Technical bulletin No.49

Package of Practices for Chia (*Salvia hispanica* L) Cultivation

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Preface

The chia plant (*Salvia hispanica* L.) is an important medicinal plant with various health-benefiting properties and also used in food industries. The plant belongs to the Lamiaceae family, which is known for its medicinal, nutritional, and ecological significance. Even though chia is grown for its seeds, the genetic variability in India is limited due to its recent introduction to the country and the non-existence of wild relatives. The crop is suitable for low rainfall areas with good relative humidity. It can also be cultivated in poorly structured soils like sandy loam, sandy gravel soils etc. However, systematic cultivation practices like seed rate, sowing time and method, irrigation, intercropping, spacing and nutrition are not standardised for chia cultivation. Therefore, there is a need to understand the complete package for cultivating chia to its full potential.

The present bulletin on cultivation practices of chia in shallow basaltic soils of the Deccan plateau region provides information on know-how about chia. This bulletin serves as a comprehensive resource that addresses the soil and climatic requirements, genetic improvement, pest and disease management, and the economics of chia cultivation. It is designed to benefit a wide range of stakeholders, including farmers, researchers, and extension personnel engaged in chia promotion. For researchers, it not only provides a valuable reference on existing knowledge but also offers a roadmap for guiding future research initiatives.

We hope this bulletin inspires appreciation for the chia plant's complexity and beauty while serving as a valuable resource for farmers, agronomists and other researchers. As the demand for chia continues to grow globally, knowing its scientific cultivation practices is essential in unlocking its full potential for sustainable agriculture and ecosystem resilience using poor soils and other resources.

Authors

Introduction

Surging health awareness among people leads to rediscovering many forgotten crops with a pack of health benefits. One among them is the Chia (*Salvia hispanica* L.), belonging to the family Lamiaceae. The plant is mainly grown for its seeds, which are a rich source of fibre and fatty acids such as Omega-3. Chia is said to have originated in Southern Mexico and Northern Guatemala. It was reported that the word "chia" is derived from the Spanish word "chian" or "chien" from Nahuan tribes, meaning "oily", indicating that seeds contain oil. Chia seeds are packed with nutritional and health benefits. The immense nutritional and medicinal values offer great scope in the food, nutraceutical and pharmaceutical industries (Fernandes *et al*., 2020). Chia has high bioactive potential and can reduce the risk of chronic heart disease. A higher amount of tocopherols, carotenoids, phytosterols and several other phenolic compounds makes chia a new and promising source of natural antioxidants (Ixtaina *et al*., 2011). Chia has the property of reducing type II diabetes due to its high fibre content and anti-hyperlipidemia and anti-hypercholesterolemia properties. Besides various chia products, the seeds are an abundant source of edible oil ranging from 20.3 to 38.6 per cent, having high α-linolenic acid (55-60%) (Ayerza and Coates, 2011), fiber (35%) and protein (20%) with a highly balanced proportion of essential amino acids. Chia seeds and their products have many applications in industry, such as food stabilizers, binders or emulsifiers in the food industry, biodegradable films, cosmetics and pharmaceuticals (Felisberto *et al*., 2015, Mansuri *et al*., 2016).

Table 1: Nutritional composition of chia seeds (per 100 g)

Nutrient	Nutrition value
Energy	486-562 kcal
Carbohydrates	26.9-42.1 g
Protein	16.5-24.2 g
Lipids/oil	30.7-40.2 g
Ash	4.7-4.8 g
Dietary fiber	30.2-34.1 g
Calcium	456-600 mg
Iron	7.7-9.2 mg
Magnesium	335-450 mg
Potassium	407-526 mg

Source: Jin et al. (2012); USDA, 2018

Table 2. Fatty acid composition of chia oil (Fig 1)

Fatty acid chemical name	**Name of fatty acid**	**Content %**
Hexadecanoic acid, methyl ester	Palmitic acid	9.2
Methyl stearate	Stearic acid	4.4
9-Octadecenoic acid, methyl ester (E)	Oleic acid (Omega-9)	9.4
9,12-Octadecadienoic acid (Z,Z)-methyl ester	Linoleic acid (Omega-6)	23.7
9,12,15-Octadecatrienoic acid, methyl ester,	A-Linolenic acid (Omega-3)	53.3

Source: Harisha *et al*. (2024)

