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Ranjeetha R

Department of Horticulture,
College of Sericulture, Chintamani,
Karnataka, India

Raviteja DH

Department of Crop Physiology
J.C. Diwakar Reddy Agricultural
College Juturu, Tadipatri - 515411
Affiliated to Acharya N. G. Ranga
Agricultural University Guntur,
Andhra Pradesh, India

Praveenakumar R

Department of Horticulture,
ICAR- Krishi Vigyan Kendra,
Chintamani, Karnataka, India

A comprehensive review on ajwain (*Trachyspermum ammi* L.) cultivation practices

Ranjeetha R, Raviteja DH and Praveenakumar R

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Abstract

Ajwain is a commercial seed spice having numerous medicinal properties. The seeds are the economic parts which are an aromatic blend of caraway and cumin. Indian culinary is never complete without the addition of ajwain. The essential oil extracted from ajwain has therapeutic potential due to antimicrobial properties. It is one of the richest sources of thymol and carvacrol, which adds unique aroma and flavor, thus making it as a potential perfumery need. This annual crop is adapted to varied climatic condition and grows luxuriously during *rabi* season. Its cultivation is seen in wide soil range with sufficient water retaining capacity and adequate drainage. It performs well both under irrigated and rainfed conditions, but rains during seed maturity will result in seed shattering. Ajwain is cultivated as mixed crop, monocrop and is suitable for double cropping. Foliar application of plant growth regulators like GA₃, thiourea, NAA has improved growth, flowering and yield in ajwain. Sufficient nutrition, timely weeding and management of pests and disease are necessary for obtaining potential yield. The seeds are harvested when brown and subjected for further processing. The average seed yield is 4-6 q under rain fed and 12-15 kg/ha under irrigated conditions.

Keywords: Ajwain, *Trachyspermum ammi* L., *rabi*

Introduction

Ajwain, botanically known as *Trachyspermum ammi* L. (2n=18) (Farooqi *et al.*, 2005) [15] is one of the medicinally important commercial seed spice of the family Apiaceae (Gersbach and Reddy., 2002) [16]. Ajwain is also referred as *Carum copticum*, due similarity with caraway. The name 'ajwain' has been derived from the Sanskrit word 'yavanaka or ajomodā' (Azhar *et al.*, 2011) [7]. It is commonly known as Ajowan/Ajwain in Hindi, Yamini in Sanskrit; Carom seed, Carom Ajowan/ Bishop's weed in English, Oma in kannada, Ajma in Gujrati, Kath in Kashmiri and Omam in Tamil (Chauhan *et al.*, 2012) [13].

Ajwain is an erect, glabrous, or minutely pubescent annual herb that grows to a height of 90 cm (Chatterjee., 1995) [12]. It produces many branched, striated leafy stems; the leaves appear feathery and are 2-3 pinnately divided (Farooqi *et al.*, 2005) [15]. The dark green leaves of ajwain consists valuable nutrients and antioxidants (carotenoids, lutein and zeaxanthin). Thus, these are used as greens for preparing salads (Sies., 1997) [51]. The white flowers are borne in compound umbels, either terminally or seemingly lateral. The seeds are single-seeded, greyish-brown cremocarps with prominent ridges and tubular surfaces (Farooqi *et al.*, 2005) [15], the seeds are produced in the umbels (Hassanshahian *et al.*, 2014) [18]. It looks like cumin or caraway seeds (Muhammad Awais Hanif *et al.*, 2021) [33].

Ajwain seeds contain carbohydrates (38.6%), protein (15.4%), fat (18.1%), fibre (11.9%), moisture (8.9%), mineral matter (7.1%) (calcium, phosphorous, iron and nicotinic acid, cobalt, copper, iodine, manganese), thiamine, riboflavin, glycosides, saponins, flavone and tannins (Pruthi., 1992 and Ranjan., 2012) [38, 40]. Additionally, it possess significant levels of ash (Singh *et al.*, 2008) [50].

Indian cooking employs ajwain as a major ingredient as it imparts a vital flavour and aroma (Davidson and Jaine., 2014) [14]. It is exceptionally fragrant, possessing a scent like thyme and appears as cumin (Kanika and Sanyogita., 2023) [19]. Thus, it is an integral part of Indian cuisines.

