APPLICATION OF BIOSTIMULANT IN COMBINATION WITH MOISTURE CONSERVATION PRACTICE ON PARAMETERS OF BRINJAL (*Solanum melongena* L.) GROWTH, QUALITY AND YIELD

Thesis Submitted for the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

Vegetable Science

By

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2026

<u>DECLARATION</u>

I hereby declared that the presented work in the thesis entitled **"Application of biostimulant in combination with moisture conservation practice on parameters of brinjal (*Solanum melongena* L.) growth, quality and yield"** in fulfilment of degree of **Doctor of Philosophy (Ph.D.)** is outcome of research work carried out by me under the supervision of **Dr. Deven Verma,** working as **Assistant Professor** in the **Department of Horticulture**, **School of Agriculture** of Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE-I

This is to certify that the work reported in the Ph.D. thesis entitled **"Application of biostimulant in combination with moisture conservation practice on parameters of brinjal (*Solanum melongena* L.) growth, quality and yield"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the **Vegetable Science**, is a research work carried out by **Saloni Thakur**, (**12208553),** is bonafide record of her original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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CERTIFICATE-II

This is to certify that thesis entitled **"Application of biostimulant in combination with moisture conservation practice on parameters of brinjal (*Solanum melongena* L.) growth, quality and yield"** submitted by **Saloni Thakur (Registration Number 12208553)** to the Lovely Professional University, Phagwara in partial fulfilment of the requirements for the degree of **Doctor of Philosophy (Ph.D.)** in the discipline of **Vegetable Science** has been approved by the Advisory Committee after an oral examination of the student, conducted in collaboration with an External Examiner.

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ABSTRACT

The research entitled **"Application of biostimulant in combination with moisture conservation practice on parameters of brinjal (*solanum melongena* L.) growth, quality and yield"** was conducted at Agricultural Research Farm Department of Horticulture Science, Lovely Professional University, Punjab during 2023 – 2024. The experiment comprised of twelve treatments and arranged in Factorial Randomized Block Design (FRBD) with three replications. The Nishant hybrid (Advanta seeds India Pvt. Limited) variety was selected for evaluation. Brinjal's significant water and nutrient requirements make it vulnerable to water scarcity and seasonal fluctuations. Hydrogel improves soil moisture retention, minimizing the need for irrigation, while Arka Vegetable Special biostimulants promote plant growth and enhance stress tolerance. The combined use of both strategies seeks to optimize water management and plant health, manage major challenges in brinjal cultivation. In the study, the hydrogel was applied during the transplanting stage mixing into soil while Arka Vegetable Special was sprayed twice, with one and half month after transplanting and 15 days interval. The treatment designated as V, H was utilized where 'V' represents concentration in grams per litre and 'H' denotes application rate in kilograms per acre. This treatment is aimed at optimizing vegetative growth. Various levels of Arka Vegetable Special and hydrogel application were tested to observe their effects on growth, yield and quality characteristics. The treatments combination used were (V_0H_0) 0 g/L + 0 kg/acre, (V_0H_1) 0 g/L + 1.0 kg/acre, (V_0H_2) 0 g/L + 1.5 kg/acre, (V_0H_3) 0 g/L + 2.0 kg/acre, (V_1H_0) 2 g/L + 0 kg/acre, (V_1H_1) 2 g/L + 1.0 kg/acre, (V_1H_2) 2 g/L + 1.5 kg/acre, (V_1H_3) 2 g/L + 2.0 kg/acre, (V_2H_0) 5 g/L + 0 kg/acre, (V_2H_1) 5 g/L + 1.0 kg/acre, (V_2H_2) 5 g/L + 1.5 kg/acre, (V_2H_3) 5 g/L + 2.0 kg/acre. Significant findings were observed in positive responses towards application of 1.5 kg/acre (H_2), 5 g/L (V_2) and (V_2) 5 g/L and (H_2) 1.5 kg/acre resulted in increase in highest growth parameters i.e plant characters, leaf characters and fruit characters etc yield and quality parameters whereas, (H_0), (V_0) and (V_0) 0.0 g/L and (H_0) 0.0 kg/acre exhibited lowest values for almost all the above mentioned parameters. These findings emphasize the potential of biostimulants and hydrogel practices in promoting sustainable agricultural productivity contributing to the goal of improving food security. The use of Arka Vegetable Special and hydrogel at various levels notably enhanced all the growth characteristics examined. This indicates the potential of combining biostimulants and hydrogel practices to optimize brinjal production providing a sustainable approach to meet the year round demand for vegetables and address water scarcity issues in agricultural systems.

Keywords – Arka Vegetable Special, hydrogel, brinjal, growth, yield, quality

Signature of the Major Advisor **Signature of the student**

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I recognize that there may be others who have offered support in various ways, and I apologize if they are not explicitly mentioned here. Please know that your contributions are nonetheless appreciated.

SALONI THAKUR

Dedicated

To

My Beloved Parents

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LIST OF ABBREVIATIONS

Abbreviated Form	Full form
%	Percentage
/	Per
@	At the rate
et al	and other
cm	Centimeter
g	Gram
/ha	Per hectare
i.e.	That is
kg	Kilo gram
m	Meter
m^2	Meter square
mg	Milligram
mg/g	Milligram / gram
pH	Potential of hydrogen
q/ha	Quintal per hectare
FRBD	Factorial Randomized Block Design
T	Treatments
TSS	Total soluble solids
RDF	Recommended dose of fertilizer
FYM	Farmyard manure
VC	Vermicompost
N	Nitrogen
P	Phosphorous
K	Potassium
EC	Electrical conductivity
°B	Degree Brix
CD	Critical Difference
SE(m)	Standard error of means
DAT	Days after transplanting
t/acre	Tones per acre
IU	International unit
AVS	Arka Vegetable Special

CHAPTER 1

INTRODUCTION

Vegetables are major attributes in almost all of the Indian diets **(Boeing *et al.*, 2012)**. They also supply nourishment, minerals and anti oxidant. Therefore, enhancing production and after harvest mechanizations of vegetables would secure food availability, employment chances and better standard of life. In Punjab, vegetables have enhanced the maximum use of commodity and in demand with small scale farmers. The popularity and utilization is frequently raising northwest section. Hence, many small land holder farmers in both urban and rural areas of Punjab have increased their vegetable production. However, vegetables crops are critically influenced by poor nutrition and water stress during their growth which causes considerable loss in yield **(Fahad *et al.*, 2017)**. Water deficit stress adversely affects growth, photosynthesis, transpiration, water uptake and development in vegetable crops leading to lower yields and poor quality produce **(Vashi *et al*., 2020)**.

Brinjal is grown as an annual but can be grown as perennial crop too. It is one of the most popular vegetables. Brinjal is recognized for its low caloric content and its abundance of macro and micro nutrients that can enhance human health. Ayurveda employs brinjal as an appetizer, cardio tonic and as a remedy.

It has been observed that from 40 to 60% of the crops cultivated in India experience various deficiencies in micronutrients. Micronutrients are essential for plants. They increase the chlorophyll content of leaves further develop photosynthesis which strengthens the absorbing impact of entire plant. Foliar nourishment is ideally designed to give numerous elements in conditions that might be restricting metabolism when supplement take up from the soil is inefficient. Micronutrients occur in lesser amounts in soil than macronutrients but are equivalently important for plant. Macro and micronutrients in plants are categorized as vital nutrients that uphold plants for their entire biochemical requirements and in the absence of which a plant is incapable of completing its life cycle. Alternative elements are unable to replace a specific function for a plant. Plants are deprived of comprehensive nourishment as each vital nutrient plays a direct role in plant nutrition. Among all the vital nutrients almost half of the elements are recognized as macronutrients and the roles of macronutrients are important. For example, carbon is necessary for the synthesis of proteins, carbohydrates, nucleic acids and other compounds or crucial plant macromolecules. Hence, micronutrients perform an important role in metabolic activity of the plant for that reason without the application of multinutrients the deficiency may occur and ultimately reduce quality and yield of the crop. Foliar application of micronutrients has been reported to gives better results than soil application as the absorption and assimilation of micro elements by application in soil takes long time. Subsequently, to adapt up to the necessities of the yield use of multi nutrients must be ensured. Moreover, recent studies have highlighted that foliar delivery of multiple micronutrients significantly improves nutrient use efficiency, enhances enzyme activation and promotes better flowering and fruit set, especially under conditions where soil nutrient availability is limited or imbalanced **(Souri *et al.*,2022)**.

Biostimulants are also beneficial to plants. There are many types of biostimulants like microbial biostimulants which contain beneficial bacteria or fungi that support the root system and improve soil health as well as natural extracts and organic biostimulants which are made from plant materials or seaweed and which encourage growth and stress tolerance. Conversely, mineral based materials such as silicon, calcium and phosphorus compounds are known as inorganic biostimulants. They are derived from non organic sources Arka Vegeatble Special comes under inorganic biostimulant category **(Du Jardin, 2015)**. Furthermore, recent studies have demonstrated that biostimulant applications significantly enhance root growth, stimulate microbial activity in the rhizosphere, and improve micronutrient availability and uptake resulting in better growth, yield and stress resilience under suboptimal soil conditions **(Kumari *et al.,* 2023)**.

Arka Vegetable Special is a type of biostimulant - micronutrient mixture. Effective management becomes imperative in order to improve the quality and quantity of vegetable. In order to address this issue, IIHR has developed a micronutrient formulation called Arka Vegetable Special which is specifically tailored according to the nutritional needs of vegetable crops. It contains essential nutrients such as Zn, B, Mn, Fe and Cu. Moreover, it effectively prevents the fixation of applied nutrients in the soil.

Water inadequacy classifies among the greatest essential factors restricting growth and productivity of plants. Vegetables are categorized as crops with maximum water necessity.