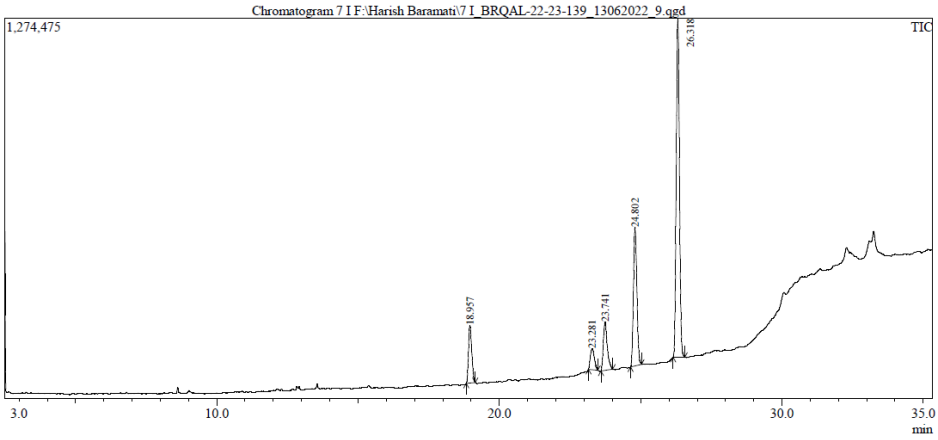


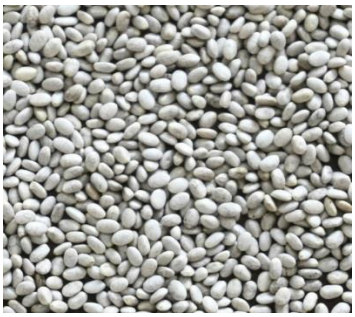
Figure 1. Chromatogram showing the fatty acids identified from Gas chromatography-Mass spectroscopy (GC-MS)

Botanical description

Chia is an annual, short-day plant that requires more than 12 hours of light for flower induction (Baginsky et al., 2016). The life cycle of the chia crop is shown in Figure 2. Typically, the plant grows more than one meter tall, depending on the weather conditions and sowing time. The main stem and branches are angular with oppositely arranged leaves. Stem colour may vary between green and purple due to pigmentation. The petiolated lime green or dark green leaves are produced oppositely on the main stem and branches, with a serrated margin. Chia flowers are small (3-4 mm) and are produced on inflorescences arranged in 5-25 clusters. Each cluster contains 50-100 flowers, which are either white or blue. The complete and hermaphrodite flowers bear tiny fused sepals (calyx) at the base and attractive purple or white coloured petals just above the corolla. The functional floral parts comprised two stamens and one bifid stigma, having four ovaries. The pollination mode is self-pollination, despite some outcrossing occurring due to insects, mainly bees. Upon pollination, in most cases, all four seeds will be set. In some

cases, only two seeds will be set to give bold seeds, as observed in mutants developed at ICAR-NIASM, Baramati. The seed colour may vary from grey or black spotted to white with grey streaks. The seed shape is oval to oblong, with sizes ranging from 1 to 2 mm (Cahill and Provance, 2002). Dry seeds have an invisible mucilage coating, and soaking them in water shows a jelly-like mucilage (fig 3).

Black seed type



White seed type

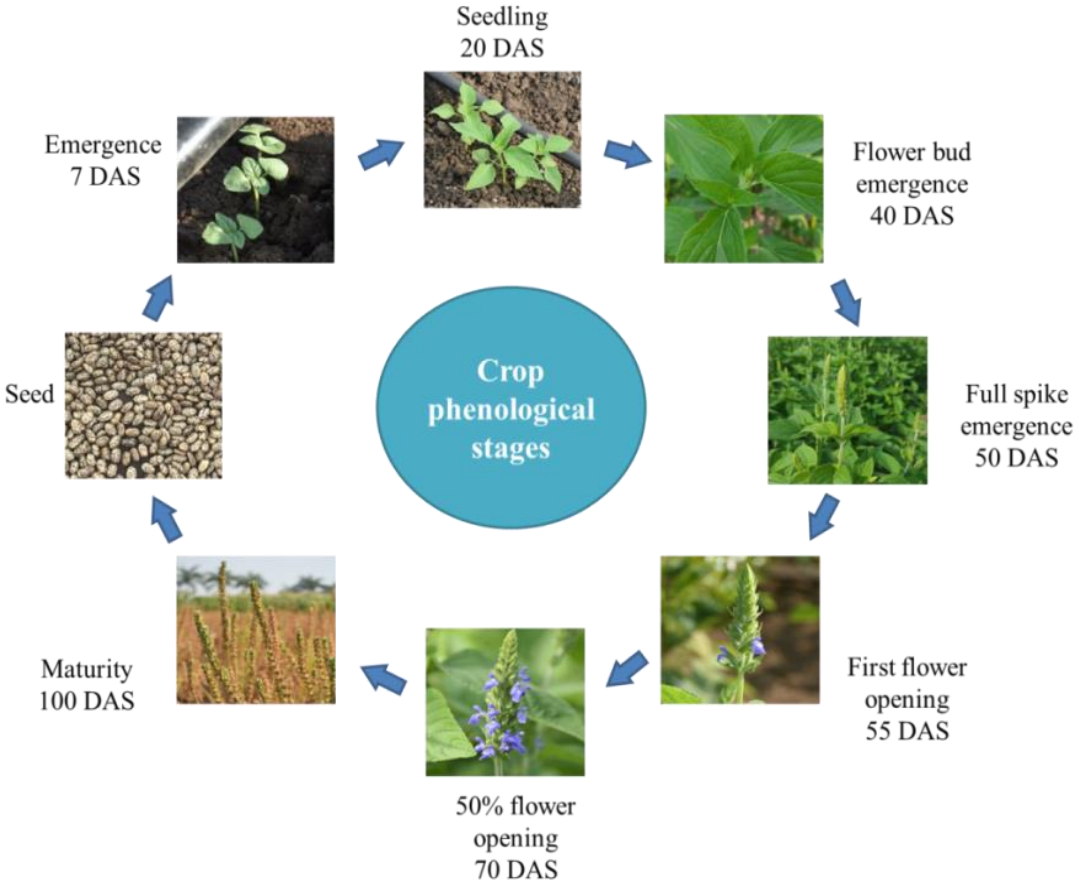


Figure 2: Life cycle of the chia crop from seed to seed

Figure 3: Comparison of feshly added (A) and well soaked (B) chia seeds showing absorption of water and formation of jelly-like mucilage around the seeds.

