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Effect of different levels of nitrogen and phosphorus on growth and seed yield of Ajwain (*Trachyspermum ammi* L. Sprague)

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Abstract
An experiment was conducted during *rabi* season of 2014-15 at Main Garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to find out effect of different levels of nitrogen and phosphorus on growth and seed yield of ajwain. The treatment consisted of four levels of N (25, 50,75, 100 kg ha^{-1}) and two levels of P (25 and 50 kg ha^{-1}). Results indicated that application of 75 kg N ha^{-1} and 50 kg P ha^{-1} significantly increased plant height, number of primary and secondary branches per plant, number of umbels per plant, number of umbellets per umbel, seed yield per plant, per plot and per ha, test weight and B:C ratio (3.11: 1).
The days to first flowerings, 50% flowering and days to harvesting was minimum with application of 25 kg N ha^{-1} and 25 kg P ha^{-1}. Similarly the interaction of different nitrogen and phosphorus levels significantly increased growth and seed yield of ajwain.

Keywords: ajwain, nitrogen, phosphorus, growth, yield

Introduction
Ajwain also known as carom seed (*Trachyspermum ammi* L. Sprague) belongs to family Apiaceae. Ajwain or Bishop's weed is an annual herbaceous plant, the seeds of which are used for flavouring foods and preservatives. It is grown in different parts of world including Iran, Egypt, Afghanistan and India. In India, it is cultivated in Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, Punjab, Tamil Nadu, Andhra Pradesh, Maharashtra, Bihar and West Bengal.
The growth and seed yield are largely influenced by the nutrient fertility status of the soil apart from genetic potential of the variety. Adequate supply of N promotes higher photosynthetic activity, vigorous vegetative growth and as a result, the plants turn into dark green in colour. A high N supply favours 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). Adequate supply of P promotes early root formation, growth, greater flowering and seed production. P deficiency delayed maturity and reduce seed size, seed number.
This crop is new specially in vidarbha region of Maharashtra. Since little information is available on the effect of different levels of nitrogen and phosphorus on growth and seed yield of ajwain, therefore the present study was undertaken.

Materials and Methods
An experiment was laid out during *rabi* season of 2014-15 at Main Garden, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi vidyapeeth, Akola with var. Ajmer Ajwain-1.The soil of the experimental plot was medium black with uniform in texture, colour and having good drainage, slightly alkaline in reaction and low in nitrogen, medium in phosphorus and relatively high in potassium availability. There were 8 treatment combinations of four nitrogen levels (25, 50, 75 and 100 kg ha^{-1}) and two phosphorus levels (25 and 50 kg ha^{-1}). The experiment was laid out in a factorial randomized block design with three replication. Half of the nitrogen and full phosphorus as per requirement of respective treatment were applied at the time of sowing and the remaining half of nitrogen was applied 30 days after sowing. All the cultural and plant protection measures were adopted as and when required. Growth parameters were studied at 30, 60 and 90 days after sowing. The data on growth and yield attributing parameters were recorded and data were analysed statistically as described by (Panse and Sukhatme, 9) to draw conclusions.

Results and Discussion

Effect of Nitrogen on growth parameters

The data in (Table 1) revealed that application of different level of nitrogen exerted significant influence on growth parameters at different growth stage. The Maximum plant height, number of primary branches per plant, number of secondary branches per plant were recorded with the application of N_3 (75 kg N ha^{-1}). While in case of number of secondary branches per plant N_3 (75 kg N ha^{-1}) is at par with N_4 (100 kg N ha^{-1}) at 60 and 90 DAS. There was no response of high dose of nitrogen towards growth parameters. This might be due to properly of nitrogen to enhance the vegetative growth and capacity of plant to utilize more amount of nitrogen. The minimum values of these parameters were recorded in N_1 (25 kg N ha^{-1}). This may be due to nutrient deficiency for the resources, which made the crop in efficient to makeup moisture and nutrients. Consequently, plant height, number of primary branches per plant, number of secondary branches per plant were adversely affected. These findings are supported by (Bhaskar) in amaranths.

Effect of phosphorus on growth parameters

The present results (Table 1) showed that the application of different levels of phosphorus significantly influenced growth parameters. The maximum plant height, number of primary branches per plant, number of secondary branches per plant were recorded with application of P_2 (50 kg P_2O_5 ha^{-1}) and minimum value of these parameter were recorded with the application of P_1 (25 kg P_2O_5 ha^{-1}).The maximum parameters of growth may be due to favourable agro climate conditions during the crop growth period, which might have resulted due to better availability of moisture and nutrients which resulted in luxurious growth due to better availability of phosphorus. These results were supported by (Das) in coriander.