Hydrogels are super-absorbent polymer networks capable of retaining and slowly releasing large quantities of water, making them highly valuable for improving soil moisture dynamics in agriculture. When incorporated into soil, hydrogels enhance water retention, reduce irrigation frequency, increase nutrient availability and improve plant growth under drought or water limited conditions **(Piccoli *et al.*, 2024)**. It is basically water absorbing polymer, which can be applied as wet or dry formulation. The polymers are long chains of big molecules that repeat. Cross linked regions of the polymer create a kind of cage that traps the water molecule as they intersect and chemically attach to one another. Hydrogel is distinguished by its neutral, positive or negative charges. The greater the capacity of gel to absorb water the stronger the attraction between the gels surrounding solutes and soil particles. The hydrogels can retain water and nutrients in the root zone for extended periods, making them sustainable agents for soil conditioning and crop support **(Oladosu *et al.*, 2022)**.

Water availability has a strong impact on brinjal growth, fruit quality and yield. Insufficient or irregular moisture reduces plant growth leads to smaller and poor quality fruits and lowers overall yield while excess water can damage roots and limit nutrient uptake. Hydrogels help by storing and slowly releasing water in the root zone preventing drought stress and reducing irrigation needs thereby improving growth, fruit quality and yield **(Malik *et al.*, 2022)**.

Moreover, the hydrogels possess a comparable level of flexibility as that found in natural tissue owing to their significant water content. During the process of irrigation, the hydrogel function by effectively absorbing and retaining water even reaching a weight that is 350 times greater than its initial dry state. In periods of drought, the hydrogel releases the stored water for the benefit of the plants.

Consequently, this soil additive diminishes the water demand for crops, enhances seed germination and offers support to farmers in regions afflicted by aridity.

Growth and yield of brinjal can be maximized by the implementation of considered composition of hydrogel and multinutrients which may have significant rise in growth and yield of brinjal due to their combining effect. Taking into account all of the aforementioned elements, the following goals will be examined and assessed following the research:

Proposed research objectives

1. To evaluate the effect of combination of biostimulant and moisture conservation practices on brinjal growth and yield
2. To determine the effect of combination of biostimulant and moisture conservation practices on quality attributes of brinjal
3. To workout economic analysis

CHAPTER 2

REVIEW OF LITERATURE

In this chapter research work related to **"Application of biostimulant in combination with moisture conservation practices on parameters of brinjal (*Solanum melongena* L.) growth, yield and quality"** carried out by different researchers across the globe has been thoroughly reviewed and presented. To give a general overview of the subject research on the use of biostimulants and moisture conservation methods as well as their impact on brinjal development has been discussed under following sub heading

2.1 Effect of micronutrient based biostimulant

2.1.1 Effect of biostimulant on brinjal

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2.2.1 Effect of moisture conservation practice on brinjal

2.2.2 Effect of moisture conservation practice on other vegetables

2.3 Combined effect of moisture conservation practices and biostimulants

2.3.1 Effect of moisture conservation practices and biostimulants on brinjal

2.1 Effect of micronutrient based biostimulant

2.1.1 Effect of biostimulant on brinjal

Ali *et al*. (2024) examined the effects of foliar treatments of boron (B) and nitrogen (N) on the growth, yield and phytochemicals of *Solanum melongena*. The research conducted of varying levels of N (0, 0.25%, 0.5% and 1%) and B (0, 0.1%, 0.25% and 0.5%). Nitrogen (0.5% foliar spray) resulted in the maximum height of plant, number of leaves, leaf area, number of branches, number of flowers per plant, number of fruits per plant, fruit length, fruit width, fruit volume, fruit weight, fruit yield, protein, total carbs as well as crude fiber increased. The least number of days at 50% appearance of flower decreased.

Mishra *et al*. (2023) studied the impact of foliar application of micronutrients on yield attributes of Brinjal. The experimental design employed was a Randomized Block Design with three replications. A total of ten treatments were formulated utilizing varying dosage of micronutrients. The treatments included T_1: control, suggested fertilizer dosage: T_2, T_2 combined with $ZnSO_4$ at 0.4%: T_3, T_2 combined with $ZnSO_4$ at 0.5%: T_4, T_2 combined with Borax at 0.4%: T_5, T_2 combined with Borax at 0.5%: T_6, T_2 combined with $CuSO_4$ at 0.4%: T_7, T_2 combined with $CuSO_4$ at 0.5%: T_8, T_2 combined with $FeSO_4$ at 0.4%: T_9 and T_2 combined with $FeSO_4$ at 0.5%: T_{10}. Yield parameters characteristics for instance the maximum flowers on a single plant (42), maximum fruit production per plant (32.68), were notably recorded in T_4 {(T_2) combined with $ZnSO_4$ at 0.5%}. The overall quantity of picking did not demonstrate significant variation as a consequence of the application of different micronutrients.

Ruban *et al.* (2019) conducted a field investigation titled "Impact of Foliar Application of biostimulants on the Growth and Yield of Brinjal" The experimental design was implemented utilizing a completely randomized framework comprising nine distinct treatments and three replicates. The nine treatments included: panchagavya at a concentration of 5 % (T_1), panchagavya at a concentration of 10 % (T_2), seaweed extract at a concentration of 5 % (T_3), seaweed extract at a concentration of 10 % (T_4), humic acid at a concentration of 5 % (T_5), humic acid at a concentration of 10 % (T_6), vermiwash at a concentration of 5 % (T_7), vermiwash at a concentration of 10 % (T_8), and control (T_9). Among the various biostimulants assessed, the application of humic acid at 10 % concentration exhibited a statistically significant enhancement in both growth and yield attributes when compared to all alternative treatments. Growth parameters such as plant height (90.33 cm), number of leaves (79.64), leaf area (78.73 cm^2), stem girth (4.85 cm), and the duration until flower initiation (37.77 days) were markedly influenced by the application of humic acid at 10 %, with humic acid at 5 % following closely in its efficacy.

Uikey *et al.* (2018) examined which micronutrients or their combinations might work best for brinjal foliar sprays an experiment was carried out. There were eight different micronutrient treatments and a control in the experiment. Growth and phenological parameters were markedly improved by the suggested fertilizer dose + Borax (0.2%) + $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) as foliar spray had the best results for all of the brinjal growth and phenological characteristics, including height of plant, the number of leaves, the number of branches, amount of fruit number per cluster.

2.1.2 Effect of biostimulant on solanaceous vegetables

Singh *et al.* (2024) examined the effect of micronutrients zinc and boron affected the tomato (*Solanum lycopersicum* L.) growth, yield and quality parameters in a naturally ventilated polyhouse. Nine treatment combinations and three replications made up the Randomized Block Design used in the trial. The study assessed how different zinc and boron concentrations (0.1% and 0.2%) affected the growth, yield and quality characteristics of the polyhouse grown tomato cultivar NS 4266. According to the results the combination of 0.2% zinc and 0.2% boron produced the tallest plant (232.53 cm), earliest flowering (28 days), thickest stem girth (25.36 cm) and shortest internodal length (8.53 cm). The highest number of clusters per plant (12.60), fruits per plant (64.5), fruits per cluster (13.46), polar and equatorial diameters (6.36 and 7.60 cm), average fruit weight (88.33 g) and fruit yield per plant (13.30 kg) were all indicated by the yield parameters and using the same treatment per 1000 m^2 (262.26 kg). Quality parameters including maximum shelf life (9 days), total chlorophyll content (1.80 mg/g) and total soluble solids (8.23°Brix) were also superior when zinc and boron were applied at 0.2%.

Rashid (2022) assessed effect of micronutrients and their application techniques on the growth and yield of the Diamant potato variety. Results showed that foliar application developed the largest yield of tuber 3.53 t/ha and basal application produced the inferior. However, the maximum yield of tubers 4.56 t/ha was achieved. The control had the inferior value when B + Zn was utilized at 2 kg B/ha + 3 kg Zn/ha. The combination of foliar micronutrient application and combined B + Zn treatment at 2 kg/ha + 3 kg/ha produced highest tuber yield of tuber 4.89 t/ha among the treatment combinations whereas, the control showed the less yield. Consequently, the foliar spray technique and the combined boron and zinc treatment improved potato growth and yield.

Reddy *et al.* (2018) studied micronutrients application to tomato cultivars Arka Saurabh and Arka Vikas as a supplement to promote healthy growth and yield. The experiment was set up in RBD with three replications and the treatments include boron, zinc, molybdenum, copper, iron, manganese, combination of all and control. At 30 days after transplanting three sprays of each micronutrient @ 250 ppm were given at 10 day intervals except manganese at 50 ppm. Zinc application had the highest growth rate (85.7%) in tomato cv. Arka Saurabh followed by micronutrient mixture (78.2%) and boron (77.5%). However, the manganese treatment 148.7% and combination of micronutrient 144.1% increased branches per plant in tomato cv. Arka Vikas.

Pandiyan *et al.* (2018) conducted investigation to assess the response of tomato to foliar application of micronutrients. The hybrid COTH 2 was selected for this study. Based on the three year average 14 different treatments with various combinations of micronutrients were applied in three replications. The analysis showed that among the different combinations the treatment involving a mixture of all micronutrients (Boric acid @ 100 ppm, $ZnSO_4$ @ 100 ppm, Ammonium molybdate @ 50 ppm, Copper sulfate @ 100 ppm, Ferrous sulfate @ 100 ppm, and Manganese sulfate @ 100 ppm) applied in three sprays at 40 days interval starting from day after planting (DAP) resulted in the highest plant height (95.7 cm), number of fruits per plant (46.4), fruit weight (61.9 g), fruit yield per plot (63.5 kg) and highest yield of 564.1 q/ha. This was followed by the spraying of the commercial formulation (Multiplex) with yield 558.8 q/ha. The highest benefit cost ratio of 3.04 was recorded with the mixture of all micronutrients followed by Zinc Sulfate @ 100 ppm with a B:C ratio of 3.00.

