

## Performance of Fennel and Ajwan as Intercrops under Different Spacings of Poplar Plantations in North-Western, India

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### ABSTRACT

*The quantitative performance of fennel and ajwan spices crops under different spacings of five year old poplar plantation in semi-arid ecosystem was studied to ascertain the seed yield of spices crops. The growth and yield of fennel and methi decreased significantly with the decrease poplar spacing. The rate of decrease in seed yield of fennel and ajwan spice crops were more under 5m x 4 m spacing. On an average the seed yield decreased up to 78.67 % and 84.84 % under 5 m x 4 m spacing as compared to the sole fennel and ajwan (1.46 and 0.99 t/ha). Yield of the crops increased with increasing spacing of poplar and minimum yield reduction (57.53 %) was recorded in fennel under poplar based agroforestry system with 18 x 2 x 2 m spacing. Based on experimental data it can be concluded that fennel (variety HF-33) should be planted in wider spacing i.e. 18 x 2 x 2 m for better yield in poplar based agroforestry system. Between the spice crops highest net returns and cost benefit ratio were also observed in fennel under poplar based agroforestry system with 18 x 2 x 2 m spacing. The net returns for other spices were also higher in poplar based agroforestry system as compared to sole cropping, due to additional returns from poplar.*

**Key words:** Poplar, Performance, Spacing, Fennel, Ecosystem.

### INTRODUCTION

Poplar is the very prominent taxonomic group of tree species in plantation forestry as well as in natural forests northwestern state of India. Its natural population is small and found only in the mountains with six indigenous species. As an exotic species (*populous deltoides*), it acquire great role afforestation/reforestation programmes, agro-forestry and conservation activities. According to India country report on

poplar and willow<sup>1</sup>, area under poplar outside the forest in India is estimated 312,000 ha. The annual return from poplar at current market rates are estimated to be around one Rs. 60-80,000 rupees acre<sup>-1</sup> year<sup>-1</sup>, which is much higher than any other on-farm intervention<sup>5</sup>.

Poplar is normally planted and grown under wide spacing accommodating 400 to 500 tree ha<sup>-1</sup>.

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Its stand density permits enough sunlight and air circulation and therefore gives better crops yields<sup>15</sup>. In many locations, farmers now plant more trees per unit area than recommended number of 400-500 trees ha<sup>-1</sup> with the hope to get increased returns. This study was therefore, planned to study the effect of different spacings on methi and coriander performance in *Populus deltoides* based agri-silvicultural system.

Poplar based agroforestry systems are economically viable and more profitable than many other crop rotations<sup>3,8</sup>. It is usually managed in 6-8 years rotation cycle under agroforestry system. Owing of its rapid growth, high biomass, adaptability, early economic returns and compatibility with crops prompted to introduce poplars in agroforestry systems. Cropping with tree species is an ancient practice and very important tools to achieve goal of National Forest Policy (1988). It has been reported as an important component of the 'evergreen revolution' movement in the country<sup>14</sup>.

Different crops are planted as intercrop with poplar like wheat, maize, berseem and vegetables. Shade loving crops can also be inter-cropped with poplar. Among vegetable shade loving crops like turmeric, ginger and aromatic species have performed well along with poplar.

Fennel (*Foeniculum vulgare* Mill.), generally known as Saunf belonging to the family Apiaceae, is a stout, aromatic annual herb (biennial with potency of regeneration). It is one of the most important medicinal and aromatic plants due to its estrogenic activities and is used as a carminative, diuretic, anti-inflammatory and antimicrobial drug. Fennel is widely cultivated throughout the temperate and sub-tropical regions of the world. In India it is mainly cultivated in Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh, Karnataka, Haryana and Punjab.

Ajwan (*Trachyspermum ammi* L.), a member of Apiaceae family, is an erect, glabrous, or minutely pubescent, branched, up to 90 cm tall, aromatic annual herbaceous plant, bearing grayish brown fruits having importance both

as a spice and medicine. Ajwan also called as Bishop's weed or carum seed is a native of Egypt. Mainly, it is a cross-pollinated crop but some flowers are self-fertile<sup>11</sup>.