Corresponding Author:

Ranjeetha R

Department of Horticulture,
College of Sericulture, Chintamani,
Karnataka, India

Ajwain is a typical ayurvedic crop which is used immensely for medicinal purpose, traditionally, seeds are used for curing various diseases such as diarrhea, dysentery, atonic dyspepsia, cholera, abdominal tumors, piles (Krishnamoorthy and Madalageri., 1999) [39] galactagogue (Aghili *et al.*, 1992) [1]. Ajwain is used as a household folk medicine for stimulating the appetite, cure stomach discomfort, smooth functioning of the respiratory system and the kidneys, cough, cold, asthma, influenza (Kolbadinejad *et al.*, 2020) [20]. It is used as antifatulent, to relieve the gas retention and flatulence, treat abdominal gas anorexia, nausea and vomiting (Hawrelak *et al.*, 2009) [17]. In unani medicinal system, ajwain has been adopted as a crude drug for amebiasis (Bairwa., 2011) [9].

The seeds of ajwain are hydro-distilled using a Clevenger-type apparatus (Masoudi *et al.*, 2002) [27] to produce a vital yellowish-brown or sunburned colour oil which has a potential odour, aroma and flavour and is used as traditional cure to many ailments and in preparation of perfumery products (Kunwar., 2009) [21]. The oil is secreted in the cubicles of the plant and its value, quantity of oil produced upon distillation is dependent on the climatic conditions during the crop growth (Zomorodian *et al.*, 2011 and Asangi *et al.*, 2020) [58, 6].

Ajwain is a rich source of volatiles and phenolics. The principal constituents which are responsible for typical flavour of ajwain seed essential oil are thymol (35-60%) and carvacrol. Thymol is the major constituent of the seeds, followed by γ -terpinene and p -cymene. Thymol is antispasmodic, germicide and antifungal (Nagalakshmi *et al.*, 2000 and Bhatt *et al.*, 2018) [10, 34] whereas, thymol and carvacrol both are antiseptic, expectorant and antitussive agents (Trease and Evans., 2002) [54]. The non-thymol content Thymene is also present (Mohagheghzadeh *et al.*, 2007) [32].

This vital oil is reasonably safe and it is used for production of antimicrobial agents for therapeutic causes. It possesses varied pharmacological properties. It is a potential antiseptic, antifungal, antibacterial and antihelminthic. It has Bronchodilatory effect (Boskabady *et al.*, 2007) [11] and anti-hypertension property.

The byproducts of ajwain such as whole seed, powdered seed, volatile oil and oleoresin are also adulterated which can be detected using suitable procedures (Malhotra and Vijay, 2004) [23].

This Egyptian native plant (Shojaaddini *et al.*, 2008) [47] came to India with the Greeks (Chatterjee *et al.*, 2012) [12]. It is distributed in many parts of India, Iran, Afghanistan, etc. In India, it covers an area of 34,500 ha with a production of 27,940 tonnes and it is mainly cultivated in Rajasthan (15,430 ha area and 10,540 tonnes production), Gujarat (5,320 ha and 5,050 tonnes), Telangana, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, Uttaranchal, Haryana, Punjab, Maharashtra, and, to a small extent, Karnataka (Anon., 2018) [5].

Cultivation Aspects

Climate and soil conditions

It is a crop of semi-arid tropics, mainly grown during the rabi season in India. (Meena *et al.*, 2009) [29]. It is also grown as kharif crop in some regions of the country (Lal *et al.*, 2014) [22]. It is a cold loving crop, and requires moderate cool and dry climate for better growth and flowering (Ranjeetha., 2021) [41]. The optimum temperature lies between 15-27 °C with a relative humidity of 60-70% during its growth period and preferably warm weather during seed development (Anon., 2016) [4]. Lower temperature hampers the growth of the crop. Low humidity especially after flowering is beneficial, continuous moist and cloudy weather favors the incidence of insect – pests and diseases (Narayan *et al.*, 2021) [36]. The crop is drought tolerant and has wider adaptability. Ajwain grows on wide range of soil, it grows on loam, alluvial and black cotton soils (Anon., 2016) [4].

Well drained sandy loam soils are best suitable, fertile clay loam soils are quite suitable if adequate drainage facilities are available (Ranjeetha., 2021) [41]. It is better to avoid gravelly/sandy soils and acidic soils as the crop doesn't thrive well in those soils (Shubha *et al.*, 2021) [49]. The soils with pH range from 6.5 to 8.5 gives higher yield and better quality of leaves. The crop is tolerant to salinity (Anon., 2016) [4].

