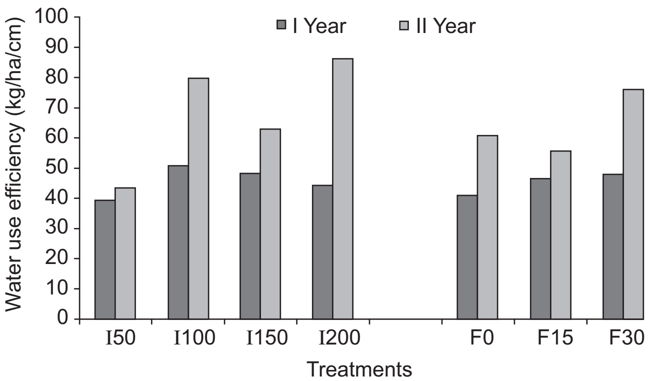

Fig 1 Effect of different treatments on water use efficiency

reproductive growth (Abdou *et al*. 2011).

Effect of irrigation and FYM on water use efficiency

The water use efficiency (WUE) was maximum under 100 mm CPE level during I year and 200 mm CPE irrigation level during II year, while minimum in case of frequent irrigations at 50 mm CPE level during both the years (Fig 1). The higher water use efficiency under limited water supply may be because of greater moisture extraction from deeper layers in less frequently irrigated plots under 100, 150 and 200 mm CPE levels.

Water use efficiency increased due to increase in FYM levels during both the years. This can be understood owing to more moisture binding capacity or organic matter added in soil through FYM. In plots with no FYM application, lack of organic matter may have caused more loss of water through evaporation and thus less utilization of water by crop. Also, slow release of moisture in high organic matter containing soil may have led more water use efficiency. Increasing levels of FYM caused enhancement in seasonal consumptive use of water during both the years due to better water retention ability of applied FYM.

It can be concluded that based on cumulative Pan Evaporation (CPE) data, 6 cm irrigation at 100 mm CPE (IW: CPE ratio of 0.6) is optimum to obtain maximum yield, quality and Water use efficiency (WUE) of European dill. The frequency of irrigation depends on rainfall. Two to three irrigations at 60 (branch development stage), 90 (flowering stage) and 105 (seed development stage) days after sowing are sufficient to meet the water requirement of the crop under *Tarai* conditions of Uttarakhand. Application of 15-30 tonnes FYM/ha has been found optimum for yield maximization.

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