## MATERIAL AND METHODS

The present study was conducted during 2012-2013 in already established 5 years poplar plantation spaced at 5 x 4 m, 10 x 2 m and 18 x 2 x 2 m at CCS Haryana Agriculture University, Hisar (29<sup>0</sup>09' N latitude and 75<sup>0</sup> 43' E longitude at an elevation 215 m above mean sea level), situated in the semi-arid region of North-Western India. The climate is subtropical monsoon with an average annual rainfall 350-400 mm, 70-80 percent of which occurs during July to September. The summer months are very hot with maximum temperature ranging from 40 to 45<sup>0</sup>C in May and June whereas, December and January are coldest months (lowest January temperature as low as 0<sup>0</sup>C). The total rainfall during 2012-2013 from September, 2012 to April, 2013 was 154.00 mm. The experiment was laid out in split plot design with three spacings of poplar and control. There were 12 treatment combinations which were replicated thrice and allotted randomly in each plot. The plot size for each treatment was 5 x 2 m<sup>2</sup>.

The fennel cultivar HF-33 was sown during the 15-30 October keeping a plant to plant and row to row distance of 30 x 45 cm with a seed rate of 10 kg/ha and applied 40 kg each of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/ha as a basal dose at the time of field preparation and again 40 kg N/ha was applied in two equal splits at 30 and 50 days sowing as top dressing.

The ajwan local cultivar was also sown during the last week of October keeping a plant to plant and row to row distance of 30 x 45 cm with a seed rate of 6 kg/ha and applied 40 kg N and 40 kg each of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/h at the time of sowing.

The height of ten randomly tagged plants was recorded from ground level to the tip of main stem at 30, 60, 90 and 120 days after sowing (DAS) and at harvest. The average height of ten plants was worked out and was expressed in centimeters (cm). The

number of branches /plant was counted on randomly selected ten plants at harvest and the average number of branches per plant was calculated. The total number of umbels in randomly selected ten plants in each treatment was counted and the number of umbels per plant was calculated by averaging the values for each treatment. The number of seeds in unbelted of randomly selected ten plants was counted and the average number of seeds per unbelted was calculated for each treatment.

Using sickle the plants were harvested in each plot separately. The harvested plants were left in the field for few days to sun dry, and later, they were threshed. After cleaning, the weight of seeds (g/plot) was recorded. The values were later converted to tonne/ hectare. The harvest index was calculated by dividing the economic yield (seed yield per plot) with total biological yield and expressed as percentage.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Hundred seeds in three replications were weighed individually and the mean of these observations was worked out. Later,

the values were converted into weight of 1000 seeds (test weight) for each treatment, and the test weight was expressed in grams.

## RESULTS AND DISCUSSIONS

### Growth of poplar:

Poplar planted at 5x4 m spacing recorded significantly more plant height (17.47 m), girth (76.67 cm), canopy width (6.80 m) and leaf fall (5.30 t /ha) than all the poplar spacings, whereas the paired row planting of poplar resulted in poor growth of poplar in terms of all the growth parameters except that girth of poplar did not differ significantly between 10x2 m and 18x2x2 m spacings (**Table 1**). Maximum growth in terms of plant height, girth, canopy width and leaf fall was recorded at 5x4 m spacing of poplar and minimum in paired row plantation. It was due to the fact that at 5x4 m spacing plants got enough space on both sides whereas in paired row plantation competition for growth resources mainly moisture and nutrients were limited in narrow space. Significant effect of spacing on tree growth of eucalyptus as well as positive effect of increased distance between trees on growth parameters of eucalypts has also been reported by Kirongo.

**Table 1: Effect of spacing of poplar on plant height, girth, canopy width and leaf fall**

Spacing	Plant height (m)	Girth (cm)	Canopy width (cm)	Leaf fall (t/ha)
5x4 m	17.47	76.67	6.80	5.30
10x2m	17.14	67.56	6.10	4.30
18x2x2m	16.93	64.32	5.08	2.70
CD at 5%	0.41	5.66	0.09	0.27

### Growth and growth attributing characters of fennel and ajwan:

In poplar based agroforestry system, the effect of different spacings of poplar on plant height of fennel showed significant variation among the treatments. The plant height (146.70 cm) in control was significantly higher than under different spacings of poplar plantations at the time of harvest. At all the stages of crop growth the plant height of fennel increased significantly with increasing spacing of poplar. On an average, 27.55, 13.02, 11.60 and 10.53 % decrease in plant height of fennel was observed after 30, 60, 90 and 120 days,

respectively under poplar based agroforestry system as compared to the fennel crop in control due to the availability of more sunlight. The sole crop of coriander recorded significantly more number of branches (8.37) than all the poplar spacings at the time of harvest (**Table 2**).

