Economics of chia (Salvia hispanica) cultivation as influenced by foliar application of different elicitors

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Abstract
Chia is an important super food crop with lot of medicinal value getting more popularity in recent days because of heart healthy omega-3 fatty acid content. The cultivation of chia in India was started by few farmers near Mysuru which is a finger millet growing area and now the cultivation has spread to other parts of the state and also neighboring states due to high returns than the traditional crops. For production of residue free quality chia seeds, elicitation may be a promising strategy which also saves the cost of chemicals by strengthening the defense system in plants. The present investigation on economics of chia cultivation revealed that the highest gross returns (Rs. 2,06,301 and Rs. 2,00,541), net returns (Rs. 1,58,588 and Rs. 1,53,064) and B: C ratio (4.32 and 4.22) was obtained from plants sprayed with foliar spray of chitosan at 200 ppm and potassium silicate at 100 ppm in black while chia respectively.

Keywords: Chia, elicitor, chitosan, potassium silicate

Introduction
Chia (Salvia hispanica) a new introduction to India from Mexico introduced by Central Food Technological Research Institute, (CFTRI) Mysuru and initially grown by farmers in few areas near Mysuru and presently the cultivation has spread to other areas of Karnataka and also to the neighboring states. There are two types, viz. black seeded with some mottling and white seeded. The white type is priced at a premium as it blends well with Indian food products. CFTRI has developed chia-blended products such as ice creams, chocolates and jams, which are being commercialized by various companies (Anonymous, 2016) [1]. Generally for chia, the cultivation costs are around 15,000/acre, which is similar to other traditional cereal crops like finger millet and maize. The average yield of chia is 500-600 kg seed/acre (Cahill, 2003) [2] but under appropriate agronomic conditions the yield of 2120 kg/hectare has also been reported (Ayerza and Coates, 2005) [3]. The increased awareness about functional food had created more demand for the chia seeds in market globally. Short duration (90-105 days), lower cultivation costs coupled with less water demand, largely untouched by pests, diseases, animals and high returns are the primary reasons for its acceptance among Indian farmers. Since it is a new crop, the information on agronomic practices is meager and the technologies with less use of fertilizers and plant protection chemicals are much needed since the demand is more for the seeds produced without any chemicals usage.

The elicitors are the substances which induce physiological changes in the plant. Application of these elicitors activates an array of mechanisms by creating stress to plants similar to the defense responses to pathogen infections or environmental stimuli which affects the plant metabolism and enhances the synthesis of phytochemicals (Baenas et al., 2014) [4]. These phytochemicals fight against external invaders and strengthen the plant defense system by avoiding pest and disease infestation (Garcia-Brugger et al., 2006) [5]. Since the chia is a new crop to India and the infestation by pest and diseases are less for now, but, as the cultivation of chia progresses new pest and diseases may emerge and therefore, elicitation may be a promising strategy to get higher yield with quality seeds and also to avoid use of plant protection chemicals to produce residue free food. These elicitors are also cost effective and reduce the overall cultivation cost by reducing use of chemicals.

Material and Methods
The study was carried out in randomized complete block design with 11 treatments and 3
replications for both black and white chia at Department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, University of Horticultural Sciences campus, Gandhi Krishi Vignana Kendra, Bengaluru during rabi season of 2018-19 and 2019-20. The chia seeds were procured from Raitha Mithra farmer producer organization via CFTRI, Mysuru. The seeds were sowed on 26th November, 2018 in the first season and on 28th October in the second season. The spacing followed was 60cm between the rows and 45 cm between the plants. The plots were watered immediately after sowing and the irrigation was given at alternate days through drip (discharge capacity - 2 liters/hour) for one hour throughout the cropping period. The fertilizers are applied based on recommendation of the study conducted by Mary et al., 2018.

The elicitors treatment was done twice at 25 and 50 days after sowing through foliar spray. The various treatments includes T1: Chitosan 200 ppm, T2: Salicylic acid 100 ppm, T3: Dry yeast 5000 ppm, T4: Methyl jasmonic acid 100 ppm, T5: Potassium silicate 100 ppm, T6: Gibberellic acid 100 ppm, T7: Kinetin 100 ppm, T8: Humic acid 200 ppm, T9: Boric acid 200 ppm, T10: Plant growth promoting rhizobacteria (PGPR) 5000 ppm and T11: Control. The chitosan was added to distilled water three days prior to application for complete solubilization. Similarly dry yeast was added to distilled water five days prior to application for the multiplication of beneficial microbes. The PGPR consortia contain Azospirillum, P-solubilizer (Bacillus megaterium) and Pseudomonas fluorescens in the proportion of 1:1:1.

