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Effect of Irrigation and Nitrogen Levels on Growth, Yield and Quality of Ajowan (*Trachyspermum ammi* L. Sprague)

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Abstract An experiment was conducted during the *rabi* season of 2013–2014 to study the effect of irrigation and nitrogen levels on the growth and yield of ajowan. The experiment consisted of 3 levels of irrigation (irrigation at 15, 20 and 25 days interval) and 4 levels of nitrogen (0, 20, 40 and 60 kg N ha^{-1}) and was evaluated under factorial RBD design with three replications. Among various levels of irrigation tried, irrigation at 20 days interval exhibited higher significant growth and yield attributes and recorded significant maximum seed yield of 17.15 q ha^{-1} which was 21.11% higher in comparison to irrigation at 25 days interval. Among the various nitrogen levels tried, 60 kg N/ha exhibited significant maximum growth, yield and quality of ajowan. Further treatment observed significant maximum seed yield 17.12 q/ha which was 23.34% higher as compared to control.

Keywords Irrigation, Growth, Nitrogen, Quality, Yield.

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Introduction

Ajowan (*Trachyspermum ammi* L. Sprague) is an annual herb in the family Apiaceae. Both the leaves and the fruit pods (often mistakenly called seeds) of the plant are used for human consumption. Most important use of ajowan is medicinal and it is a household remedy for indigestion. Its seed and oil is much valued for its antispasmodic, stimulant, tonic and aromatic carminative properties. In India, it is cultivated on commercial scale in the states of Madhya Pradesh, Andhra Pradesh, Gujarat, Maharashtra, Uttar Pradesh, Rajasthan, Bihar and West Bengal. The total area and production of ajowan in India is about 35 thousand hectare and 27 thousand MT and average productivity 90 kg/ha respectively NHB [1]. Productivity of ajowan is very low due to scarcity of water at critical stage of crop growth and improper nitrogen application to the ajowan crop. As water is one of the important environmental factors in crops production and water shortage in crop production may leads to high damages on growth and development and effective materials of herbal plants. Water is important from ecological and physiological aspects, because it interferes in most of the internal processes. Most of the plants cell's metabolically activities are due to presence of water. It even acts as a structural agent. When plant cells contain an abundance of water they are turgid and the plant stands erect, when there is a moisture deficiency, the cells are flaccid and the plant droops and wilts. Nitrogen is a constituent of pro-

Table 1. Effect of irrigation and nitrogen levels on growth and quality of ajowan.

Treatments	Plant height (cm)			Branches/plant at harvest		Chlorophyll content in leaves (SPAD)	
	60 DAS	90 DAS	120 DAS	Primary	Secondary	60 DAS	90 DAS
Irrigation interval							
I_1 (15 DA)	46.38	96.63	121.92	12.12	51.10	1.21	2.10
I_2 (20 DA)	50.34	103.54	126.36	13.46	62.28	1.28	2.33
I_3 (25 DA)	39.29	86.71	116.32	11.11	42.42	1.13	2.10
SEm±	0.37	0.58	0.61	0.15	0.70	0.03	0.04
CD at 5%	1.08	1.71	1.80	0.43	2.03	0.09	0.12
Nitrogen (kg ha^{-1})							
N_1 (0)	43.26	92.41	117.59	11.44	47.59	0.89	1.88
N_2 (20)	44.54	94.50	120.32	11.98	50.38	1.22	2.10
N_3 (40)	45.95	96.49	122.97	12.50	53.84	1.34	2.33
N_4 (60)	47.60	99.11	125.24	13.00	55.93	1.39	2.39
SEm±	0.43	0.67	0.71	0.17	0.80	0.03	0.04
CD at 5%	1.25	1.97	2.08	0.49	2.34	0.10	0.14

Table 1. Continued.

Treatments	Days to 50% flowering	Fresh weight of plant (g)		Dry weight of plant (g)		Essential oil content of seed (%)
		60 DAS	90 DAS	60 DAS	90 DAS	
Irrigation interval						
I_1 (15 DA)	84.85	40.62	247.23	11.97	60.03	2.64
I_2 (20 DA)	87.73	56.92	277.74	17.47	67.95	2.96
I_3 (25 DA)	83.11	31.86	194.22	8.70	45.67	2.45
SEm±	0.26	0.71	3.07	0.43	0.72	0.03
CD at 5%	0.75	2.08	9.02	1.27	2.13	0.11
Nitrogen (kg ha^{-1})						
N_1 (0)	83.05	36.44	220.39	10.62	53.02	2.53
N_2 (20)	84.42	40.58	235.07	12.14	56.60	2.58
N_3 (40)	86.12	46.55	245.51	13.61	59.81	2.74
N_4 (60)	87.32	48.96	257.96	14.47	62.12	2.88
SEm±	0.30	0.82	3.55	0.50	0.83	0.04
CD at 5%	0.87	2.40	10.41	1.47	2.46	0.12