Area, production and demand

Chia is widely cultivated in various countries, including Mexico, Guatemala, Colombia, Peru, the United States of America, Southeast Asia, Bolivia, Argentina, European countries, Brazil and the Australian continent (Migliavacca *et al*., 2014). In India, the crop was introduced in 2015 and was grown in parts of Karnataka, Tamil Nadu, Maharashtra and Kerala. However, due to unorganised cultivation and marketing, chia's precise area and production are unknown. The global chia seed market is expected to be valued at USD 232.8 million in 2025 and is projected to grow at a CAGR of 7.1%. Therefore, it is expected to reach USD 462.3 million by 2035 (Chia market insights, 2025 (https://www.futuremarketinsights.com/reports/chia-seed-market accessed on 22nd April 2025). In 2024, the largest importer of chia seeds is the USA (USD 174.7 million), followed by the UK (USD 50.8 million). Meanwhile, in 2022-23, Paraguay was the leading exporter of chia seeds, valued at USD 112 million, followed by China, worth USD 88 million.

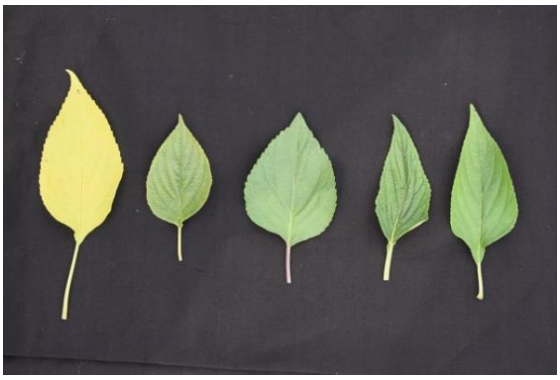
Genetic variability and varieties in chia

Chia is a newly introduced crop in India. Therefore, no systematic crop improvement was made due to lack of genetic variability, non-availability of genetic resources or germplasms and limited cultivation. An effort has been made at ICAR-NIASM, Baramati, Pune, to create genetic variability in chia through gamma (γ)-induced mutation breeding. The mutation breeding successfully generated moderate to high levels of genetic variability in black and white seeded chia. The γ radiation doses of 400, 500 and 600 Gy were found suitable for generating greater variability in chia.

The variation is observed in several agronomically important traits such as plant height, stem pigmentation, leaf shape and colour, inflorescence length, inflorescence size, calyx and corolla colour, flowering time, maturity, seed size and colour. The selection of stabilized promising lines is in progress. Promising breeding lines with high seed yield, bold seed, and early flowering are being studied for further identification and release (Annual report, 2024). The detailed variability observed in chia plants is depicted below (Figure 4).


Plant stem pigmentation


Plant height variants



Leaf colour and shape variants

Spike shape and size variants

Flower colour variant

Spike colour variant

Figure 4. Observed morphological variability in chia plants

Soil

Chia can be grown in several soil types: sandy, loam and medium black with good organic matter. Studies also demonstrated that chia could be effectively cultivated on poor, gravelly, shallow basaltic soils with protective irrigation. In light-textured soils, the crop performs well. In contrast, in black or heavy soils, compaction may create poor emergence and seedling growth, leads to stunting and yellowing of plants. Crop performs on soils with near-neutral pH. However, the crop is sensitive to saline conditions (soil and irrigation water). Therefore, saline or alkaline soils may be avoided for chia cultivation.

Climate

The crop originated in Mexico, which is known for its tropical climate. Being a short-day crop requires <12 hours of light for flower induction. Hence, the sowing window should be adjusted to achieve good flowering at the correct stage of the crop. Crop can be grown at an altitude of 400-1500 m above MSL. The crop requires a mean relative humidity of 65-75% and a mean maximum temperature of 30-31℃ with a diurnal variation of 8-10℃. Evenly distributed 250-350 mm rainfall during cropping is most favourable for chia.

Choosing the appropriate sowing season determines the yield of chia. Considering the above climatic factors, sowing the crop from 1st August to 1st September is ideal in semi-arid regions of India to achieve the potential yield (Harisha et al., 2025).

Field preparation

The chia crop requires fine soil for proper germination. The field should be thoroughly ploughed and harrowed to make the soil fine tilth. Clods may be crushed by a tractor-drawn rotavator before sowing. For the sowing of seeds, flatbeds (light soils), ridges and furrows or narrow trenches (black soils) can be prepared according to spacing.

Seed rate: Chia seeds are small and each gram contains 1100-1200 seeds. Seed rate of 2 kg per ha is optimum for line sowing and 2.5-3 kg for broadcasting.

Sowing method: Seeds can be sown in lines or broadcast in the field. Sowing such tiny seeds requires precision in sowing depth. This can be achieved by mixing chia seeds with sand or coarse soil of 2 mm particle size in a 1:10 ratio. In the broadcasting method, a large bush of lantana or babul can be passed to cover the soil gently after sowing (Fig. 5 and 6). Care should be taken to ensure uniform sowing in line and broadcasting. This will help to maintain a uniform and optimum plant population via reducing the gaps in the field and the thinning of overcrowded plants.