Ahmed *et al.* (2017) determined the ideal zinc and boron dosage for maximizing capsicum yield. The results showed that $B_{2.0}Zn_{3.0}$ the combination treatment produced the highest mean yield *i.e.*, 31.8 t ha^{-1}, maximum individual weight of fruits is 122 g, maximum fruit diameter is 7.34 cm, maximum fruit length is 9.29 cm and maximum average number of fruits per plant is 11.1. As a result of applying $B_{2.0}Zn_{3.0}$ kg ha^{-1} produced 84.8% more yield than control (B_0Zn_0).

2.1.3 Effect of biostimulant on other vegetables

Sai *et al.* (2023) studied the impact of foliar micronutrient application on the quality features of cabbage. According to the results, treatment T_9-Zn (0.25%) + B (0.2%) + Mn (0.25%) + Mo (0.25%) had the highest chlorophyll content (2.70 mg/100 g), vitamin-A (114.32 IU/100 g) and the longest shelf life of cabbage heads (10.25 days) at room temperature. This treatment combination was significantly better than the other treatments. Treatment T_{11} (control) had the chlorophyll content lowest (1.80 mg/100 g), the lowest vitamin-A (104.43 IU/100 g), and the shortest shelf-life at room temperature (7.46 days). Treatment T_{11} (control) had the lowest vitamin-C content (43.77 mg/100 g), while treatment T_{10}-Zn (0.5%) + B (0.4%) + Mn (0.5%) + Mo (0.5%) had the highest content of vitamin-C (51.61 mg/100 g), which was noticeably better than the other treatments.

Javed *et al.* (2023) assessed the influence of foliar elements implementation on okra (*Abelmoschus esculentus* L.) yield, quality and profitability. Fourteen treatments were used in the research. Result shows that mixture of nutrients produced the highest yield/plant (241.74 g), the highest fruit quality in terms of dry matter content *i.e.*, 11.46%, crude protein content is 9.94%, vitamin C content is 13.10 mg/100 g and chlorophyll content is 1.80 mg g^{-1} compared to the control. The research proved that it was much more profitable to grow okra using micronutrient mix i.e., (B:C = 4.36) as compared to control (B:C = 3.13).

Vinay *et al.* (2022) determined the impact of different treatment combinations including Micronutrient and bioagent foliar application and seed coating on plants development, seed production and yield contributing factors of the pea cultivar Punjab-89 during 2018–19 was assessed in a field experiment. Among the various treatments it was found that With the highest field emergence 92.67%, the plant height 91.03 cm, pods/plant is 27.07, 9.81 cm is length of pod, 7.93 is seeds/pod, the 100 seed weight 17.11 g, seed yield is 13.98 g/plant and maximum B:C ratio is 2.00, by application of a seed coating with Rhizobium @ 30 g + PSB @ 30 mL kg^{-1} seed and two foliar sprays of $ZnSO_4$ + $FeSO_4$ @ 0.3% each at 50% flowering and 15 days after the first spray had a significant impact on nearly all the parameters.

Pramanik *et al.* (2020) examined how micronutrients affect the performance of onions (*Allium cepa* L.) in terms of total dry matter yield. Foliar treatment of the micronutrient mixture, which includes 2.5% iron, 0.5% boron, 3% zinc, 1% copper and 1% manganese at the rate 0.5% @ 30 and 45 DAP, was found to be effective. Compared to the other treatments, it significantly raised the maximum gross income 2.68 lakhs/ha, the net income 1.95 lakhs/ha, the number of leaves per plant 12.62, the total bulb output 268.28 q/ha, the dry matter yield of the leaves 1.18 t/ha and the bulb 4.74 t/ha.

Hassan *et al.* (2012) carried out a study to investigate Effect of biostimulant rabbit manure, Mycorrhiza and Bacillus sirculans on growth, flowering and chemical constituents of periwinkle (*Catharanthus roseus* L.) plants. It was noted that the application of rabbit manure to periwinkle (*Catharanthus roseus* L.) resulted in a 22% increase in plant height, 21.5% increase in number of branches, and 10% increase in dry weight when compared to the control treatments.

Pankaj *et al.* 2018 (a) examined the effects of several micronutrients on the produce quality of broccoli. The experiment's findings demonstrated that different treatment combinations differed significantly from one another. T_5 (B + Mn + Zn) had the highest T.S.S value at 8.80 followed by T_9 (Zn) *i.e.*, 7.90 T_0 (control) had the least T.S.S value 6.45. The highest amount of vitamin C @ T_5 (B + Mn + Zn) had the highest mg/100gm (94.80 mg) followed by T_6 (Mo + Mn) that is 88.73 mg, control had the least vitamin C (79.02 mg) preceeded by T_2 (Mo) *i.e.*, 82.23 mg. The application of the four micronutrients B, Mo, Mn and Zn had a notable effect on the quality of broccoli.

Pankaj *et al.* 2018 (b) conducted experiment on impact of several micronutrients on the vegetative development of broccoli. Treatments with Zn, Mn, B and Mo micronutrients applied in plot single and in combination (3:0.5:2:2.5 kg/ha) were part of the Randomized Block Design experiment which had 10 treatments and 3 replications. The findings demonstrated that micronutrient treatments had significant effects on head diameter with T_5 (B + Mn + Zn) having the largest head diameter (18.02 cm) followed by T_8 (B + Zn) and T_7 (B + Mo + Mn + Zn) at 16.87 cm. Along with the maximum yield (138.58 q/ha), T_5 also had the highest weight of head (511.50

g) and number of frouds (18.32). The yield of T_7 (B + Mo + Mn + Zn) was 116.23 q/ha. The head weight (198.02 gram) and yield (72.98 q/ha) of the control (T_0) was the lowest.

2.2 Effect of moisture conservation practice

2.2.1 Effect of moisture conservation practice on brinjal

Abdel Nabi *et al*. (2024) observed the effects of soil additions, irrigation schedules, antitranspirant sprays applied concerning the eggplant fruit quality, yield and its constituent parts, as well as the effects of the foliage treatments. The maximum values of growth characteristics, yield its components and chemical constituents of brinjal plants were obtained in the treatment with irrigation at every 10 days, soil additions by polymer at a rate of 30 kg/fed and spraying the leaves with potassium silicate at a rate of 2.5 mL/L. In order to attain maximum growth, production and fruit quality in brinjal while simultaneously conserving irrigation water, in addition to adding polymer to the soil at a rate of 30 kg/fed and spraying the leaves with potassium silicate at a rate of 2.5 mL/L it can be advised to water plants every 15 days.

Salles *et al.* (2020) conducted a study to evaluate use of nanocomposite hydrogel enriched with different proportions of N-urea in the production of brinjal seedlings. The research comprised of a commercial substrate *viz*., Carolina Soil® and its different combinations with nano-composite hydrogel. Along with the Dickson Quality Index the following factors were assessed: height (3.64 cm), number of leaves (3.720, stem diameter (1.26 cm), shoot dry matter (0.033 g), root dry matter (0.014 g) and total dry matter (0.047 g). The best seedlings may be produced with a dose of 0.075g of hydrogel and 28.83% N-urea per 15 mL of the substrate.

Mnyika *et al*., (2020) evaluated the influence of rabbit manure and SAP on moisture of soil for eggplant growth and yield. Manure of rabbit, hydrogel, hydrogel + manure of rabbit and control were the treatments studied. Growth, yield and soil moisture characteristics were observed. In comparison to the control, superabsorbent polymer + rabbit manure enhanced soil moisture, eggplant growth and yield which was confirmed by parameters like plant height (76 cm), number of leaves (108.3), stem diameter (3.1 cm), etc.

Naing and Lay (2017) evaluated the effects of a constant weight of SAPs (3 g/l.5 kg of growth media) [made by using varying doses (10-30 kGy) of gamma radiation to crosslink acrylic acid at different percentages (30%, 40% and 50%) onto coir dust] on brinjal plant. On the basis of eggplant growth in prepared soil media fifteen samples and sixteen pots were set up. In the experiment 3 g of different types of super absorbent polymer was utilized with the same soil (1.5 kg). The plants received adequate hydration for the first two weeks after which the watering schedule was shortened to three days per container. The results of the data analysis showed that SAP had a significant impact on plant growth parameters like yield/plant (1308 g) and plant height (139 cm). The findings showed that a high yield was achieved by the sample containing 50% acrylic acid and 6 g coir dust prepared by radiation grafting using gamma radiation (20 kGy).

Jin-Hee *et al.* (2016) examined the effects of varying hydrophilic polymer (HP) ratios on eggplant development in green roofs including control (media *viz*., Sunshine® mix #1), media with 1.0%, 2.5%, 5.0% and 10.0% HP. The water content in the media remained high (95%) during the growing phase according to the results, when the HP ratio was higher than 5%. Plant growth however, declined as the HP ratio increased growth index decreased by 1/5 at 10.0% HP and by 1/3 at 5.0% HP in comparison to the control. HP10.0% plants had the smallest leaves and the lowest dry weight, whereas, stem and root dry weight, leaf number and leaf size all declined with an increase in HP%. After three months, survival rates for HP1.0%, HP2.5% and HP5.0% were 100% whereas only 56% in HP10.0%. According to the study, hydrophilic polymers are beneficial during dry spells but too much of them can stunt plant growth. This highlights the necessity for careful mixture selection depending on the type of plant and the media.

2.2.2 Effect of moisture conservation practice on other vegetables

Pahlevanyan *et al.* (2023) studied the impact of hydrogel Aquasource on melon seed efficiency and production capacity for 3 years (2020-2022) and found that when compared to the control the ratios of Soil mix + Aquasource (3:0.15) and Soil mix + Aquasource (3:0.2) had a favorable impact on the early appearance of female flowers while reducing the days taken for marketable maturity and fruit quality. The marketable yield for melons was similarly higher than the control (230.9±2.73 c/ha) coming in at 287.5±2.94, 308.0±2.27 and 307.0±3.05 c/ha in that order. Regarding seed yield a comparable trend was noted: 360.7±2.87, 399.6±10.01 and 392.1±9.20 kg/ha in that orders while the control produced 287.2±8.05 kg/ha.