Crop improvement

Total germplasm assemblages of seed spices at ICAR-NRCSS, Ajmer (Annual Report., 2021) [3]

Institute	NRCSS		AICRP on spices	Total
	Indigenous	Exotic		
Ajwain	114	1	9	124

Varieties of Ajwain

Sl. no	Variety	Characters
1.	AA-1	Suitable for rainfed and irrigated condition (Ranjeetha <i>et al.</i> , 2021) [43].
2.	AA-2	It matures in 147 days, produces an average yield of about 12.83 q/ha under irrigated condition and 5.2 q/ha under rainfed condition. It possesses resistance to powdery mildew and has essential oil content of 3% (Ranjeetha <i>et al.</i> , 2021) [43].
3.	AA-73	It is medium maturing (165-170 days) and high yielding variety. It shows high tolerance to root rot and Sclerotium rot. AA-73 yields 1500-1600 kg/ha seeds (Akshatha <i>et al.</i> , 2014) [2].
4.	AA-93	AA-93 population which is open pollinated variety developed through mass selection (Meena <i>et al.</i> , 2014) [28]
5.	Gujarat Ajwain-1	Non shattering and late maturing variety (Ranjeetha <i>et al.</i> , 2021) [43].
6.	Lam Sel-1	It is an erect, early maturing variety (120 days), produces good quality seed (Sharangi <i>et al.</i> , 2018) [46]
7.	Lam Sel-2	It is spreading and bushy type, matures in 132 days (Sharangi <i>et al.</i> , 2018) [46]
8.	Pratap Ajwain	Moderately resistant to leaf blight and powdery mildew (Sharangi <i>et al.</i> , 2018) [46]
9.	RPA-68	Richa <i>et al.</i> , 2020 [44]
10.	Azad Ajwain-1	Resistant to <i>Sclerotinia sclerotiorum</i> (Tripathi., 2010) [55]

Ajwain collections: NP (P)-79, NP(J)8, NP(J)66, NP(P) 15, NP(K)15, S25, S95, S47, S84, IC3743, DAC-1, DAC-2, DAC-3, DAC-4, DAC-5, DAC-6, DAC-7 (Ranjeetha *et al.*, 2021) [41].

Varietal studies

A crop growth is a complex of genetic nature, physical environment and the agroclimatic conditions prevailing during the period of the production. It has been reported by many

researchers in ajwain that vegetative, reproductive and yield varied and was significant. The genotype AA-93 plants are morphologically erect in nature having 80 cm height (Meena *et al.*, 2014) [28]. Flowering is a typical plant character, which is

decided by its genetic constitution coupled with prevailing environmental conditions. The variations in flowering can take place due to growth differences, accumulation of carbohydrates, suitable weather conditions for changing into reproductive phase. As the flowering takes place early, the other process of seed set and maturity also follows early. The genotype AA-93, took less number of days to first flower appearance, 50% flowering, umbel formation and days to maturity (53.00, 65.00, 78.67 and 136.67 days, respectively), while, Lam Ajwain-2 took maximum days to first flowering, 50% flowering and umbel formation (89.00, 96.33 and 109.67 days, respectively) and maximum days to seed maturity was observed in Lam Sel-1 (168.33 days). This confirms that, AA-93 genotype is an early maturing type. (Ranjeetha *et al.*, 2021) [43].

The seed yield is a complex character of any genotype affected by environmental conditions during the growth period. The variations in seed yield are a combined effect of production of umbels, umbellets and seed set. The numbers of primary and secondary branches have resulted in production of better number of umbels per plant and umbellet per umbel; good seed set is due to better pollination and fertilization. Test weight differences are due to accumulation of dry matter and photosynthates in seeds. LTA-26 recorded the maximum number of umbels (262.8) whereas; the minimum number of umbels was recorded in DAC-2 (148.7). The genotypes LTA-26 recorded the highest test weight (1.63 g) the lowest test weight was recorded in AA-93 (1.34 g) (Sushma *et al.*, 2022) [52]. The genotype GA-1 produced maximum number of seeds per umbel (415.73) while, Lam Sel-1 produced minimum number of seeds per umbel (177.33). The maximum seed yield per plant registered in GA-1 (13.37 g plant⁻¹) followed by DAC-8 (12.41 g plant⁻¹) while, minimum yield was observed in Lam Sel-1 (5.02 g plant⁻¹). Maximum test weight was recorded in DAC-6 (1.15 g) minimum was recorded in AA-93 (0.62 g). Maximum harvest index was recorded in DAC-8 (19.97%) and minimum was recorded in DAC-5 (14.38%) (Ranjeetha *et al.*, 2021) [43].