Figure 5: Sowing by broadcasting and covering of soil after sowing

Figure 6. Effect of different seed rates on plant stand in the field and its growth at harvest

Nursery raising:

Chia can also be sown by raising the nursery in the plug trays. Raising seedlings in soil is not feasible as they are susceptible to root damage, and uprooting seedlings from the soil damages the roots, thereby reducing the survival percentage. Therefore, raising seedlings in plug trays with soil+vermicompost (1:1) media, keeping the media intact, gives better seedlings good growth and less damage to roots (fig 7). Further use of 50 cell plug trays is more suitable than 98 cell trays (Fig 8). The ideal transplant stage to the main field is between 15 and 20 days after sowing (Harisha et al., 2023).

Figure 7. Chia seedlings raised in various growing media in plug tray

Figure 8. Chia seedlings are ready to transplant in the main field

Sowing time: The time of sowing determines the yield of chia due to its photosensitive nature and positive response to humid conditions. Chia is a short-day plant that responds well to sowing dates. Sowing early in the kharif/rainy season (up to 31st July) leads to excessive growth, and invariably, flowering starts in September once a short day condition (<12 hours) commences. Due to sowing between August and September, a seed yield of 793-811 kg/ha can be obtained. Early sowing also leads to crop lodging due to excess growth and high rainfall. Consequently, a penalty in the yield. Contrary to early sowing, the delayed sowing in winter, i.e., December onwards, leads to poor growth with less branching, early flowering, and in extreme cases (delayed beyond January-February) observed phyllody-like symptoms i.e retransformation of floral growth to vegetative growth (Harisha et al., 2024) (Fig. 9). Therefore, areas with > 12 hours of day length during the cropping period may be avoided to get better growth and yield.

Figure 9: Transformation of reproductive growth to vegetative growth under delayed sowing after 15th December

Spacing

The chia crop responds to sowing time and climatic conditions. Yield strongly correlates with the number of primary and secondary branches per plant. Because the

spikes/inflorescences appear at the end of each primary, secondary and tertiary branch directly influence the seed yield. Closer spacing or dense population results in poor branching and elongated growth, leading to fewer spikes. Therefore, spacing is decided based on soil type and sowing season. For early sowing, August-September, a wider spacing of 60 cm × 30cm and for late season sowing from October to November, 50 × 30 cm is optimum.

Irrigation

Chia crops respond to irrigation. The seedling (20-30 DAS) and flowering stage (45-55 DAS) are critical for moisture deficit stress. However, the crop shows some waterlogging tolerance by producing aerial roots at the collar region. Crop is sensitive to moisture deficit stress and needs protective irrigation for good growth and yield. No irrigation is required if the crop is grown under rainfed conditions and receives evenly distributed rain. When the crop is cultivated in winter, irrigation is a must. Irrigation intervals of 6-8 days in shallow basaltic soils and 10 days in the case of black soils may be followed. The chia crop needs 300-350 mm of irrigation. First irrigation should be given just after sowing, followed by the 6^{th} day of sowing. After 3^{rd} irrigation, watering may be withheld for 15 days to encourage deep rooting, which helps with stress tolerance. The crop can be irrigated by flood or drip irrigation (Fig 10). Drip irrigation saves water and provides good crop growth and yield. Under the drip irrigation method, in medium black soils a 4-5 day irrigation interval may be followed depending on the evaporation. In total, 8-9 irrigations are required to complete the crop cycle. Irrigation of the chia crop at 60% ETo and foliar application of 0.5% KNO_3 twice at 30 and 45 DAS can save 40% of irrigation water in chia cultivation (Harisha et al., 2023).

Figure 10: Field installed with drip irrigation for cultivation of chia

Nutrient management

Chia requires balanced nutrition and may be supplied via manures and fertilizers to maintain optimum growth and yield. The crop responds very quickly to applied nutrients through chemical fertilizers. Poor nutrition leads to inferior growth and small spikes. Therefore, applying organic manure in resource-poor soil well before sowing is mandatory. Generally, blanket application of well decomposed organic manure or FYM at 10 t/ha during field preparation is recommended. A nutrient dose of 90:60:75 kg of N, P_2O_5 and K_2O per hectare may be applied. At the time of sowing, a basal dose of 45 kg N and 60 and 75 kg of P_2O_5 and K_2O respectively may be applied either by seed cum fertilizer drill or manually. Non-application of the basal dose of fertilizers in poor fertile soil leads to poor initial crop vigour, thereby reducing the growth and biomass production (Fig. 11). Apart from 50% basal N, the remaining 50% nitrogen may be applied in two equal splits one at 30 and the other at 45 DAS. Fertilizers are applied at the base of the plant, leaving 5 cm from the stem and light mixing of the soil is required to reduce the loss of N. If drip irrigation is adopted water-soluble fertilizers may be used and applied through irrigation water. The details of fertilizer calculation are provided below (Table 3).