Mahgoub (2020) studied the efficiency of hydrogel treatment on the growth of tomatoes (*Solanum lycopersicum* L.) and some characteristics of sandy soil when drip irrigation is used. The researcher has found that plants treated with 4 g hydrogel + half suggested fertilizer dosage (HG_2 + 0.5 F) increased the concentration of potassium (19.53 g kg^{-1}), phosphorus (1.89 g kg^{-1}) and nitrogen (36.53 g kg^{-1}) in fruits. It also increased number of fruit per plant and individual fruit weight. Moreover, introducing 4 g $plant^{-1}$ (HG_2) and 2 g $plant^{-1}$ (HG_1) hydrogel decreased pH by 0.08–0.18.

Kumar *et al.* (2018) Three distinct irrigation intervals (M_1= 7 days, M_2= 14 days, and M_3= 21 days) along with eight varying concentrations of Pusa hydrogel (S_1= Control, S_2= 2.0 kg/ha, S_3= 2.5 kg/ha, S_4= 3.0 kg/ha, S_5= 3.5 kg/ha, S_6= 4.0 kg/ha, S_7= 4.5 kg/ha, and S_8= 5.0 kg/ha of hydrogel) were systematically assigned to main plots and subplots, respectively. The findings indicated that the application of hydrogel, the irrigation frequencies, and their interactions statistically significant influence on the growth parameters, fresh yield, and essential oil composition of ginger. Notably, the optimal outcomes in terms of plant height, leaf count, tiller number, fresh rhizome yield per individual plant, yield per hectare, and essential oil concentration were observed in the treatment incorporating 5.0 kg/ha of Pusa hydrogel with an irrigation regimen set at a 14-day interval.

Pazderu and Koudela (2013) conducted an experiment to determine how hydrogel affected the germination of onion and lettuce seeds at varying moisture levels. Agrisorb (water solution 1, 3 and 5 g/L) was evaluated in a germination box with 30 mL and 15 mL of water under different moisture conditions. Variants with lower water levels germinated noticeably more slowly (MGT parameter) than standard variants, despite the fact that there were only slight variations in overall germination at the end of the test. The germination energy (GE) of the treated lettuce seed variations increased statistically significantly on the first day (GE_1, both water levels), but decreased statistically significantly on the second day (columns GE_2, 15 mL).

Higher dosages of Agrisorb dramatically reduced the germination of lettuce seeds (GE_2, 30 mL + dose 5 g/L); this decrease was equally evident for GE_3 (both water content) and GE_2 (15 mL, doses 1, 3, and 5 g/L). In onions, a similar but insignificant effect was observed. Higher hydrogel dosages also resulted in longer mean germination times for onions and lettuce.

EI Hady *et al.* (2012) Using irrigated tomatoes as the indicator plant, researchers examined the conditioning effect of hydrogels when grafted onto or coupled with organic composts on the efficiency of water and nutrient production and consumption. The following treatments were examined untreated soil, soil treated with 0.5 kg and 1 kg of organic compost (OM)/plant pit, soil treated with 2 and 4 g of polyacrylamide K polyacrylate gel (G)/plant pit, soil treated with mixtures of 0.5 kg OM + 1 g G, 0.5 kg OM + 2 g G, 1 kg OM + 1 g G and 1 kg OM + 2 g G/plant pit and soil treated with 12.5 and 25 g of polyacrylamide K polyacrylate grafted on organic compost (grafted G)/plant pit. 1 kg OM + 2 g G/plant pit has been shown to be a successful soil conditioner in sandy soil because it increases plant growth and the efficiency with which fertilizer and water are used.

Hassandokht and Masturi (2006) studied the impact of applying dark mulch and varying concentrations of the hydrophilic polymer Tarawat A200 (0, 2, and 4 g/plant) on vegetative growth and yield in field cultivated cucumber cv. Superdaminus in autumn culture for two years. Early and higher yield was obtained in the treatment of 4 g per plant of hydrogel combined with dark mulch which was about four times than that of the control. When compared to the control, 76% increase in overall yield was achieved using 4 g per plant of hydrophilic polymer. When dark mulch and 4 g per plant hydrophilic polymer treatment were applied, the overall yield was 115% of control. Therefore, for improved yields, it was concluded to apply 4 g per plant of the hydrogel Tarawat A200 combined with dark mulch to field-grown cucumber.

2.3 Effect of moisture conservation and biostimulants

2.3.1 Effect of moisture conservation and biostimulants on brinjal

Helaly *et al.* (2018) studied the influence of biostimulants and micronutrients with or without mulching type on tomato crop growth and yield. Mulching alone affected a number of physiological and growth characteristics in tomatoes. Fruit quality, ions percentage, photosynthetic pigments, and all growth and yield characteristics were increased as biostimulants were applied. Highest yield of tomatoes per plant was obtained in the treatment where plastic mulch and seaweed extract were applied together for both seasons. Interaction between moisture conservation practice and biostimulant has positive effect on individual fruit weight. Thus, the findings suggested that, in order to maximize productivity and enhance fruit quality, tomato crops should be sprayed with 500 mg/L seaweed extract or black plastic mulch 35 and 50 days after transplanting.

2.4 Research Gap

Based on the thorough review of the literature available on this topic, it becomes clear that although several studies have addressed related aspects these particular areas remain underexplored and require further investigation

1. Arka Vegetable Special micronutrient based biostimulant and hydrogels which enhance soil water retention, have shown potential in improving plant growth, nutrient uptake, fruit quality and overall yield. However, their effectiveness has not been systematically evaluated in different vegetable crops under the specific agro-climatic conditions of Punjab**.** Factors such as soil type, temperature, rainfall and irrigation practices in Punjab may influence the performance of these inputs and without region-specific studies their true potential for local vegetable production remains unclear.
2. The combined or interaction effect of Arka Vegetable Special and hydrogels on vegetable crops has not been studied so far. While each of these inputs individually can improve growth, nutrient uptake and yield, it is unclear how their simultaneous application influences plant performance**.** Understanding this interaction is important because the presence of hydrogel may affect nutrient availability and absorption from the biostimulant, and vice versa. Investigating their combined effect can reveal potential synergistic benefits or limitations**,** which is essential for developing optimized, region-specific management practices for vegetable production.

CHAPTER 3

MATERIAL AND METHODS

This research titled as **"Application of biostimulant in combination with moisture conservation practices on parameters of brinjal (*Solanum melongena* L.) growth, quality and yield"** was carried out in the year 2023 and 2024 at Lovely Professional University, Department of Horticulture, School of Agriculture. A thorough description of the tools and methods utilized throughout the investigation is given in this chapter.

3.1 Experimental site

The field study was carried out at Lovely Professional University Vegetable Farm, Department of Horticulture during summer seasons of 2023 and 2024.

3.1.1 Location and climate

In tehsil Phagwara, the climatic conditions are categorized as mild and moderate. In the summer season there is much more rainfall compared to the winter. In Phagwara, the mean yearly temperature is 23.2°C. The precipitation level on a yearly basis amounts to 816 mm. The minimum relative humidity varies from 40% to 20% during the summer months. **Table 3.1 and Table 3.2** provide summary meteorological conditions for 2023 and 2024 during the cropping period. These factors include important climate variables that are necessary for understanding their impact on crop development and yield such as wind speed, temperature, humidity, rainfall and evaporation.

3.1.2 Soil property

Before experiment started the soil samples were taken in order to observe parameters like pH, electrical conductivity (EC), nitrogen (N), phosphorus (P) and potassium (K). These findings help in evaluating how farming methods affect the fertility and health of the soil. These results help in assessing the effects of farming practices on soil fertility and health. By keeping updated on these variables, one may examine changes over time and gain understanding of soil structure.

Table 3.1: Weekly meteorological observations during crop season 2023

Date	Max. Temp (°C)	Min. Temp (°C)	Max. RH (%)	Min. RH (%)	Wind speed (km/h)	Rain (mm)	Evaporation (mm)
01st to 07th May 2023	34.86	20.86	66.43	41.71	14.42	0.81	8.85
08th to 14th May 2023	40.86	23.43	47.71	35.71	11.57	0.00	10.01
15th to 22nd May 2023	42.88	24.75	72.38	37.00	7.37	0.95	8.31
23rd to 31st May 2023	34.30	21.70	81.00	45.11	9.66	4.73	5.36
01st to 07th June 2023	34.43	20.86	81.86	41.42	6.00	4.88	4.00
08th to 14th June 2023	38.29	23.57	82.43	38.28	3.14	5.05	6.71
15th to 22nd June 2023	37.00	25.75	82.25	49.50	3.12	2.80	5.50
23rd to 30th June 2023	36.00	27.56	83.33	56.62	2.62	0.30	4.20
01st to 07th July 2023	34.43	25.57	85.29	62.14	1.71	12.77	2.90
08th to 14th July 2023	32.57	25.29	88.57	69.00	7.57	10.74	3.15
15th to 22nd July 2023	34.88	27.50	86.88	68.50	5.75	6.27	3.97
23rd to 31st July 2023	33.40	27.00	91.30	71.22	4.77	7.13	1.92
01st to 07th Aug 2023	35.43	27.30	89.71	69.85	5.14	8.05	2.70

Table 3.2: Weekly meteorological observations during crop season 2024

Date	Max. Temp (°C)	Min. Temp (°C)	Max. RH (%)	Min. RH (%)	Wind speed (km/h)	Rain (mm)	Evaporation (mm)
01st to 07th May 2024	36.91	17.64	74.71	23.43	9.27	0.00	7.16
08th to 14th May 2024	37.63	21.90	72.14	31.43	9.27	0.00	8.70
15th to 22nd May 2024	41.98	23.53	70.88	25.25	9.69	0.00	9.23
23rd to 31st May 2024	43.21	25.11	70.56	24.89	9.80	0.00	9.33
01st to 07th June 2024	40.53	24.26	74.43	30.00	8.59	1.33	10.54
08th to 14th June 2024	42.29	23.67	72.43	23.29	10.80	0.00	12.44
15th to 22nd June 2024	40.71	26.83	72.13	37.25	12.56	0.00	12.90
23rd to 30th June 2024	38.08	27.63	82.63	53.13	7.56	0.35	13.19
01st to 07th July 2024	33.91	26.61	88.29	70.14	10.13	0.54	4.01
08th to 14th July 2024	36.06	27.11	90.57	62.86	6.07	0.00	6.06
15th to 22nd July 2024	37.21	28.03	88.13	64.75	5.00	0.18	5.65
23rd to 31st July 2024	35.53	28.05	90.50	74.00	4.37	0.38	5.24
01st to 07th Aug 2024	34.91	27.70	91.86	74.14	5.86	1.44	4.51

Table 3.3: Available nutrients status and chemical properties of the soil of 1st trial and 2nd trial experimental field (pre-cultivation)

RESULTS		
	1st trial	**2nd trial**
Soil pH	7.60	7.60
Electrical conductivity (mmhos/cm)	0.43	0.44
Nitrogen (kg/ha)	140.00	143.00
Phosphorus (kg/ha)	13.52	27.53
Potassium (kg/ha)	249.56	205.70

3.2 Plant material

The plant material used in this study was a popular private sector hybrid of brinjal known by the name Nishant F1 hybrid. Using a widely cultivated hybrid increases the practical applicability of the study findings for farmers, compared to public-sector varieties recommended by Punjab Agricultural University. **Table 3.4** provides comprehensive details regarding the characteristics of plant material.