Table 1: Effect of different levels of nitrogen and phosphorus on growth of ajwain

Treatments	Plant height			No. of primary branches per plant			No. of secondary branches per plant		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Nitrogen levels (kg ha^{-1})									
25	10.20	43.18	84.72	1.76	4.03	7.42	7.32	23.47	52.97
50	12.06	45.04	86.04	2.00	4.57	7.87	7.82	25.27	55.38
75	14.71	47.66	89.06	2.34	5.12	9.06	8.72	26.83	56.70
100	13.43	46.44	87.75	2.21	4.95	8.34	8.33	26.57	56.55
SEm±	0.37	0.35	0.40	0.02	0.04	0.06	0.05	0.11	0.12
CD at 5%	1.12	1.07	1.21	0.07	0.11	0.19	0.14	0.34	0.35
Phosphorus levels (kg ha^{-1})									
25	9.99	42.87	84.70	1.73	3.82	7.38	7.38	23.60	53.29
50	15.20	48.29	89.08	2.43	5.51	8.96	8.72	27.47	57.51
SEm±	0.26	0.25	0.28	0.02	0.03	0.04	0.03	0.08	0.08
CD at 5%	0.80	0.75	0.85	0.05	0.08	0.14	0.10	0.24	0.25

Effect of Nitrogen on yield attributes and yield

The data presented in (Table 2) showed that application of different levels of nitrogen significantly influenced yield attributes and yield. The days to first flowering recorded minimum with application of N_1 (25 kg N ha^{-1}) which was at par with N_2 (50 kg N ha^{-1}) and N_3 (75 kg N ha^{-1}). However, days to 50% flowering, days to harvesting recorded minimum with application of N_1 (25 kg N ha^{-1}) which was at par with N_2 (50 kg N ha^{-1}). The maximum value for these parameter were recorded with application of N_4 (100 kg N ha^{-1}). This might be due to the fact that, more utilization of nitrogen resulted into the more vegetative growth for longer span and ultimately delayed flowering have been produced. Similar results were obtained by (Lokhande, 8) in coriander. Whereas, The maximum number of umbels per plant, seed yield per plant, seed yield per plot, seed yield per hectare were recorded with the application of N_3 (75 kg N ha^{-1}). While, The number of umbellets per umbel was recorded maximum with the application of N_3 (75 kg N ha^{-1}) which is at par with N_4 (100 kg N ha^{-1}) Similarly, The test weight was recorded maximum with the application of N_3 (75 kg N ha^{-1}) which is at par with N_4 (100 kg N ha^{-1}) and N_2 (50 kg N ha^{-1}) and minimum value of these parameter were recorded with the application of N_1 (25 kg N ha^{-1}). All the yield and yield attributes were comparatively low even though the nitrogen level (N_4) was increased. Application of nitrogen affect physiological and bio-chemical process in plant, which thoroughly enhanced 50% flowering in plants. Thus, on one hand profuse branching might have led to formation of maximum number of flowers, while on the other inversed availability on nitrogen to these developing characters seems to have resulted in greater retention of flowers leading to development of umbels per plant. Similar findings reported (Kaswan) in fenugreek and (Salarazai) in fennel.

Table 2: Effect of different levels of nitrogen and phosphorus on seed yield of ajwain

Treatments	Days to 1st Flower Ing	Days to 50% flower Ing	No. of umbels per plant	No. of umbellets per umbel	Days to harvesting	Seed yield per plant (g)	Seed yield per plot (g)	Seed yield per ha (qt)	Test wt.
Nitrogen levels (kg ha^{-1})									
25	55.61	72.33	168.18	13.13	166.96	6.64	398.5	9.97	1.19
50	56.16	73.09	170.03	14.35	167.49	7.39	443.3	11.09	1.23
75	57.03	74.04	173.10	15.40	168.42	8.35	501.2	12.53	1.26
100	57.62	74.66	172.18	15.18	169.36	8.03	481.8	12.05	1.25
SEm±	0.49	0.40	0.18	0.08	0.37	0.06	3.55	0.09	0.01
CD at 5%	1.49	1.20	0.55	0.25	1.12	0.18	10.75	0.27	0.04
Phosphorus levels (kg ha^{-1})									
25	55.41	71.82	167.01	12.94	166.58	6.79	407.2	10.18	1.18
50	57.80	75.24	174.74	16.09	169.54	8.42	505.3	12.63	1.29
SEm±	0.35	0.28	0.13	0.06	0.26	0.04	2.51	0.06	0.009
CD at 5%	1.10	0.85	0.39	0.18	0.79	0.13	7.60	0.19	0.03

Effect of phosphorus on yield attributes and yield

Application of different levels of phosphorus significantly influenced yield attributes and yield (Table 2). Days to first flowering, days to 50% flowering, days to harvesting recorded minimum with treatment P_1 (25 kg P_2O_5 ha^{-1}) and maximum values of these parameters were recorded in treatment P_2 (50 kg P_2O_5 ha^{-1}). Similarly, The maximum number of umbels per plant, number of umbellets per umbel, seed yield per plant, seed yield per plot, seed yield per hectare, test weight were recorded with application of P_2 (50 kg P_2O_5 ha^{-1}) and minimum values of these parameters were recorded in treatment P_1 (25 kg P_2O_5 ha^{-1}). Application of P might have resulted in increased carbohydrate accumulation and their remobilization to reproductive parts of the plants, resulting in increased flowering, fruiting and seed formation. Similar findings were reported by (Krishnamoorthy) in ajwain, (Kumar) in French bean and (Azizi) in anse.