Without Nutrients

With Nutrients (90:60:75 kg N, P_2O_5 and K_2O/ ha)

Figure 11: Chia crop without nutrition and with nutrition at 45 days after sowing

Table 3: Various possible fertilizers combinations for chia crop

Fertilizers-1	**Kg/ ha**	**Fertilizers-2**	**Kg/ ha**
Urea	195	DAP	130
SSP	375	Urea	145
MOP	125	MOP	125

Fertilizers-3		**Fertilizers-4**	
Amm. sulphate	428	20:20:0	300
SSP	375	Urea	65
MOP	125	MOP	125

Weeding and thinning

Overcrowding of plants leads to elongated growth and thin seedlings, which gives a poor yield. Therefore, having an optimum plant population is ideal. Crop requires thinning 2-3 times, depending upon the seed rate and sowing efficiency. First thinning should be done 15-20 days after sowing along with the weeding operation. The 2nd thinning at 30 DAS and 3rd after one week of 2nd thinning is sufficient for an optimal plant population.

The crop requires weed-free conditions for good growth. Early season sowing during August requires weed free environment for 30-45 DAS as it is fast growing during the initial phase. Subsequently, high ground cover smothers the weeds. Weeding is necessary for up to 60 DAS in late-sown crops. Generally, depending on soil type, two weedings are required to harvest a good yield. First, weeding is done with a small hoe-like implement to break the crust and remove the weeds at 15-20 DAS, and second, weeding may be done manually between 30 and 45 DAS.

Intercropping

Most of the Indian farmers are small and marginal landholders who cultivate crops, vegetables, and other commercial crops to meet their food and economic needs. In that situation, intercropping is one of the best ways to introduce new industrial crops, such as chia, into existing cropping patterns to increase the productivity of small and marginal farms. Intercropping aims to cultivate two or more crops on the same land simultaneously. During the initial growth stage, most of the land space remains vacant and more evaporation occurs due to land exposure. Thus, the early stage of the crop can be utilized for growing short-duration (30-45 days) leafy vegetable crops like coriander, dill, amaranthus, spinach, radish and fenugreek. Therefore, intercropping of leafy vegetables with chia can increase the productivity of small landholdings while satisfying the diversified demands of consumers, farmers, and industries.

Several short-duration vegetables such as coriander, fenugreek, dill, amaranthus, radish and spinach were studied for the suitability of intercropping in chia. The main crop was sown at 60cm distance and the intercrops (leafy vegetables) were sown between two main crop lines at a spacing of 30cm between rows (1:2 row proportion). It was observed that growing fenugreek as an intercrop with chia (Fig. 12A) realized a net income of Rs. 75,188 ha^{-1} and Rs. 1,07,246 under 50% deficit irrigation and 100% ET_0 based irrigation, respectively, as compared to chia monocrop (Rs. 53,000/ha and Rs. 75,213/ha under 50% ET_0 and 100% ET_0 respectively). Apart from fenugreek, intercropping of coriander (Fig 12A) and dill (Fig.13) was also proved economical compared to chia monocrop and intercropping with radish and spinach (Harisha et al., 2024).

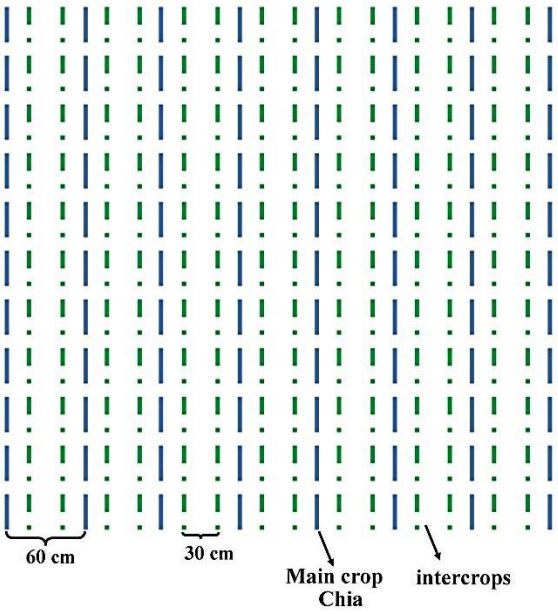


Figure 12: Arrangement of main crop (chia) and intercrop (leafy vegetables)

Figure 12A: General view of intercrops in 1:2 ratio; chia+fenugreek and chia+coriander at 30 DAS

Figure 13: General view of intercrops in 1:2 ratio chia +dill and chia + spinach at 30 DAS

Pollination

Chia bears beautiful white and blue flowers rich in nectar and pollen. Even though flowers are devoid of scent, huge pollinators like honey bees, flies, carpenter bees, and butterflies (Fig 14) visit the flowers for foraging. Among the various insect visitors, honey bees are major pollinators. *Apis dorsata* (Rock bee) visits throughout the day and *Apis florea* visits in cooler months, especially from October to January. In the early season crop, butterflies, *A. dorsata* and carpenter bees visit in large numbers. This enhances the pollination in chia and helps to set better seeds and complete the crop cycle early due to efficient pollination. Even though the quantity of nectar collected and the economics of pollinators in chia are unknown, this could be a possible way to enhance the crop yield and an additional source of income. Growing the crop in open conditions may enhance the anemophily in the crop, leading to better fruit set.