teins, enzymes, hormones, vitamins, alkaloid and chlorophyll. Reddy and Reddi [2]. Plant growth is adversely affected due to deficiency of nitrogen. Adequate supply of N promotes higher photosynthetic activity and vigorus vegetative growth and as a result, the plants turn into dark green color. A high N supply favors the conversion of carbohydrate into protein which, in turn, promotes the formation of protoplasm. Protoplasm, being highly hydrated, is conducive for the succulent plant growth. Balasubramaniyam and Palaniappan [3]. Therefore considering significance of ajowan in the national economy, the present investigation entitled "Effect of irrigation and nitrogen levels on growth, yield and quality of ajowan (*Trachyspermum ammi* L. Sprague)" was envisaged.

Materials and Methods

The experiment was conducted at the Horticulture Research Farm, College of Horticulture, Mandsaur (Madhya Pradesh) during the year 2013–2014. The soil of the experimental field was light black loamy in texture with low nitrogen (140.0 kg/ha), medium in phosphorus (21.0 kg/ha) and low in potassium (144.0 kg/ha) and alkaline in reaction (pH 7.1). The experiment consisted of 3 levels of irrigation at 15 days interval (I_1), at 20 days interval (I_2) and at 25 days interval (I_3) and 4 levels of nitrogen 0 kg ha^{-1} (N_1), 20 kg N ha^{-1} (N_2), 40 kg N ha^{-1} (N), and 60 kg N ha^{-1} (N_4). These treatments were evaluated in factorial RBD design with three replications. The sowing of crop was done on 20th November, 2013 and harvested on 6th May, 2014. The seeds were treated with carbendazim @ 3 g/kg seed and then sown in rows, spaced 45 × 25 cm using 2.5 kg seed/ha of cultivar NRCSS AA–1. A uniform dose of 40 kg P_2O_5 and 20 kg K_2O/ha was applied basal. The oil content was estimated by using essential oil distillation assembly A. O. A. C. [4]. The data on cost of production and net profit were calculated on the basis of prevailing market prices. The experimental data recorded were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhatme [5].

Results and Discussion

Effects of irrigation

Growth attributes

Different levels of irrigation significantly influenced the growth attributes of ajowan (Table 1). Application of irrigation at 20 days interval to ajowan gave significant higher plant height at 60, 90 and 120 DAS, number of primary and secondary branches at harvest, fresh and dry weight at 60, 90 DAS. These significant variations may be attributed to varied moisture status. The vigorus growth in ajowan means production of more leaves, which helped in the synthesis of more photosynthates and thus resulting in increased accumulation of carbohydrates and other metabolites, which ultimately determined the plant height, number of primary branches and secondary branches, fresh weight and dry weight. The above findings are in close conformity with the findings of Mehta et al.[6] in ajowan crop.

Yield and yield attributes

Data on yield components of the crop under influence of irrigation intervals indicates that optimum level (20 days) of irrigation interval significantly improved days to 50% flowering, number of umbels per plant, number of umbellets per umbel, test weight, yield per plant, seed yield, straw yield, biological yield and harvest index (Table 2). Application of irrigation at 20 days interval maintained favorable moisture status in the soil resulting in significant increase in seed yield of ajowan by 12.61 and 21.11% over 15 and 25 days interval of irrigation, respectively. It seems that biomass is regulated by the current supply of photosynthates as well as mobilization of assimilates produced during vegetative stage to the reproductive phase i.e. transfer of the stored assimilates in vegetative tissue to the sink material. The significant increment in yield attributing characters like number of umbels per plant, number of umbellets per umbel and test weight having significant influence on seed yield of crop. The above findings are in close conformity with the findings of Nik et al. [7], Mehta et al. [6] and Nassiri et al. [8] in ajowan crop.

Quality attributes

The data indicated at 20 days interval of irrigation significantly improved chlorophyll content of leaves and essential oil of seed (Table 1). Optimum moisture level in the root zone increased the mobility of nutrients in the soil and consequently increased the minerals uptake by plant and carbohydrates assimilation. Increased accumulation of nutrients especially in vegetative plant parts possibly with improved metabolism led to greater translocation of these nutrients to reproductive organs (seed) of the crop to improve in quality attributes. The above findings are in close conformity with the findings of Nik et al. [7], Mehta et al. [6] and Nassiri et al. [8] in ajowan crop.

Table 2. Effect of irrigation and nitrogen levels on yield attributes, yield and economics of ajowan.