The harvesting was done based on the maturity and the spikes were separated and dried. Threshing of seeds was done by beating the spikes placed in a tarpaulin with sticks gently. The threshed seeds were winnowed in air, cleaned and packed in a gunny bags.

Cost of cultivation

The cost incurred towards inputs and farm labours charges that were prevailed during the study period in Bengaluru region are considered while computed per hectare cultivation cost and presented in Table 1. The quantity of elicitors used and their respective cost are presented in Table 2. While, the total cost of cultivation (in rupees) incurred towards cultivation of black and white chia are presented in Table 3 and Table 4.

Gross returns and net returns

Gross income was calculated based on the market price of seeds prevailed at the time of harvest i.e., rupees 160 per kg which was offered by the food industry NutriPlanet to the farmer (Rs. 160 kg⁻¹) in an MOU signed between University of Horticultural Sciences, Bagalkot. The net income per hectare was calculated by subtracting total costs from the gross income.

Benefit: Cost ratio (B: C ratio)

The benefit cost ratio was worked out by using the following formulae.

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\text{Benefit : Cost ratio} = \frac{\text{Gross income (Rs. ha}^{-1})}{\text{Total cost (Rs. ha}^{-1})} 
\]

Table 1: Cost of inputs and labour used for raising chia for one hectare

| Particulars                        | Quantity per ha | Rate (Rs/unit) | Cost (Rs.) |
|------------------------------------|-----------------|----------------|------------|
| Land preparation (Tractor)         | 8 hours         | Rs 600/hour    | 4,800      |
| FYM                                | 10 t/ha         | Rs 1850/t      | 18,850     |
| Seeds                              | 250 g/ha        | Rs 500/kg      | 125        |
| Fertilizers (40:20:20 kg NPK/ha)   |                 |                |            |
| Urea                               | 195 kg          | Rs 6.4/kg      | 1,248      |
| SSP                                | 375 kg          | Rs 8.4/kg      | 3,150      |
| MOP                                | 125 kg          | Rs 16/kg       | 2,000      |
| Sowing                             | 5 labours       | Rs 275/labour  | 1,375      |
| Weeding                            | 15 labours      | Rs 275/labour  | 4,125      |
| Plant protection chemicals:        |                 |                |            |
| Carbendazim                        | 0.5 kg          | Rs 1340/kg     | 670        |
| Chloropyriphon 20 EC               | 500 ml          | Rs 600/L       | 300        |
| Application of plant protection chemicals | 2 labours  | Rs 275/labour  | 550        |
| Harvesting and processing          | 30 labours      | Rs 275/labour  | 8,250      |
| Packaging material                 | 50 gunny bags   | Rs 20/bag      | 1,000      |
| Miscellaneous                      |                 | Rs 1500       | 1,500      |
| Total                              |                 |                | 47,943     |

Table 2: Quantity required and cost of elicitors used per ha

| Particulars        | Quantity required (g or kg) | Rate (Rs / g or ml) | Total cost (Rs.) |
|--------------------|----------------------------|---------------------|------------------|
| Chitosan 200 ppm   | 266.4 g                    | 0.60                | 160              |
| Salicylic acid 100 ppm | 40 g          | 1.2 Rs/g            | 48               |
| Dry yeast 5000 ppm | 2 kg                       | 3668 Rs/kg          | 7,336            |
| Methyl jasmonic acid 100 ppm | 42 ml     | 780                 | 32,760           |
| Potassium silicate 100 ppm  | 117.6 ml   | 0.35 Rs/l           | 42               |
| GA: 100 ppm        | 40 g                       | 180 Rs/g            | 7,200            |
| Kinetin 100 ppm    | 40 g                       | 566.6 Rs/g          | 22,656           |
| Humic acid 200 ppm | 88 g                       | 0.30 Rs/g           | 26               |
| Boric acid         | 80 g                       | 0.90 Rs/g           | 72               |
| PGPR 5000 ppm      | 6 kg                       | 0.15 Rs/kg          | 900              |

Note: Spray solution required for one ha is 200 and 600 litres per hectare at 25 and 50 days after sowing respectively.
Table 3: Cost of cultivation of black chia as influenced by different elicitors (Rs/ha)

| Treatments | FYM | Land preparation | Seeds | Sowing | Fertilizers | Elicitors | Weeding | Plant protection | Harvesting and processing | Packaging material | Miscellaneous | Total (Rs/ha) |
|------------|-----|------------------|-------|--------|-------------|-----------|---------|-----------------|--------------------------|-----------------|---------------|--------------|
| T1         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 160       | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 47,553       |
| T2         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 48        | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 47,445       |
| T3         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 7,336     | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 54,729       |
| T4         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 32,760    | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 80,153       |
| T5         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 42        | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 47,435       |
| T6         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 72        | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 47,465       |
| T7         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 22,656    | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 48,293       |
| T8         | 18,850 | 4,800           | 125   | 1,375  | 6,998       | 900       | 4,125   | 970             | 8,250                    | 1,000           | 1,500         | 47,393       |