Interaction effect

The data given in (Table 3) revealed that the interaction of different nitrogen and phosphorus levels significantly influence on growth parameter of ajwain. The maximum plant height, number of primary branches per plant, number of secondary branches per plant recorded with N_3 (75 kg N ha^{-1}) and P_2 (50 kg P_2O_5 ha^{-1}). However, Interaction of different nitrogen and phosphorus levels significantly influence on yield attributes and yield of ajwain (Table 4). The minimum days to first flowering, days to 50% flowering, days to harvesting recorded with N_1 (25 kg N ha^{-1}) and P_1 (25 kg P_2O_5 ha^{-1}) which is at par with N_2 (50 kg N ha^{-1}) and P_1 (25 kg P_2O_5 ha^{-1}). Whereas, The maximum number of umbels per plant, number of umbellets per umbel, seed yield per plant, seed yield per plot, seed yield per ha, test weight recorded with N_3 (75 kg N ha^{-1}) and P_2 (50 kg P_2O_5 ha^{-1}).

Table 3: Interaction effect of different levels of nitrogen and phosphorus on growth of ajwain.

Treatment combination	Plant height			No. of primary branches per plant			No. of secondary branches per plant		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
N_1P_1	07.03	40.01	81.67	1.29	3.56	6.90	6.58	21.26	49.77
N_1P_2	13.37	46.34	87.76	2.23	4.50	7.94	8.06	25.67	56.17
N_2P_1	09.82	42.50	83.89	1.65	3.67	7.20	7.30	23.73	53.90
N_2P_2	14.29	47.57	88.18	2.35	5.47	8.53	8.33	26.80	56.87
N_3P_1	11.53	44.39	86.55	1.95	3.97	7.73	7.73	24.47	54.50
N_3P_2	17.88	50.93	91.57	2.73	6.27	9.47	9.70	29.20	58.90
N_4P_1	11.59	44.57	86.70	2.03	4.10	7.67	7.90	24.93	55.00
N_4P_2	15.26	48.31	88.80	2.39	5.80	8.91	8.77	28.20	58.10
SE(m)±	0.53	0.50	0.56	0.03	0.05	0.06	0.06	0.16	0.16
CD at 5%	1.59	1.51	1.71	0.10	0.16	0.19	0.19	0.48	0.50

Table 4: Interaction effect of different levels of nitrogen and phosphorus on seed yield of ajwain

Treatment combinat Ion	Days to 1st flowering	Days to 50% flowering	No. of umbels per plant	No. of umbellets per umbel	Days to harvesting	Seed yield per plant (g)	Seed yield per plot (g)	Seed yield per ha (qt)	Test wt.
N_1P_1	54.62	70.53	165.05	12.00	165.69	5.68	341.0	8.53	1.15
N_1P_2	56.61	74.13	171.30	14.27	168.23	7.60	456.0	11.4	1.24
N_2P_1	55.27	71.08	166.17	12.57	166.20	6.65	399.2	9.98	1.17
N_2P_2	57.04	75.11	173.90	16.13	168.79	8.12	487.4	12.19	1.28
N_3P_1	55.70	72.49	168.07	13.40	166.83	7.31	438.4	10.96	1.19
N_3P_2	58.36	75.59	178.13	17.40	170.01	9.40	564.0	14.1	1.34
N_4P_1	56.06	73.19	167.00	13.80	167.58	7.50	450.0	11.25	1.21
N_4P_2	59.18	76.13	175.63	16.57	171.14	8.56	513.6	12.84	1.31
SE(m)±	0.23	0.19	0.26	0.12	0.17	0.08	5.02	0.13	0.13
CD at 5%	0.70	0.57	0.78	0.35	0.53	0.26	15.21	0.38	0.38

Table 5: Economics of treatments

Treatment Combination	Cost of cultivation (Rs./ha)	Gross returns Rs./ha (160 Rs./kg)	Net returns (Rs./ha)	B:C ratio
N_1P_1	55641.78	136400	80758.22	2.45
N_2P_1	59620.2	159680	100059.80	2.68
N_3P_1	62332.02	175360	113027.98	2.81
N_4P_1	63203.81	180000	116796.19	2.85
N_1P_2	65124.95	182400	117275.05	2.87
N_2P_2	67316.7	194960	127643.30	2.90
N_3P_2	72521.85	225600	153078.15	3.11
N_4P_2	69260.31	205440	136179.69	2.97

Economics of treatments

Net return and B:C ratio was significantly influenced with different levels of nitrogen and phosphorus (Table 5). The above parameters were recorded maximum with the application of N_3 (75 kg N ha^{-1}) and P_2 (50 kg P_2O_5 ha^{-1}).

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