Table 3.4: Characteristics of plant material used for trial

Nishant hybrid	
Plant habit	Erect
Fruit shape	Oval
Fruit colour	Violet
Fruit size (Average)	80 g
Fruit colour	Purple/Violet
Calyx colour	Green
Source	Advanta seeds private limited

3.3 Biostimulant

Biostimulants are substances which are beneficial to plants. Arka Vegetable Special is a type of biostimulant. It contains essential nutrients such as Zn, B, Mn, Fe and Cu. Moreover, it is a cost effective and easy to use. **Table 3.5** shows the composition of Arka Vegetable Special.

Table 3.5: Arka Vegetable Special composition

Composition (Research formula of ICAR-IIHR)	
Nutrient	**Percentage (%)**
Zinc	4.50
Boron	1.00
Manganese	0.85
Iron	2.10
Copper	0.10

3.4 Moisture conservation practice

The primary aim of soil moisture conservation is to reduce the volume of water evaporating from the ground as a result of evaporation (direct water loss from the soil) transpiration, and evapotranspiration. During this research the soil moisture conservation practice adopted was the soil application of superabsorbent polymer known as hydrogel. The trade name of natural organic hydrogel and its manufacturer is given below in **Table 3.6**.

Table 3.6 Described details regarding hydrogel

Fasal Amrit	
Manufacturer	EF Polymer Private Limited
Form	Granules
Origin	India

3.5 Experimental details

The experimental setup used in the study is described in detail in **Tables 3.7, 3.8** and **3.9**.

Table 3.7: Details of the experiment

Factor A	Biostimulant (Arka Vegetable Special)
Factor B	Moisture conservation practice (Hydrogel)
Design of experiment	Factorial Randomized block design (FRBD)
Number of replications	3
Total treatments	12
Total plots	36
Size of plot per treatment	12 m^2 (3m×4m)
Row × Row	60 cm
Plant × Plant	45 cm
Total area	504 m^2
Number of plants in one treatment	30
Variety F1 Hybrid	Nishant (Advanta Seeds India Pvt. Limited)

Table 3.8: Details of the treatment used for experiment

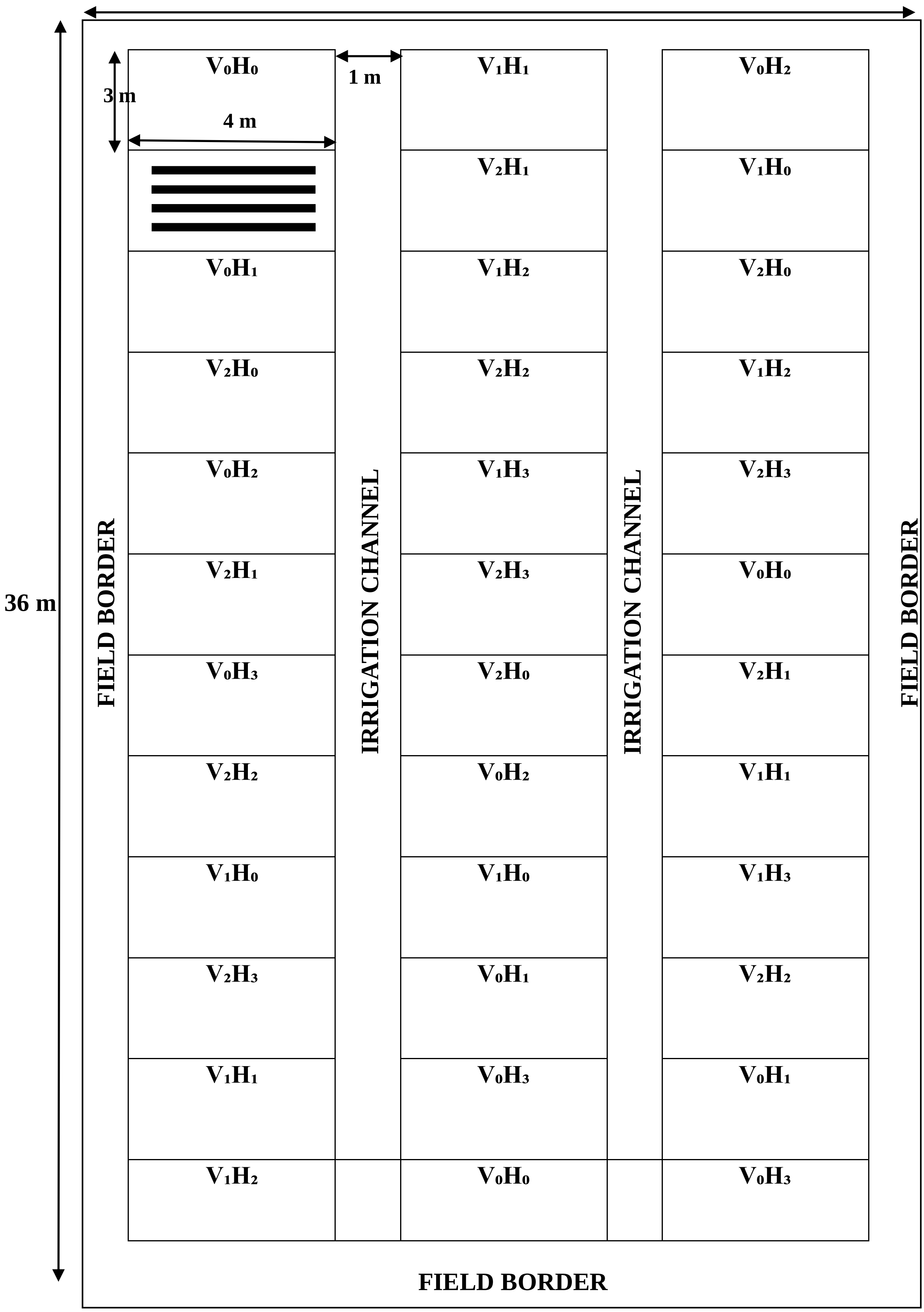
FACTOR A (Arka Vegetable Special) (g/L) in 150 L of water per acre per spray	**FACTOR B (Hydrogel) (kg/acre)**
V_0- 0 g/L	H_0- 0.0 kg/acre
V_1- 2 g/L	H_1- 1.0 kg/acre
V_2- 5 g/L	H_2- 1.5 kg/acre
	H_3- 2.0 kg/acre

Specific symbols that indicate various combinations of the applied parameters are utilized to symbolize the treatments used in this investigation. The Arka Vegetable Special is denoted by the letter "V" for FACTOR A. The Hydrogel is represented by the letter "H" for FACTOR B. The following represents the combinations of these factors:

Table 3.9: Treatments symbol and their description

Treatment symbol	Description
V_0H_0 (Control)	0 g/L + 0 kg/acre
V_0H_1	0 g/L + 1.0 kg/acre
V_0H_2	0 g/L + 1.5 kg/acre
V_0H_3	0 g/L + 2.0 kg/acre
V_1H_0	2 g/L + 0 kg/acre
V_1H_1	2 g/L + 1.0 kg/acre
V_1H_2	2 g/L + 1.5 kg/acre
V_1H_3	2 g/L + 2.0 kg/acre
V_2H_0	5 g/L + 0 kg/acre
V_2H_1	5 g/L + 1.0 kg/acre
V_2H_2	5 g/L + 1.5 kg/acre
V_2H_3	5 g/L + 2.0 kg/acre

Fig 3.1: Layout of experimental area



The several field activities carried out during the study are listed in **Table 3.10**. Every procedure was carefully planned and carried out to ensure accuracy and uniformity throughout treatments.

Table 3.10: Date wise schedule of field operations in 2023 and 2024

Field operations	2023	2024
Field preparation	28th April	25th April
Fertilizer application	(during field preparation) FYM–10 tonnes/acre N-25 kg/acre P_2O_5-25 kg/acre K_2O-12 kg/acre (After 2 Pickings) N-25 kg/acre	(during field preparation) FYM –10 tonnes/acre N-25 kg/acre P_2O_5 -25 kg/acre K_2O -12 kg/acre (After 2 Pickings) N-25 kg/acre
Application of hydrogel	At the time of field preparation	At the time of field preparation
Date of transplanting of the plants	1st May	1st May
1st irrigation	Light irrigation immediately after transplanting	Light irrigation immediately after transplanting
Gap filling	9th May	11th May
Irrigations	As per the moisture availability in different treatments	As per the moisture availability in different treatments
Application of AVS	One and half month after transplanting *i.e.*, 16th June	One and half month after transplanting *i.e.*, 16th June
	After 15 days *i.e.*,	After 15 days *i.e.*,

	on 30th June	on 30th June
1st weeding	16th May	18th May
2nd weeding	2nd June	5th June
3rd weeding	8th July	11th July
4th weeding	19th July	21st July
1st picking	14th July	16th July
2nd picking	25th July	26th July
3rd picking	8th August	5th August

3.6 Planting and agronomic practices

3.6.1 Soil analysis

Before initiating the experiment, soil samples were taken from a depth of 0-20 cm, while following all suggested guidelines for soil sampling **(Black *et al.*, 1965)**. The samples were transported to the laboratory for chemical analysis.