The effect of different spacings of poplar on plant height of ajwan showed significant variation among the treatments. The sole crop of ajwan recorded significantly more plant height (122.80 cm) than sown under different spacings of poplar at harvest. The plant height of ajwan increased significantly with

increasing the spacing of poplar at all the stages except that the differences between 10x2 m and paired row planting at 60 DAS were not significant. On an average, 23.03, 13.30 and 8.38 % decrease in plant height of ajwan was observed after 30, 60 and 90 days, respectively under poplar based agroforestry system as compared to the ajwan crop in open due to the availability of more sunlight. Like plant height the number of branches of ajwan increased significantly with increasing spacing. The sole crop of ajwan recorded significantly more number of branches (39.37) than all the spacings of poplar (Table 2).

Growth parameters like plant height, number of branches and yield attributing characters like pods/plant seeds/pod,

umbel/plant, umbellate/umbel, seeds/umbel, test weight decreased and consequently seed yield of all the test crops decreased significantly under all the spacings of poplar. This might be attributed to competition of poplar with test crops for growth resources like light, moisture and nutrients. Several authors<sup>10</sup> have reported reduced yield of crops due to decrease light intensity under trees. Gill *et al.*<sup>6</sup> have also reported reduced yield of fennel and ajwan under poplar plantation. Similarly Islam *et al.*<sup>7</sup> have reported higher yield of tomato, chilli, carrot, onion, garlic, turnip and French bean under full sunlight over guava- coconut based multistrata agroforestry system allowing 50% photosynthetically active radiation (PAR).

**Table 2: Effect of different spacings of poplar on plant height & number of branches of fennel and ajwan**

fennel cultivar-FH-33						
Spacing	Plant Height (cm)					No. of Branches
	30 DAS	60 DAS	90 DAS	120 DAS	Harvest	
5x4m	6.71	33.69	63.42	100.51	120.63	5.90
10x2m	7.61	36.48	68.22	106.82	127.50	6.13
18x2x2m	8.93	39.67	72.04	115.28	133.33	6.60
Control	10.45	42.09	76.80	120.19	146.70	8.37
CD at 5%	0.36	0.93	1.83	1.42	4.88	0.35
ajwan cultivar- Local						
5x4m	6.60	31.56	59.04	90.08	98.66	19.19
10x2m	7.67	35.78	63.01	92.60	104.37	24.50
18x2x2m	9.21	37.99	65.47	95.68	111.60	29.58
Control	10.16	40.50	68.22	102.39	122.80	39.37
CD at 5%	0.63	2.69	1.24	0.69	2.63	1.47

#### **Yield and yield attributing characters of fennel and ajwan:**

The effect of different spacings of poplar on all yield and yield parameters of fennel showed significant variation among the treatments. The sole crop of fennel recorded significantly more yield (1.46 t/ha) compared to different spacings of poplar. All the yield and yield parameters of fennel increased significantly with increasing spacing of poplar except that the difference between 5x4 m and 10x2 m spacing were not significant in respect of number of umbelets /umbel, number of seeds /umbel, test weight and biological yield (Table 3).

Chauhan *et al.*<sup>4</sup> have also reported, the yield attributes of all the spices also increased significantly with increasing row spacing. However the differences between 5x4 m and 10x2 m spacing in respect of number of pods per plant and number of seeds per plant in fennel; number of umbelets per umbel and number of seeds per umbel were not significant. Similarly the differences between 10x2 m and paired row spacing in respect of number of umbelets per umbel in coriander were not significant while test weight showed no significant variations between poplar spacings in fennel and ajwan.

**Table 3: Effect of different spacings of poplar on yield and yield parameters of fennel**

Spacing	Dry matter at harvest (g)	No. of umbels per plant	No. of umbels per umbel	No. of seeds per umbel	No. of seeds per umbellet	Test weight (g)	Harvest index (%)	Biological yield (t/ha)	Seed yield (t/ha)
5x4m	24.31	6.13	14.95	100.49	6.87	5.03	20.52	1.51	0.31
10x2m	32.79	6.58	16.01	114.76	7.09	5.21	21.08	1.85	0.39
18x2x2m	45.07	7.36	18.22	145.65	7.87	5.81	21.68	2.86	0.62
Control	68.83	10.06	21.82	206.38	9.51	7.61	22.63	6.45	1.46
CD at 5%	5.03	0.27	1.21	23.31	0.21	0.21	0.17	0.76	0.04

The effect of different spacings of poplar on all yield and yield parameters of ajwan showed significant variation among the treatments. The sole crop of ajwan recorded significantly more yield (0.99t/ha) compared to different spacings of poplar. All the yield parameters increased significantly with increasing spacing except test weight which did not exhibit significant difference between 5x4 m and 10x2 m spacing. Similarly biological yield also did not differ significantly between 10x2 m and 18x2x2 m spacing of poplar (Table 4)

Kaushik *et al.*<sup>9</sup> reported that yield of different crops was not affected by different tree combinations during initial two years.