Carpenter bee *Apis dorsata* *Apis florea* Hover fly

Figure 14: Presence of different pollinators on chia plant

Pest and diseases

The chia crop is comparatively tolerant to pests and diseases. However, a few insect pests like Bihar hairy caterpillar (BHC) and aphids (Fig 15), can be observed during the cropping season. BHC sporadically appears in the field by colonizing leaves and

feeding on them. Severe defoliation may occur if the pest is not controlled at the proper stage. This can be easily managed by removing the young larval mass and the entire plant. Spraying neem oil with 1% solution gives reasonable control.

Aphids are seen on inflorescence and they suck the sap from inflorescence during winter months. An early sown crop escapes from the aphid infestation. The October-December sown crop may be infected with aphids. Due sucking of sap, poor seed setting and chaffy seeds may be seen. To manage aphids in chia, fipronil 5% SC or Imidacloprid 18% SL @ 0.3ml l^{-1} can be sprayed at the flowering stage twice at 15 day intervals. Reducing excessive irrigation will reduce the colonization and yield loss.

Figure 15: Chia plants infested with BHC and aphids

Harvesting

The maturity of chia crops varies with varieties, sowing time, and management practices to some extent. Because of the short-day nature, early sown (July or August) chia matures after 130 days. In contrast, delayed sowing in January leads to early maturity, 60-70 days after sowing. Most of the time, sowing is done between September and October and the crop matures within 95-110 days as weather and short day conditions during the period favours early flowering and maturity. The crop maturity can be identified when the plants turn yellow, the inflorescence shows partially dried spikes, and some remain yellow (fig 16). The crop is harvested by pulling the entire plant or cutting the stem from the base with a sickle. The harvested crop can be left in the field for drying in open conditions for 4-5 days. Once the harvested material is dried, it can be heaped and shifted to the threshing floor for threshing.

Figure 16: Crop at maturity and ready for harvest

Threshing and winnowing

After drying in an open field, threshing is done by beating with sticks (Fig 17)and separated by winnowing. Mechanical threshing by tractor-operated thresher (Fig 17) with an appropriate sieve, suitable for threshing any minor millets, could be employed for quick and efficient threshing.

Figure 17: Manual and mechanical threshing of chia

Yield

Crop yield is complex and determined by various factors such as genotypes, climate, sowing methods, date, and management practices. Early sowings yield better, as good vegetative growth results in better production. As chia bears inflorescence on the end of branches, the yield is positively correlated with plant spread and the number of branches. Therefore, the more the plant spreads, the higher the number of spikes, resulting in higher seed yield. Among black and white seed types, the black seeded variety yields about 10% higher seed yield than white seeded chia variety. Depending on sowing time and management practices, an average seed yield of 400-850 kg/ha can be harvested. The

highest seed yield of 811 kg/ha can be obtained by sowing between 1st August and 1st September. Late sowing on 1st January or onwards results in a low yield of <200 kg/ha.

Post harvest value addition

Chia is rich in essential fatty acids, especially Polyunsaturated fatty acids (PUFA), fibre and protein. Therefore, proper value addition will enhance the availability of nutrients. Chia seeds can be used in various ways to have their benefits, either in whole seed form by soaking in water, extraction of oil and blending with other vegetable oils to balance the fatty acids ratio, use of chia seeds as whole in preparation of cookies, ice creams, curd, blending the chia seeds powder with wheat flour, grinding of chia powder with buttermilk.

Extraction of chia oil

Chia seeds are a rich source of oil. Chia seeds contain 30-35% oil. To extract the oil, the seeds should be dried to a moisture content of 8-10%. The oil can be extracted by mechanical expeller or solvent extraction at an industrial level. Mechanical extractors suitable for tiny seed oil extraction can be used with or without heat (Fig 18). Upon extraction, 25% of oil recovery can be expected. FSSAI, 2023, has recently given quality standards for chia oil (Table 4 and 5).

Chia oil is oil extracted by mechanical expression without the application of any heat. It should be clear without any suspended materials, moisture-free, and free from argemone seed oil.

Table 4: Quality parameters of chia seed oil safe for consumption (FSSAI, 2023)

S.No.	Parameters of oils/fat	Permissible Limits
1	Refractive index at 40°C	1.470 – 1.480
2	Saponification value	185-199
3	Iodine value	Not less than 180
4	Acid Value	Not more than 2.0mg KOH/g Oil
5	Unsaponifiable matter	Not more than 1.5%

Table 5: fatty acid composition permissible limit in chia seed oil

Fatty acid	Chia oil composition
C14:0	0.1 Max
C16:0	6-8

C16:1	0.5 max
C18:0	3-4.5
C18:1	6-9
C18:2	17-22
C18:3	58-65
C20:0	0.5 max
C22:0	0.2 max

After oil extraction, chia cake is obtained (Fig 19), which can be a good source of fibre and protein. The cake can be used to prepare various food items like cookies, groundnut chia cake energy bars, chia cake blended protein. The cake is also viable for animal, fish and poultry feed.

Figure 18: Mini table top oil extraction machine for chia oil extrcation

Chia seed oil Chia seed cake

Figure 19: Chia seed oil and oil cake after extraction from mini table top oil extraction machine

Economics of chia cultivation

Cultivation of chia involves minimal resources and field operations as compared to commercial vegetables and other field crops. However, the detailed cost of inputs prevailed in the market during 2023 was considered for calculating the cost of cultivation of chia (Table 6).