3.6.2 Land preparation

The research field was prepared through tilling, harrowing and levelling which help to break the soil pan and make it fine textured. Weeds stubbles and stones were removed from the field. Plots were prepared with the help of rotavator and 1 m wide irrigation channels were made in between the two blocks. The nature of experiment, especially soil application of hydrogel, required separation of plots to ensure avoiding of contamination during surface irrigation in different treatments. Within the plots the plants were transplanted on four ridges (30 cm apart) at spacing of 45 cm between plants as shown in **Fig 3.1**.

3.6.3 Application of fertilizer

The plots received uniform application of plant nutrients with half of the total nitrogen, phosphorus and potassium doses applied just before transplanting on a puddle surface and incorporated into the top 15 cm of soil manually using a spade.

Plate 3.1:Selection of land

Plate 3.2: Collection of sample

Plate 3.3: Divide sample into equal parts

Plate 3.4: collect sample for sampling

Plate 3.5: Ploughing of field

Plate 3.6: Different concentration of hydrogel

Plate 3.7: Transplanting

Plate 3.8: Flowering

Plate 3.9: Irrigation

Plate 3.10: General view of experimental area

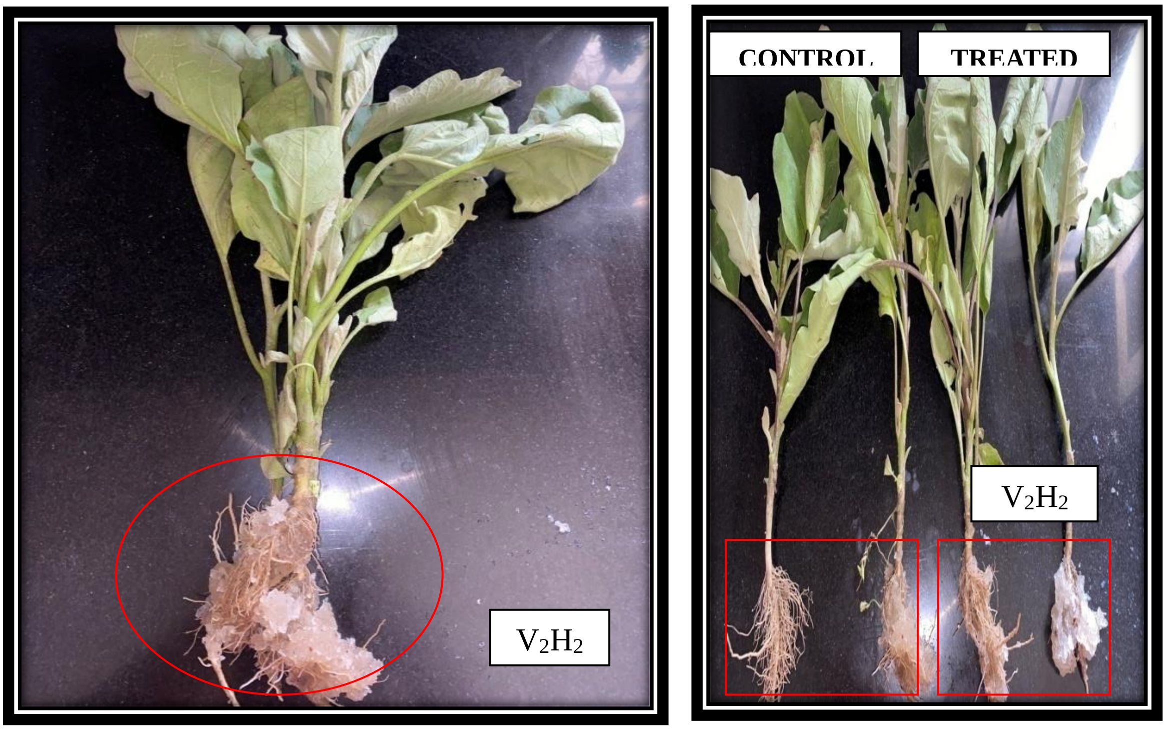


Plate 3.11: Variations observed in control and V_2H_2

Plate 3.12: Individual marketable fruit weight

Plate 3.13: Measuring fruit length

Plate 3.14: Measuring TSS with refractometer

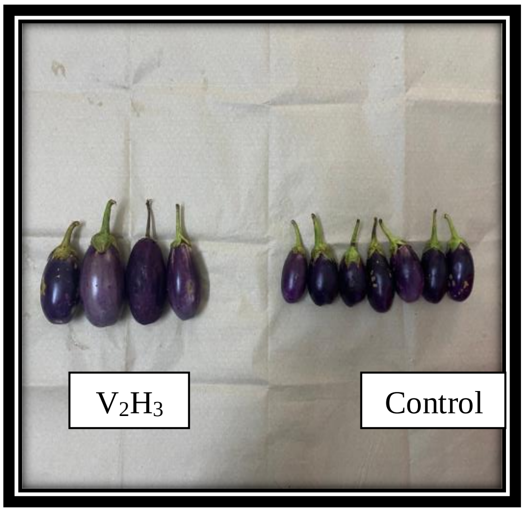


Plate 3.15: Variation observed in control and V_2H_3

Plate 3.16: Measuring Dry matter content

3.6.4 Application of hydrogel

At the time of field preparation different concentration of hydrogel was mixed in soil as per treatment combination.

3.6.5 Transplanting

Healthy Nishant F1 hybrid seedlings were procured from contract farmers a day prior to transplanting. Seedlings chosen were 10-15 cm in height with 4-5 true leaves. Transplanting was done in main field on flat beds on 1st of May during late afternoon to evening hours. The field was irrigated lightly immediately after transplanting.

3.6.6 Irrigations

Depending on the soil's moisture content, irrigations were applied at a depth of 5 cm which was analysed by using soil moisture meter (Tensiometer).

3.6.7 Weeding

Throughout the whole crop production period, all plots were kept free of weeds. In the plots, hand weeding was carried out when needed. Every intercultural procedure was carried out by hand using a tool known as a *khurpi*.

3.6.8 Harvesting

The crop was harvested when the fruits obtained marketable maturity. As all the fruits do not mature at the same time, three pickings were done at 8-9 days intervals.

3.7 Observations recorded

During this research the effect of different treatments on growth, yield and quality of brinjal was analysed by the help of growth, yield and quality parameters. This section enlists and describes the different parameters as below:

Growth parameters

1. Plant height (cm) 55 and 70 DAT
2. Number of leaves per plant 55 and 70 DAT
3. Absolute growth rate (cm/day)
4. Leaf length (cm) 55 and 70 DAT
5. Leaf width (cm) 55 and 70 DAT
6. Petiole length (cm)

7. Average leaf area per plant (cm²) 55 and 70 DAT
8. Leaf area index
9. Days to fruit initiation
10. Days to marketable maturity
11. Average marketable fruit weight (g)
12. Fruit length (cm)
13. Fruit diameter (cm)
14. Pedicle length (cm)

Yield parameters

1. Number of fruits per plant
2. Fruit yield per plant (kg/plant)
3. Fruit yield per plot (kg/plot)
4. Fruit yield (t/acre)

Soil moisture analysis

1. Number of irrigations

Quality parameters

1. Total Soluble Solids (°Brix)
2. Moisture content of fruit (%)
3. Dry matter content (%)
4. Ash content (% on dry weight basis)

Economic analysis

1. Cost of cultivation (₹/acre)
2. Gross return (₹/acre)
3. Net return (₹/acre)
4. Benefit cost ratio

3.7.1 Growth parameters

Plant height (cm)

Height of 5 tagged plants from the crop stand was taken at 55 DAT and 70 DAT using a measuring scale, the height of the plant was measured from the base to the tip in centimetres and its average was calculated for each treatment in all three replications.

Number of leaves per plant (cm)

At 55 and 70 DAT, the average number of leaves per plant was determined by counting the fully developed leaves from each treatment of the tagged plants.

Absolute growth rate (cm/day)

At the beginning of the growth period first measurement (H_1) was taken at 55 DAT and at the end of the period (*i.e.*, 70 DAT) final measurement (H_2) was recorded. AGR was calculated for each and every treatment using the following formula:

$$AGR = \frac{H_2\text{-}H_1}{t_2\text{-}t_1}$$

Where, H_2 is the plant height at 70 DAT, H_1 is the plant height 55 DAT, T_2 is 75 DAT and T_1 is 55 DAT.

Leaf length and width (cm)

The length of each plant's five randomly chosen leaves was measured 55 and 70 DAT from the petiole end of leaf to the leaf tip in centimetres. The leaf width was measured as the maximum distance between any two points on the edge of the blade that is perpendicular to the axis of leaf length which represents the line connecting the apex and base of the leaf.

Petiole length (cm)

Five leaves from tagged plants had their petiole lengths measured with a ruler, and the average was determined.

Average leaf area per plant (cm^2)

A young fully opened leaf from fourth node was initially selected from tagged plants in each treatment. The leaf area of selected leaf was then measured with a Leaf Area Meter 211 (LI-COR Biosciences). Then the leaf area of the sampled leaf was multiplied by the total number of leaves on the plant to approximate the average leaf area per plant.

Leaf area index

The LAI was calculated by using the following formula

$$\text{Leaf area index} = \frac{\text{Average leaf area per plant}}{\text{Spacing}}$$

Number of days to fruit initiation and marketable maturity

Five tagged plants from each treatment were observed for the number of days taken from transplanting to fruit initiation until the harvest.