Among the spices crops maximum return was recorded from fennel, coriander and minimum from ajwan it was due to higher yield production from these crops than ajwan crop. The return from spice crops increased with increasing spacing of poplar due to increased yield of spices crops with increasing row spacing.

Nandal and Hooda<sup>13</sup> have also reported variable performance of crops under different spacing of poplar. The comparative seed yield recorded between fennel and ajwan, in ajwan seed yield found maximum decrease of 71 per cent under poplar.

**Table 4: Effect of different spacings of poplar on yield parameters of ajwan**

Spacing	Dry matter at harvest (g)	No. of umbels per plant	No. of umbels per umbel	No. of seeds per umbel	No. of seeds per umbellet	Test weight (g)	Harvest index (%)	Biological yield (t/ha)	Seed yield (t/ha)
5x4m	26.13	36.91	9.03	194.19	21.53	0.23	9.15	1.64	0.15
10x2m	31.62	39.75	9.21	215.13	22.42	0.25	9.52	2.31	0.22
18x2x2m	36.21	44.02	9.76	234.74	23.49	0.30	10.90	2.75	0.31
Control	62.56	71.45	10.31	295.62	28.21	0.47	12.12	8.17	0.99
CD at 5%	3.68	2.04	0.12	17.36	0.87	0.04	0.05	0.57	0.03

### The economics of the system

The data on economics of the spices based on agro-forestry system is present in table 5. The monocropping of all the spices proved less economical than cultivation of these species with poplar as expressed in terms of net return and cost benefit ratio values. The data showed that both net return and cost benefit ratio increased with increasing the spacing of poplar and the maximum net returns were recorded under paired row plantation of poplar. The differences in net return and cost benefit ratio between 5x4 m and 10x2 m spacing were marginal.

Bari and Rahim<sup>2</sup> have also reported higher income from coconut and Aloe vera combination than sole Aloe vera cultivation. Higher net returns from *Melia* + dhaincha-berseem crop rotation have also been reported by Nandal and Kumar<sup>12</sup> and in similar way Kaushik *et al.*<sup>9</sup> reported that yield of different crops was not affected by different tree combinations during initial two years. Between the spice crops maximum return was recorded from fennel. The return from spice crops increased with increasing spacing of poplar due to increased yield of spices crops with increasing row spacing.

Table 5: Net returns from spices crops in intercropping system with poplar plantation

Economics of fennel under poplar based agroforestry system						
Spacing	Gross return (Rs./ha)	Total cost of cultivation (Rs./ha)	Discounted Cost (Rs./ha)	Net returns (Rs./ha)	Discounted returns (Rs./ha)	B:C
Control	131400	58585	26509	72815	32948	1:1.24
5x4m	162900	71810	32493	91090	41217	1:1.27
10x2m	170100	71810	32493	98290	44475	1:1.37
18x2x2m	190800	71810	32493	118990	53842	1:1.66
Economics of ajwan under poplar based agroforestry system						
Control	99000	58185	26328	40815	18468	1: 0.70
5x4m	150000	71410	32312	78590	35561	1:1.10
10x2m	157000	71410	32312	85590	38729	1:1.20
18x2x2m	166000	71410	32312	94590	42801	1:1.32

### CONCLUSION

Yield reduction in all the spices crops was recorded under different poplar spacings as compared to sole cropping. Yield of all the crops increased significantly with increasing in poplar spacing except that in the biological yield of fennel when raised in 5x4 m and 10x2 m spacings while in ajwan under spacings 10x2 m and 18x2x2m. Minimum yield reduction was recorded in fennel under poplar based agroforestry system with 18 x 2x 2 m spacing.

Between the spice crops highest net returns and cost benefit ratio were also observed in fennel under poplar based agroforestry system with 18 x 2 x 2 m spacings. The net returns for other spices were also higher in poplar based agroforestry system due to additional returns from poplar. Based on experimental data it can be concluded that fennel (variety HF-33) should be planted in wider spacing i.e. 18 x 2 x 2 m for better yield per hectare under poplar based agroforestry system.

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