Seed rate (Anon., 2016) [4]

- Mixed crop :1 kg seed/ha
- Monocrop (drilling) : 1.5 kg/ha
- Monocrop (broadcasting): 4 kg seed/ha
- Rabi season crop : 2.5 - 3.0 kg/ha
- Kharif season crop : 4-5 kg/ha

Cropping system with Ajwain

Double cropping: In this type of sequential cropping two crops per year are grown in a sequence and ajwain is a suitable crop in double cropping (sequential cropping) (Malhotra., 2007) [24].

1. Green gram/ Black gram- Coriander/ Ajwain
2. Maize/ Pearl-millet- Fenugreek/Ajwain
3. Cluster-bean/ Cowpea- Dill/Ajwain/Coriander

Seed sowing

Date of sowing is a critical factor in any crop production process as it affects the overall performance of the crop by fully exploiting the crops genetic potential. The climate conditions during the sowing period directly influences the productivity of the crop (Malhotra., 2017) [26]. The crop sown on 30th October produced significantly higher Plant height, number of primary and secondary branches per plant, plant spread, stem diameter, number of umbels per plant, number of umbellets per umbel, number of seeds per plant, and seed yield per plant compared to the crop sown on 15th October and 14th November (Nath *et al.*, 2008) [37]. Ajwain should be sown at a depth of 1.0 cm with a

spacing of 30 cm x 20 cm (Malhotra., 2012) [25]. Maximum seed yield (10.77 q ha⁻¹) were obtained with spacing 30 cm x 10 cm as compared to the spacing 30 cm x 20 cm (10.53) 30 cm x 30 cm (7.02 q ha⁻¹) (Nath *et al.*, 2008) [37].

Sowing duration in India (Anon., 2016) [4]

- Northern plains (rabi season crop) - September and October
- Northern plains (kharif season crop) - July to August.
- Normally - September to November
- Early crop - First week of October
- Late crop - November-December
- Madhya Pradesh- August.
- Southern part (Andhra Pradesh, Karnataka and Tamil Nadu) - middle of August.
- Early crop (rainfed) - August
- Main season crop - September to October.
- For realizing yield, it is better to adjusted sowing time in such a way that the seed development and seed maturity phase coincide with a dry and rain free period

Irrigation studies

It is cultivated both as a rainfed crop and irrigated crop. Immediately after sowing a light irrigation has to be provided. Again a light irrigation is given after 4-5 days to facilitate germination. Depending on climate and soil type subsequent irrigation are applied at interval of 15-25 days (Anon., 2016) [4]. The crop irrigated at 0.8 IW:CPE ratio resulted in less oil content (3.05%) and higher yield (36.10 kg/ha), whereas under rainfed conditions, essential oil content was higher (3.22%) but the total yield of essential oil was lower (25.92 kg/ha) (Tattimani *et al.*, 2023) [53]. The maximum number of umbels /plant, umbellets /umbel, seeds/umbellets, and test weight were recorded with application of irrigation at 18 days interval was at par with irrigation at 15 days interval (Mehta *et al.*, 2013) [30].

Nutrition studies

Soil application of 10 tons of well decomposed FYM during last ploughing is recommended for raising a healthy irrigated crop. 30 kg N, 40 kg P₂O₅ and 30 kg K₂O /ha should be applied to the soil. In addition, 30 kg nitrogen can be given in two equal splits one at 45 days after sowing and second before flowering.

In the rain fed conditions, 40 kg N, 20 kg P₂O₅ and 20 kg K₂O /ha should be applied at the time of sowing (Anon., 2016) [4].

Significantly higher yield attributes, yield net return of Rs. 20320 /ha and BCR (0.97) in ajwain were obtained with application of 50 +25 kg N and 50 kg P₂O₅ /ha. (Mehta *et al.*, 2013) [30]. Application of Nitrogen at 60 kg/ha produced maximum seed yield at 15th, 30th Oct and 14th Nov 10.09, 11.68 and 8.67 q/ha (Nath *et al* 2008) [37].