Cost of cultivation

Table 6: Details of the cost and BC ratio of chia cultivation.

Operations	**Cost (Rs./ha)**
Field preparation-Sowing (deep plough and harrow)	4000
Drip layout (repair and labour)	2000
Fertilizers (Urea: DAP: MOP)	5183
Seed 2.5 kg	375
Irrigation cost (4 irrigations)	4000
Weeding and intercultural operations	6000
Harvesting and threshing	8500
Land cost	3000
Drip irrigation cost (over 8 years)	10100
Marketing	2000
Other	3500
Cost on money invested @7% interest	2679
Total COC (Rs/ha)	**47,337/-**

Returns and BC ratio

Seed yield	817 kg/ha
Price of produce (seed)	Rs. 150/kg
Gross returns	Rs. 1,22,550/ha
Cost of cultivation	Rs. 47,337/ha
Net returns	Rs. 75,213/ha
B:C ratio	1:2.58

Future prospective

Chia is a valuable and nutrient rich commodity. There is huge scope for research and development to utilize its full benefits. With the growing demand, India can be a major producer and exporter of chia globally. To achieve this, a few aspects need to be looked into. The important future needs are mentioned below

- Expansion of area under chia cultivation with proper monitoring to get better production in suitable areas
- Crop improvement is required to develop genetic variability for maturity, seed characters, high seed and oil yield, and oil quality.
- Development and identification of photo-insensitive genotypes to cultivate in all locations and throughout the year.
- Development of proper value-added products to have the benefits of chia
- Regular monitoring of the emerging pests and diseases in the crop
- Seed standards for chia to avoid admixture and maintain genetic purity

Frequently asked questions

1. **Nutritional benefits of chia**

   Chia is a rich source of dietary fibre (30-35%) and protein (17-20%) and fat rich in Omega 3 (55% in oil)

2. **How do you consume chia?**
   - Chia can be consumed in various ways, like whole seeds soaked overnight or soaked seeds mixed with fruit juice, buttermilk, lemon water etc.
   - Chia seeds are ground with dry fruits or made into smoothies.
   - Chia seed oil can be used to dress salads and veggies in limited quantities.
   - It is also blended with other vegetable oils like groundnut, palm oil, sunflower, soybean, and safflower at the proportion of 10-15% to bring an ideal ratio of 1:1.5:1 of saturated, monounsaturated and polyunsaturated fatty acids, respectively.
3. **Why to grow Chia?**
   - Chia is a good food supplement for reducing weight, improving gut health, and reducing cardiovascular diseases.
   - Chia is a high-demanding crop in the market and easy to cultivate.

- Chia can be grown on poor, shallow basaltic soils
- It is a long-lasting crop that grows quickly without pests and diseases.

4. **What climate is best suited for chia**

   A cool and humid climate with a diurnal temperature difference of 8-10℃, average rainfall of 300-350 mm and relative humidity of 75-80% is most suitable for cultivation.

5. **Which is the best season to grow chia**

   August to September is the best time for optimum growth and a high seed yield. Sowing before July and later in December should be avoided.

6. **Is chia crop drought tolerant?**

   Chia is a short-duration crop and hence requires less water. In dry areas with low relative humidity, crops quickly show wilting symptoms.

7. **Are there any varieties of chia?**

   No commercial varieties are available in chia, but morphotypes such as white and black seeds are widely cultivated.

8. **What is the optimum plant spacing and nutrient dose for chia?**

   - Chia requires wide spacing if sown in the early season (60 × 30 cm); in other seasons, 50 × 30 cm is ideal.
   - A nutrient dose of 90:60:75 kg N, P_2O_5 and K_2O per ha is ideal.

9. **Are there any pests and diseases that affect the chia crop**

   No pests and diseases are seen in chia, but sometimes caterpillars and aphids may be seen.

10. **What are the maturity indices for chia?**

    Chia can be harvested when the crop turns yellow and primary inflorescence starts drying.

11. **Where to sell chia seeds**

    Chia seeds are sold to retailers or wholesalers on a demand basis with a prior purchase contract. No market is officially procuring chia seeds due to a new crop in India. However, Neemuch in Madhya Pradesh is the best place to sell the seeds.

Table 7: Summary of cultivation practices

S. No.	Operations	Brief description
01	Variety	Black and white seed types
02	Soil	Light soils with neutral pH, sensitive to saline soil and saline irrigation water. Cultivation in heavy soils should be avoided
03	Climate	Crop requires the following weather during the cropping period. Humid climate (mean RH of 70-75%), well distributed rainfall of 300-350 mm, cool season, mean Temp of 28-35°C, diurnal Temperature difference of 8-10°C.
04	Field preparation	Fine tilth, ridges and furrow or flat bed method
05	Sowing method	Line sowing or broadcasting by mixing seed with sand 1:10 ratio, seeds placed uniformly to ensure even distribution
	Sowing window	1st August to 15th Septemebr in low rainfall areas
06	Spacing	60 × 30cm for July-September sowing 50×30 cm for October onwards sowing
07	Seed rate	Seed rate 2-3.0kg/ha Line sowing: 2.0 kg/ha Broadcasting: 2.5-3 kg/ha
08	Nutrients	FYM: 10 t/ha 90:60:75 kg N P_2O_5, K_2O per ha 50% N in two splits at 30 and 45 DAS
09	Irrigation	300-350 mm of water in 6-8 irrigations
10	Thinning and Weeding	Thinning can be done at 15-30 DAS or during the first weeding to maintain uniform spacing. Two to three manual weeding depending on weed intensity at 15 and 45DAS