Results and Discussion

In black chia, the perusal of data (Table 5) indicates that the cost of cultivation as affected by different elicitor treatments was maximum (Rs. 1,12,913) towards the application of methyl jasmonate 100 ppm followed by kinetin 100 ppm treatment (Rs. 92,705). While, the least expenditure was incurred in control (Rs. 47,393) followed by humic acid (Rs. 47,445), potassium silicate (Rs. 47,477), salicylic acid (Rs. 47,489), boric acid (Rs. 47,493), gibberellic acid (Rs. 47,495), and humic acid (Rs. 47,497). The B: C ratio also was maximum (3.98) towards the application of methyl jasmonate 100 ppm followed by dry yeast (1.78). The net returns were also highest from chitosan (Rs. 1,58,419) followed by dry yeast (Rs. 1,42,298), boric acid (Rs. 1,41,855) and humic acid (Rs. 1,41,430). The B: C ratio also was more in chitosan (4.32) followed by boric acid (3.98), humic acid (3.98) and salicylic acid (3.76) while the least B: C ratio was observed in methyl jasmonic acid (1.65) and kinetin (1.78).

Table 5: Economics of black chia as influenced by elicitors application

| Treatments | Cost of cultivation (Rs ha⁻¹) | Gross returns (Rs ha⁻¹) | Net returns (Rs ha⁻¹) | B:C ratio |
|------------|-------------------------------|-------------------------|-----------------------|-----------|
| T1: Chitosan 200 ppm | 47,713 | 2,06,301 | 1,38,588 | 4.32 |
| T2: Salicylic acid 100 ppm | 47,489 | 1,78,726 | 1,05,377 | 3.76 |
| T3: Dry yeast 500 ppm | 62,065 | 2,04,363 | 1,42,298 | 3.29 |
| T4: Methyl Jasmonic acid 100 ppm | 112,913 | 1,86,611 | 1,31,237 | 1.74 |
| T5: Potassium silicate 100 ppm | 47,477 | 1,66,592 | 1,19,115 | 1.65 |
| T6: Gibberellic acid 100 ppm | 61,793 | 1,64,419 | 1,02,626 | 2.66 |
| T7: Kinetic 100 ppm | 92,705 | 1,65,454 | 72,749 | 1.78 |
| T8: Humic acid 200 ppm | 47,445 | 1,88,875 | 1,41,430 | 3.98 |
| T9: Boric acid 200 ppm | 47,537 | 1,89,372 | 1,41,855 | 3.98 |
| T10: PGPR 5000 ppm | 49,193 | 1,79,746 | 1,30,553 | 3.65 |
| T11: Control | 47,393 | 1,74,195 | 1,26,802 | 3.68 |

Similarly for white chia cultivation also, the cost incurred was maximum (Rs. 1,12,913) towards methyl jasmonate at 100 ppm treatment followed by kinetin 100 ppm (Rs. 92,705), treatment followed by dry yeast (Rs. 2,04,363) and the least returns(Rs. 1,64,419) was seen in case of gibberellic acid. The net returns was also highest from chitosan (Rs. 1,58,588) followed by dry yeast (Rs. 1,42,298), boric acid (Rs. 1,41,855) and humic acid (Rs. 1,41,430), The B: C ratio also was more in chitosan (4.32) followed by boric acid (3.98), humic acid (3.98) and salicylic acid (3.76) while the least B: C ratio was observed in methyl jasmonic acid (1.65) and kinetin (1.78).
Maximum gross returns of rupees 2,00,541 was obtained from potassium silicate applied plots followed by boric acid (Rs. 1,85,048), methyl jasmonic acid (Rs. 1,84,414), dry yeast (Rs. 1,82,875) and PGPR (Rs. 1,80,581) treated plots. The net returns was also more from potassium silicate (Rs. 1,53,064) treated plots followed by boric acid (Rs. 1,37,511), PGPR (Rs. 1,31,388), chitosan (Rs. 1,29,060) and humic acid (Rs. 1,25,793).