Weed management studies

The initial growth in ajwain is very slow, weed is an important factor lowering yield of ajwain, which is responsible for reducing crop growth by two mechanisms. First by giving competition for resources and second is by allelopathic effect, which involves releasing of toxin into the environment. So, maintaining weed free condition is necessary for getting better growth and yield parameters. Manual weeding is highly recommended as the seed will be started to grow and using chemicals will be detrimental to the crop. A total of 2-3 manual weeding and hoeing are required. The the first weeding should be done after 30 days of sowing accompanied by thinning from rows after maintaining suggested intra row spacing. The

subsequent weeding is done at 30 days intervals as per requirement (Anon., 2016) ^[4]. The maximum number of umbel/plant (244.0), number of umbellate/umbel (14.67), seed yield (638.15 kg/ha) and straw yield (2136.24 kg/ha) respectively were recorded at weed free conditions throughout growth period (Yogi *et al.*, 2015) ^[56]. Significantly higher number of umbels per plant, seeds per plant and test weight and higher seed yield (1,155 kg/ha) and haulm yield (1316 kg/ha) were obtained with hand weeding (Nalini *et al.*, 2017) ^[35].

Growth regulators

Foliar application of growth regulators has an impact on growth and yield of ajwain. GA₃ application at 100 ppm is effective to give maximum growth and seed yield (7.47 g) as it is involved in cell elongation leading to increase in cell wall plasticity (Mohit *et al.*, 2016) ^[31]. The higher number of umbels per plant (184.0), number of seeds per umbel (212.30) and seed (1112 kg/ha), straw (3082 kg/ha) and biological yields (4195 kg/ha) were obtained with application of thiourea @ 500 ppm spray at 40 and 60 DAS (Sheeshpal *et al.*, 2017) ^[48]. Application of 100 mg/L NAA emerged as the best treatment to enhance the yield attributes followed by GA₃. The positive effect of foliar PGRs on essential oil production is attributed to the improved plant growth and metabolism (Yogita *et al.*, 2013) ^[57].

Plant protection

Diseases such as Root rot (*Rhizoctonia solani* Kuhn.) and powdery mildew (*Erysiphe polygoni* D. C.) are found affecting ajwain. Root rot is a serious problem in ajwain growing areas and it drastically reduces the yield whereas powdery mildew generally appears late in the season and is of minor importance (Anon., 2016) ^[4]. The highest grain yield (0.51 kg/plot) and per cent increase in grain yield (94.37%) was highest in plots treated with Bavistin + Neem oil + *Trichoderma viride*. Combination of seed treatment with Bavistin + Neem oil + *Trichoderma viride* was also effective in suppression of the root rot disease (Babu *et al.*, 2017) ^[8].

Pests such as aphids (*Myzus persicae*), jassids (*Empoasca* spp.) and seed bug (*Nysus* spp.) are common on ajwain (Anon., 2016) ^[4]. The incidence of polyphagous semi looper, *Thysanoplusia orichalcea* (Fabricius); the tortrix moth, *Archips* sp. and stem fly is the first record on ajwain in a field experiment at Eastern dry zone of India (Ranjeetha *et al.*, 2020) ^[42]. The mean pest population was 2.23 defoliators per plant (*Thysanoplusia orichalcea* and *Archips* sp. together), 4.98 per cent stem fly infestation resulting in 1.73 per cent plant mortality per 3.8 m² plot and the aphid population was 61.85 aphids per 5 cm apical shoot (Ranjeetha *et al.*, 2020) ^[42].

Harvesting and yield

The crop matures in 130-180 days depending upon the variety and season. The crop is harvested from February to May. The seeds develop in umbels and at maturity it appears brown in colour (Anon., 2016) ^[4]. Usually harvested manually, and stacked up for drying. Average seed yield is about 4-6 q/ha under rain fed condition and 12-15 kg/ha under irrigated conditions (Meena *et al.*, 2009) ^[29]. The harvesting stage of fruits had a significant effect on the essential oil content and composition of *T. ammi*. The highest mean of essential oil content (7.1% w/w) was obtained from the fruits which were harvested at pasty stage (with 54% moisture), while the essential oil mean of fruits which collected at ripening stage (with 5% moisture) was 3.2%. The essential oil content of pasty fruits was 110% more than ripened stage (Saharkhiz *et al.*, 2013) ^[45].

Conclusion

Ajwain cultivation is influenced by diverse factors ranging from climatic preferences and soil adaptability to varietal characteristics and agronomic practices. Its resilience to semi-arid conditions makes it suitable for both rabi and kharif seasons in India, with specific varieties like AA-2 and AA-93 exhibiting distinct advantages in terms of yield and disease resistance. Optimal growth requires careful management of irrigation, nutrition, and weed control practices. Despite challenges posed by pests and diseases, advancements in crop protection strategies are enhancing productivity. Ajwain's significance in agricultural systems underscores its potential for sustainable crop diversification and economic viability, paving the way for future research and development in its cultivation practices.

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