11	Pests and diseases	Aphids and Bihar hairy caterpillar can be controlled by the removal of infected plants in the early stages and spraying of neem oil.
12	Crop maturity	Early sowing: 130-150 days Late sowing: 90-110 days
13	Harvesting method	Harvesting when spikes turn yellow (100-110 days), cutting the plants from the base and drying in the open field for 5-6 days before threshing
14	Threshing	Threshing manually by beating or by tractor operated multicrop thresher
15	Yield	Seed yield of 400-850kg/ha

References

- Ayerza R. and Coates W. 2011, Protein content, oil content and fatty acid profiles as potential criteria to determine the origin of commercially grown chia (*Salvia hispanica* L.). Ind. Crop. Prod., 34:1366-1371.
- Baginsky C, Arenas J, Escobar H, Garrido M, Valero N, Tello D, Pizarro L, Valenzuela A, Morales L, and Silva H. 2016, Growth and yield of chia (*Salvia hispanica* L.) in the Mediterranean and desert climates of Chile. Chilean J. Agric. Res., 76(3): 255–264.
- Cahill JP and Provance MC. 2002, Genetics of qualitative traits in domesticated chia (*Salvia hispanica* L.). J. Hered., **93**(1):52–55.
- Chia market insights, 2025. https://www.futuremarketinsights.com/reports/chia-seed-market accessed on 22 April 2025.
- Felisberto MHF, Galvão MTEL, Picone CSF, Cunha RL, Pollonio MAR. 2015. Effect of prebiotic ingredients on the rheological properties and microstructure of reduced-sodium and low-fat meat emulsions. LWT - Food Science and Technology 60:148155 DOI 10.1016/j.lwt.2014.08.004.
- Fernandes SS, Romani, VP, da Silva Filipini G, Martins VG. 2020. Chia seeds to develop new biodegradable polymers for food packaging: Properties and biodegradability. Polym. Eng. Sci., 60, 2214–2223.
- Harisha CB, Boraiah KM, Basavaraj PS, Halli HM, Singh RN, Rane J, Reddy KS, Halagundegowda GR, Chaudhary A, Verma AK, Ravi Y, Asangi H, Senthamil E. 2025. Optimizing sowing time and weather conditions for enhanced growth and seed yield of chia *(Salvia hispanica* L.) in semi-arid regions, Peerj, 13:e19210 http://doi.org/10.7717/peerj.19210
- Harisha CB, Rane J, Halagunde Gowda GR, Chavan SB, Chaudhary A, Verma AK, Ravi Y, Asangi H, Halli HM, Boraiah KM, Basavaraj PS, Kumar P, Sammi Reddy K, 2024. Effect of Deficit Irrigation and Intercrop Competition on Productivity, Water Use Efficiency and Oil Quality of Chia in Semi-Arid Regions. Horticulturae 2024, 10, 101. Doi:10.3390/horticulturae10010101.
- Harisha CB, Narayanpur VB, Rane J, Ganiger VM, Prasanna SM, Vishwanath YC, Reddi SG, Halli HM, Boraiah KM, Basavaraj PS et al. 2023. Promising Bioregulators for Higher Water Productivity and Oil Quality of Chia under Deficit Irrigation in Semiarid Regions. Plants 2023, 12, 662.https://doi.org/10.3390/plants12030662.

- Harisha CB, Basavaraj PS, Boraiah KM, Rane J and Halli HM. 2023. Optimization of rapid nursery raising and field establishment protocol in chia (*Salvia hispanica* L.) Vegetos 36 (4), 1418–426. https://doi.org/10.1007/s42535-022-00531-y.
- Ixtaina VY, Martinez ML, Spotorno V, Mateo CM, Maestri DM and Diehl BWK, 2011, Characterization of chia seed oils obtained by pressing and solvent extraction. J. Food Compos. Anal., 24:166-174.
- Jin F, Nieman DC, Sha W, Xie G, Qiu Y, Jia W. 2012. Supplementation of milled chia seeds increases plasma ALA and EPA in postmenopausal women. Plant Foods Hum. Nutr. 67: 105–110.
- Mansuri S, Kesharwani P, Jain K, Tekade RK, Jain NK. 2016. Mucoadhesion: A promising approach in drug delivery system. React. Funct. Polym. 100: 151–172.
- Migliavacca RA, Silva TRB, Vasconcelos ALS, Mourao Filho W, Baptistella, JLC. 2014. Chia's cultivation in Brazil: future and perspectives. J. Agron. Sci., 3:161–179.
- USDA National Nutrient Database for Standard Reference, Release 28. 2018. Available online: http://www.ars.usda.gov/ba/bhnrc/ndl (accessed on 3 May 2019).
- Chia oil, 2023, FSSAI food product standards, Fats aoils and fat emulsions, Chapter 2. https://www.fssai.gov.in/upload/uploadfiles/files/Chapter%202_2_Fats_oil_fat%20emulsions.pdf (Accessed on 30 April 2025).

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