| Treatments               | Cost of cultivation (Rs ha⁻¹) | Gross returns (Rs ha⁻¹) | Net returns (Rs ha⁻¹) | B:C ratio |
|--------------------------|-------------------------------|-------------------------|-----------------------|-----------|
| Ti: Chitosan 200 ppm     | 47,713                        | 1,76,773                | 1,29,060              | 3.70      |
| T2: Salicylic acid 100 ppm | 47,489                        | 1,66,573                | 1,19,084              | 3.51      |
| T3: Dry yeast 5000 ppm   | 62,065                        | 1,84,414                | 71,501                | 1.63      |
| T4: Methyl Jasmonic acid 100 ppm | 1,12,913                    | 2,00,541                | 1,53,064              | 4.22      |
| T5: Potassium silicate 100 ppm | 47,477                        | 61,793                  | 97,652                | 2.58      |
| T6: Gibberellic acid 100 ppm | 92,705                        | 1,73,218                | 80,513                | 1.87      |
| T7: Kinetin 100 ppm      | 47,445                        | 1,73,238                | 1,25,793              | 3.65      |
| T8: Humic acid 200 ppm   | 49,193                        | 1,80,581                | 1,31,388              | 3.67      |
| To: PGPR 5000 ppm        | 47,937                        | 1,85,048                | 1,37,511              | 3.89      |
| T11: Control             | 47,393                        | 1,61,219                | 1,13,826              | 3.40      |

Maximum cultivation cost associated with the high cost of chemicals in methyl jasmonic acid and kinetin treatments which also resulted in least B: C ratio (Figure 1). Similar results were reported in black cumin where negative B: C ration was found in methyl jasmonic acid treatment due to its high cost (Arpitha, 2019) [2]. Similarly Anil et al. (2021) reported high cultivation cost in kinetin treatment even he used it in small concentration (25 ppm). The low returns in GA3 treatment was due less seed yield (data not presented). Whereas, the increased gross returns, net returns and B: C ratio in chitosan (100 ppm) sprayed plants in black chia may be attributed to higher seed yield (1289.38 kg ha⁻¹) coupled with lower cultivation costs and zero infestation of pest and diseases (data not presented) compared to all other treatments. Spraying of potassium silicate at 100 ppm to white chia plants resulted in getting 1.25 times higher yield than of control in white chia and the cost incurred toward cultivation was also least i.e. only 84 more rupees than control. Hence, the B: C ratio, gross returns and net returns computed per hectare was 2.26, 1.26 and 2.14 times greater than kinetin, GA3 and methyl jasmonic acid treatment respectively.

**Fig 1:** Benefit: Cost ratio of black and white chia as affected by different elicitor application

**Conclusion**

The cost incurred towards the cultivation of black chia was maximum for methyl jasmonic acid at 100 ppm and kinetin at 100 ppm sprayed plants in both black and white chia. Whereas, the highest gross returns, net returns and B: C ratio was obtained from plants treated with chitosan at 200 ppm and potassium silicate at 100 ppm treatment in black and white chia respectively. Hence, foliar spraying of chitosan at 200 ppm for black chia and potassium silicate at 100 ppm for white chia at 25 and 50 DAS can be recommended for
commercial cultivation for getting maximum yield coupled with superior quality seed and higher returns.

References
1. Anonymous. Annual report (2015-16), CSIR - Central Food Technological Research Institute, Mysore, Karnataka 2016.
2. Arpitha HS. Studies on varietal performance and effect of elicitors on growth, yield and quality of black cumin (Nigella sativa L.). M.Sc. (Hort.) Thesis: Uni. Hort. Sci., Bagalkot, (India) 2019.
3. Ayerza R, Coates W. Chia: Rediscovering a forgotten crop of the Aztecs. University of Arizona Press 2005.
4. Baenas N, Garcia-Viguera C, Moreno DA. Elicitation: A tool for enriching the bioactive composition of foods. Molecules 2014;19:13541-13563.
5. Cahill JP. Ethno-botany of chia, Salvia hispanica L. (Lamiaceae). Econ. Bot 2003;57(4):604-618.
6. Garcia-Brugger A, Lamotte O, Vandelle E, Bourque S, Lecourieux D, Poisso B et al. Early signaling events induced by elicitors of plant defenses. Mol. Plant Microbe. Interact 2006;19:711-724.
7. Mary J, Veeranna HK, Girijesh GK, Dhananjaya BC, Gangaprasad S. Effect of different spacings and fertilizer levels on growth parameters and yield of chia (Salvia hispanica L.). Int. J. Pure Appl. Biosci. 2018;6:259-263.
8. Kumar AGS, Umesha K, Basavaraj G, Halesh GK. Economics of black cumin (Nigella sativa L.) cultivation as influenced by different elicitors and manual pinching under Bangalore conditions 2021.