Treatments	Number of umbels/ plant	Number of umbellets/ umbel	Test weight (g)	Seed yield/ plant (g)	Seed yield (q/ ha)	Straw yield (q/ ha)	Biological yield (q/ ha)	Harvest index (%)	Gross returns (Rs/ ha)	Net returns (Rs/ ha)	Benefit cost ratio
Irrigation interval											
I_1 (15 DA)	116.3	12.6	1.28	18.44	15.23	51.57	64.01	23.39	94412	69236	3.75
I_2 (20 DA)	120.8	13.9	1.37	20.24	17.15	55.77	69.09	25.14	106355	83198	4.41
I_3 (25 DA)	101.7	11.1	1.20	16.66	14.16	49.65	60.85	20.46	87811	65013	3.83
SEm±	1.54	0.12	0.02	0.33	0.27	0.29	0.49	0.76	1695	1761	0.07
CD at 5%	4.51	0.34	0.05	0.98	0.80	0.86	1.43	2.23	4972	5167	0.20
Nitrogen (kg ha^{-1})											
N_1 (0)	102.7	11.9	1.18	16.46	13.88	50.78	61.96	18.14	86042	62446	3.64
N_2 (20)	110.3	12.3	1.25	17.72	14.86	51.75	63.73	21.98	92138	69371	3.83
N_3 (40)	117.8	12.8	1.31	19.21	16.20	52.85	65.57	24.67	100456	76336	4.16
N_4 (60)	120.7	13.2	1.39	20.39	17.12	53.93	67.35	25.88	106136	81774	4.36
SEm ±	1.77	0.13	0.02	0.39	0.32	0.34	0.56	0.87	1957	2034	0.08
CD at 5%	5.21	0.39	0.06	1.13	0.92	1.00	1.65	2.58	5741	5967	0.23

Effect of nitrogen

Growth attributes

Significantly higher plant height at 60, 90 and 120 DAS, number of primary and secondary branches at harvest, fresh and dry weight at 60 and 90 DAS was recorded as a result of higher levels of N fertilizer (Table 1). Higher levels of nitrogen may be attributes to better nutritional environment in the root zone as well as in the plant system. It is an established fact that nitrogen is one of the essential constituent required for the synthesis of protein, chlorophyll and other organic compounds of physiological significance in the plant system. Since, in the plant system most of the nitrogen accumulated in the reproductive structure is translocated from vegetative parts, the assumption seems to be justified that nitrogen application lead to increased nitrogen content in the plants right from stage of crop growth. Thus, increased endogenous level of nitrogen in plant by virtue of its increased availability in the soil medium and there after efficient absorption and translocation in various growths by way of active cell division and elongation resulting in greater plant height, number of primary and secondary branches at harvest, fresh weight and dry weight at 60 and 90 DAS. The findings of this investigation are in close conformity with those of Krishnamoorthy and Madalagari [9], Marks et al. [10], Nath et al. [11] and Naruka et al. [12] in ajowan crop.

Yield and yield attributes

Data on yield attributes of the crop under influence of nitrogen application indicates that increasing level of nitrogen up to 60 kg N/ha significantly improved days to 50% flowering, number of umbels per plant, number of umbellets per umbel, test weight, yield per plant, seed yield, straw yield, biological yield and harvest index. In general, the significant improvement in yield attributes of ajowan with the nitrogen fertilization could be ascribed to overall improvement in vigor and crop growth. The faster growth of plants evidenced from increased biomass per plant at successive stages of crop growth with nitrogen subscribe to the views that there was better availability of metabolites and nutrients, which synchronized to the demand for the growth and development of each reproductive structure of the ajowan plant. The present

trend of increase in seed yield, straw yield and biological yield of ajowan with the application of nitrogen is in close conformity with the findings of Krishnamoorthy and Madalagari [9], Marks et al. [10], Nath et al. [11] and Naruka et al. [12].

Quality attributes

The results indicated that increasing levels of nitrogen significantly improved chlorophyll content of leaves and essential oil of seed (Table 1). Significantly higher chlorophyll content of leaves and essential oil of seed was recorded as a result of higher levels of N fertilization may be attributed to better nutritional environment in the root zone as well as in the plant system. The biological role of nitrogen as an essential constituent of chlorophyll in harvesting solar energy, phosphorylated compounds in energy transformations, nucleic acids in the transfer of genetic information and the regulation of cellular metabolism and biological catalysts is well known. The mark improvement in quality characters due to N is in close agreement with findings of Krishnamurthy and Madalagari [9] and Marks et al. [10] in ajowan crop.

Economics

The significant maximum gross return, return and B:C ratio of Rs 106137/ha, 81774 /ha and 4.36 was recorded with 60 kg N/ha, respectively followed by 40 kg N/ha. Further, application of 60 kg N/ha gave 18.93% higher gross return over control. Similarly significant maximum gross return, return and B:C ratio of Rs 106355/ ha, 83198/ha and 4.41 was recorded with treatment irrigation at 20 days interval. Similar results were also found by Mehta et al. [6] in ajowan crop.

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