Average marketable fruit weight (g)

The fruit from five tagged plants were weighed individually on an electronic balance and the average weight was computed in gram.

Fruit length (cm)

The length of five fruits was recorded from the floral end of the fruit to the calyx of the fruit by using a ruler and the mean expressed in cm.

Fruit diameter (cm)

For fruit diameter five fruits were chopped longitudinally and equatorial diameter was measured with the help of scale.

Pedicle length (cm)

The pedicle length was measured with ruler in 15 fruits from each treatment.

3.7.2 Yield characters

Number of fruits per plant

The number of healthy marketable brinjal fruits per plant, harvested during three pickings was recorded and summed up.

Fruit yield per plant (kg/plant)

The yield per plant of three pickings was recorded for marketable fruits, and the summed up was stated in kg.

Fruit yield per plot (kg/plot)

The yield per plot of marketable fruits from three pickings was recorded and the sum value was stated in kg.

Fruit yield (t/acre)

From the data on cumulative yield per plot the yield per ha was estimated and presents the yield in tones per acre.

3.7.3 Soil moisture analysis

Number of irrigations

Soil moisture analysis was carried out using soil moisture meter (Tensiometer) which was utilized to gauge the quantity of water present in the soil. This portable soil moisture meter was used at the depth of 5 cm at various locations. The readings in terms of wet soil and dry soil were noted. The treatments showing wet were not provided irrigation.

3.7.4 Quality parameters

Total Soluble Solids (°Brix)

For measurement of Total Soluble Solids first the refractometer (HANNA HI96081) was calibrated using distilled water. A small portion of representative fruits (5) and juice was squeezed out to create the sample few drops of the brinjal juice were dropped onto the prism of the refractometer using a sterile dropper ensuring that the juice was distributed equally. TSS value was shown in degrees Brix on the digital display.

Moisture content of fruit (%)

For measurement of moisture content first sample of fresh brinjal was taken and washed to get rid of any residue or debris. Fruit was cut it into finer pieces for faster drying. Fresh weight (W_1) of the sample was taken by using an analytical balance. For 48 hours sample was placed in hot air oven maintained at 70°C, after drying it was cooled to room temperature in desiccator. Dry weight (W_2) of the dried sample was taken using the same analytical balance. Moisture content of the fruit was calculated using the formula given below:

$$\text{Moisture content (\%)} = \frac{\text{Initial weight of sample} - \text{final weight of sample}}{\text{Initial weight of sample}} \times 100$$

Dry matter content (%)

The detailed process to calculate per cent dry matter content of brinjal fruit is given above. It was calculated by subtracting per cent moisture content from 100.

Ash content (% on dry weight basis)

The resultant substance obtained from loss of moisture content was then exposed to 600 degrees Celsius for duration of approximately two hours in a muffle furnace. The resulting ash showed a whitish colour was subsequently allowed to cool to room temperature in dessicator. Dried sample weight was taken as initial weight and weight of resulting ash was taken as final weight. Ash content was calculated by using following formula:

$$\text{Ash value (\% on dry weight basis)} = \frac{\text{Initial weight– final weight}}{\text{Initial weight}} \times 100$$

3.7.5 Economic analysis

Cost of cultivation (₹/acre)

The cost incurred for the cultivation was determined by using current pricing for all supplies and labour expenses at the time they were used.

Gross return (₹/acre)

The total revenue generated from harvested fruits was calculated using the ongoing market value. Gross return per treatment was calculated using the following formula:

$$\text{Gross return} = \text{Market price} \times \text{Yield (in kg per ha)}$$

Net return (₹/acre)

Net return was calculated by subtracting cost of cultivation from gross return.

Benefit cost ratio

Benefit cost ratio was calculated by using the formula below:

$$\text{B: C ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

3.8.5 Statistical analysis

All observations recorded during the experimental investigation were systematically compiled and tabulated. The data were analyzed using Analysis of Variance (ANOVA) appropriate for a Factorial Randomized Block Design (FRBD) to evaluate the significance of treatment effects. The Critical Difference (CD) at 5% level of significance was calculated to compare treatment means. All statistical computations, including ANOVA and mean comparisons, were performed using OP-STAT software to ensure accurate and reliable interpretation of the results.

Table 3.11: Skeleton of ANOVA

Source of variation	**Sum of Square (SS)**	**Degree of Freedom (DF)**	**Mean Square(MS)**	**F-Value**
Factor V (AVS)	SS_V	v–1	$MS_V = SS_V/v-1$	$F_0 = MS_V / MS_H$
Factor H (Hydrogel)	SS_H	h–1	$MS_H = SS_h/h-1$	$F_0 = MS_H / MS_E$
Interaction (V×H)	SS_{VH}	(v–1)(h–1)	$MS_{VH} = SS_{VH}/(v-1)(h-1)$	$F_0 = MS_{VH} / MS_E$
Error	SS_E	vh(n–1)	$MS_E = SS_E/vh(n-1)$	
Total	SS_T	vhn–1		

Where,

v = number of levels of Factor V

h = number of levels of Factor H

n = number of replications (or blocks) per treatment combination

SS= sum of squares for each source

MS = mean squares (SS divided by DF)

F_0= calculated F-value for hypothesis testing

CHAPTER 4

RESULT AND DISCUSSION

The observations recorded on different features of growth, yield and quality of brinjal as influenced by biostimulant and moisture conservation practice are discussed in this chapter. To facilitate comparison and comprehension of the results are methodically recorded in both tabular and graphical representations. The mean performance data provides a thorough summary of the effects of various treatments on brinjal physiological and agronomic characteristics. The effectiveness of both individual and combined treatments has been evaluated critically for each character providing important insights into the way biostimulants and moisture conservation practice can improve brinjal quality and productivity in Punjab's agroclimatic conditions. In addition to advancing our scientific knowledge of brinjal crop management these findings offer farmers useful advice on how to increase production sustainability and resource efficiency.

4. GROWTH PARAMETERS

4.1 Plant height (cm)

Plant height showed significant variations among the treatments in both the growing years 2023 and 2024. For easy and comparative understanding the results are shown in **Table 4.1 and Figures 4.1, 4.2** and discussed underneath:

The application of hydrogel 1.5 kg/acre (H_2) significantly improved plant height at 55 and 70 days post-transplanting with final heights of 34.69 cm and 54.30 cm respectively in 2023. This was markedly better than the 1.0 kg/acre (H_1) and control which had lower heights of 33.54 cm (55 DAT) and 51.74 cm (70 DAT) respectively. For AVS, 5 g/L (V_2) achieved higher plants of 35.87 cm (55 DAT) and 55.11 cm (70 DAT) compared to the control (V_0) which had heights of 32.07 cm (55 DAT) and 51.12 cm (70 DAT), respectively. The best results were observed with the combination of V_2 + H_2 with plant height 36.47 cm (55 DAT) and 59.26 cm (70 DAT) while the lowest height were noted with V_0 + H_0 at 31.25 cm and 50.8 cm at both the observations.

In 2024, hydrogel at 1.5 kg/acre (H_2) again significantly enhanced plant heights at 55 and 70 days with averages of 37.54 cm and 56.49 cm. The 1.0 kg/acre (H_1) and 0 kg/acre (H_0) showed lower plant heights of 36.48 cm (55 DAT) and 53.47 cm (70 DAT). The biostimulant at V_2 resulted in plant heights of 39.17 cm (55 DAT) and 57.32 cm (70 DAT) significantly higher than the control (V_0) which had heights of 34.71 cm (55 DAT) and 52.62 cm (70 DAT). The highest growth was achieved with the combination of V_2 + H_2 39.70 cm (55 DAT) and 61.52 cm (70 DAT). The lowest plant heights were found in control measuring 33.95 cm and 52.14 cm at both the observations.

During both years, hydrogel at 1.5 kg/acre (H_2) consistently produced the highest plant heights with averages of 36.14 cm (55 DAT) and 55.40 cm (70 DAT). These were significantly higher than the control (H_0) which had average heights of 34.62 cm and 52.62 cm. The biostimulant at 5 g/L (V_2) also showed a significant impact with average heights of 37.25 cm (55 DAT) and 56.22 cm (70 DAT) compared to the control (V_0) which had lower heights of 33.41 cm (55 DAT) and 51.88 cm (70 DAT). The best plant growth was achieved with V_2 + H_2 with average 38.11 cm and 60.40 cm. The lowest heights were observed with V_0-0 g/L + H_0-0.0 kg/acre at 32.60 cm and 51.47 cm at both the observations.

Hydrogels enhance soil water availability, maintaining plant water potential and cell turgor which supports continuous cell expansion and elongation. They improve root hydraulic conductivity and nutrient absorption sustains photosynthetic efficiency and optimizes the physiological status of the plant collectively resulting in increased plant height and vegetative growth. Similar phenomena was observed by **El Saied *et al*., 2016** in rice straw based hydrogel. Additionally, applying AVS supported plant growth by applying crucial elements necessary for development. The plants that are being treated demonstrated a notable rise in height, highlighting the importance of proper nutrition for optimal growth. The combination of hydrogels and micronutrients can greatly improve the height of brinjal plants by creating a consistent growing environment with sufficient water retention and nutrient supply. Similar findings were published by **Suganiya *et al*. (2015)** in brinjal by using foliar spray of boron.

Table 4.1: Analysis of plant height (cm) as influenced by hydrogel and AVS

2023						**2024**						**POOLED**					
55 DAT																	
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	31.25	31.77	32.99	32.28	32.07	**V_0**	33.95	34.36	35.52	35.04	34.71	**V_0**	32.60	33.07	34.29	33.66	33.41
V_1	34.21	33.65	34.63	35.12	34.40	**V_1**	36.91	36.47	37.38	38.02	37.19	**V_1**	34.71	35.06	36.01	35.51	35.33
V_2	35.96	35.21	36.47	35.83	35.87	**V_2**	39.19	38.63	39.70	39.15	39.17	**V_2**	36.54	36.92	38.11	37.44	37.25
Mean	33.80	33.54	34.69	34.41		**Mean**	36.68	36.48	37.54	37.40		**Mean**	34.62	35.02	36.14	35.54	
		V	**H**	**V × H**				**V**	**H**	**V × H**				**V**	**H**	**V × H**	
CD (p=0.05)		0.008	0.01	0.017		**CD (p=0.05)**		0.012	0.013	0.023		**CD (p=0.05)**		0.016	0.018	0.032	
SE(m) ±		0.003	0.003	0.006		**SE(m) ±**		0.004	0.005	0.008		**SE(m) ±**		0.005	0.006	0.011	
70 DAT																	
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	50.8	51.02	51.43	51.24	51.12	**V_0**	52.14	52.44	52.99	52.93	52.62	**V_0**	51.47	51.73	52.21	52.09	51.88
V_1	51.72	52.01	52.22	52.17	52.03	**V_1**	53.48	53.88	54.98	54.18	54.13	**V_1**	52.60	52.95	53.60	53.18	53.08
V_2	52.72	53.36	59.26	55.12	55.11	**V_2**	54.81	55.49	61.52	57.47	57.32	**V_2**	53.77	54.43	60.40	56.30	56.22
Mean	51.74	52.13	54.30	52.84		**Mean**	53.47	53.93	56.49	54.86		**Mean**	52.62	53.04	55.40	53.86	
		V	**H**	**V × H**				**V**	**H**	**V × H**				**V**	**H**	**V × H**	
CD (p=0.05)		1.22	1.41	2.44		**CD (p=0.05)**		0.016	0.019	0.023		**CD (p=0.05)**		0.615	0.71	1.23	
SE(m) ±		0.41	0.47	0.82		**SE(m) ±**		0.006	0.006	0.011		**SE(m) ±**		0.208	0.241	0.417	

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L V=Arka Vegetable Special H=hydrogel

Figure 4.1: Analysis of plant height (cm) 55 DAT as influenced by hydrogel and AVS

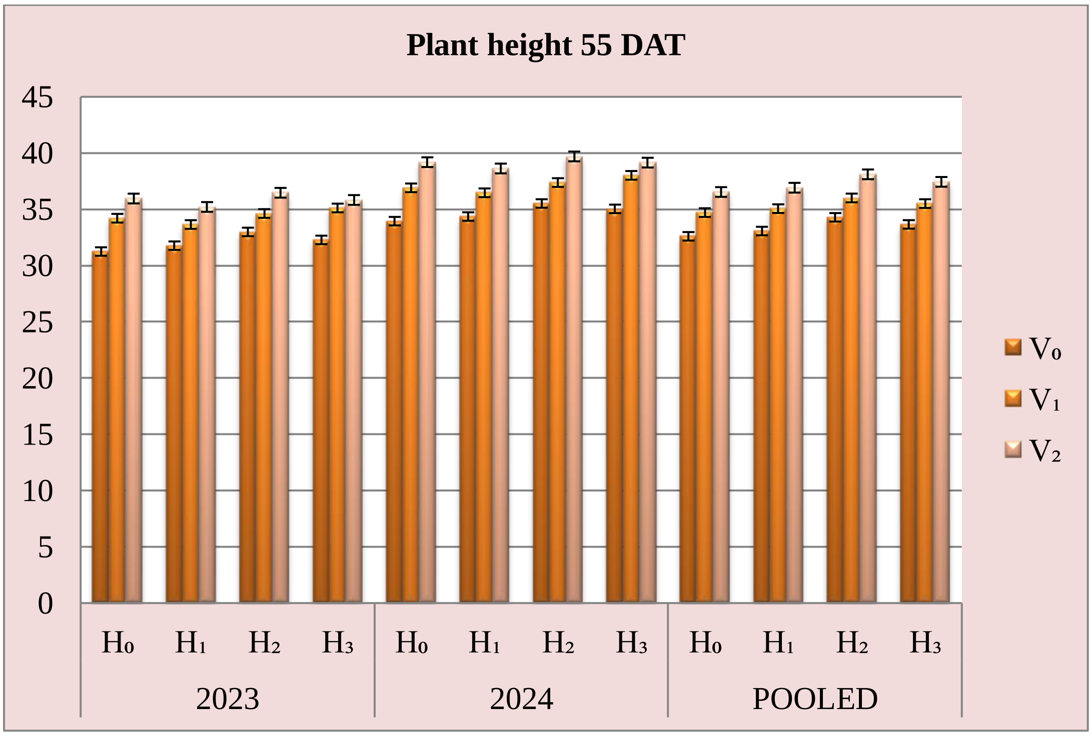
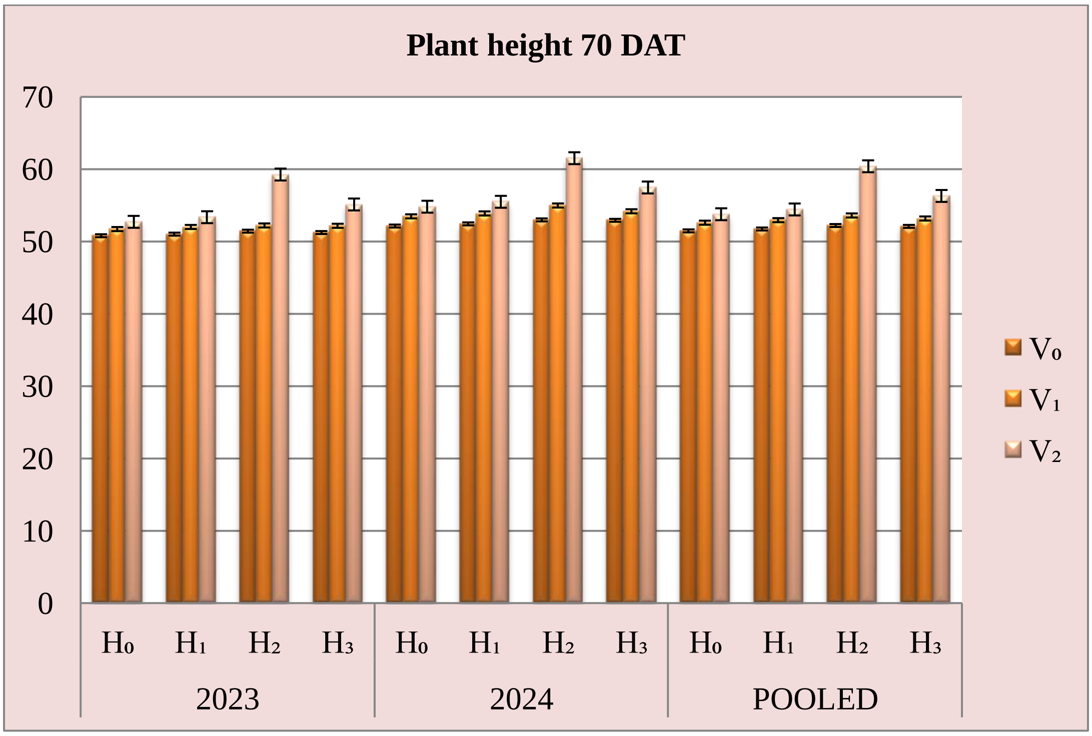


Figure 4.2: Analysis of plant height (cm) 70 DAT as influenced by hydrogel and AVS



4.2 Number of leaves per plant

Number of leaves per plant showed significant variations among the treatments in both the years 2023 and 2024 as evident by ANOVA. For easy and comparative understanding the results are shown in **Figure 4.3, 4.4** and **Table 4.2** and discussed here. In 2023, the hydrogel treatment at H_2 the most effective resulting in significantly higher number of leaves 28.69 and 46.50. The control (H_0) had significantly less number of leaves 27.31 and 45.99. Biostimulant application at 5 g/L (V_2) similarly resulted in maximum number of leaves 30.00 (55 DAT) and 47.37 (70 DAT) compared to the control (V_0) with number of 26.08 (55 DAT) and 45.44 (70 DAT). The combination of V_2-5 g/L + H_2-1.5 kg/acre shows the maximum number of leaves with values of 30.64 and 47.50 whereas the less number of leaves were found with V_0-0 g/L + H_0-0.0 kg/acre 25.19 and 45.00 at both the observations.

In 2024, the hydrogel treatment at 1.5 kg/acre (H_2) again showed superior results with number of leaves 29.99 (55 DAT) and 48.50 (70 DAT). The control (H_0) had less number of leaves 27.86 (55 DAT) and 45.51 (70 DAT). Biostimulant at 5 g/L (V_2) also led to maximum number of leaves 31.95 (55 DAT) and 50.83 (70 DAT) compared to (V_0) with 25.69 (55 DAT) and 42.53 (70 DAT) number of leaves. The combination of V_2-5 g/L + H_2-1.5 kg/acre produced the maximum number with average of 32.83 and 51.83. The combination of V_0-0 g/L + H_0-0.0 kg/acre resulted in the less number 23.54 and 40.14 at both the observations.

Combining data from both years, hydrogel at 1.5 kg/acre (H_2) consistently resulted in maximum number of leaves with average of 29.34 (55 DAT) and 48.16 (70 DAT) which were significantly higher than the control (H_0) with averages of 27.59 (55 DAT) and 46.11 (70 DAT). The biostimulant at 5 g/L (V_2) also showed a significant increase in number of leaves average 30.98 (55 DAT) and 49.96 (70 DAT) in contrast to the control (V_0), which had averages of 25.88 (55 DAT) and 44.07 (70 DAT). The optimal growth combination was V_2+ H_2 with average number of 31.74 and 50.75. The less number of leaves were observed with V_2 + H_0 at 24.37 and 42.57 at both the observations. The combination of water retention and nutrient availability promotes healthier growth overall, which directly translates into an increase in the number of leaves. Similar results were observed by **Mahgoub (2020)** in tomato used hydrogel led increase in cation exchange capacity and **Sultana *et al.* (2016)** in tomatoes used super water absorbent.

Figure 4.3: Analysis of number of leaves 55 DAT as influenced by hydrogel and AVS

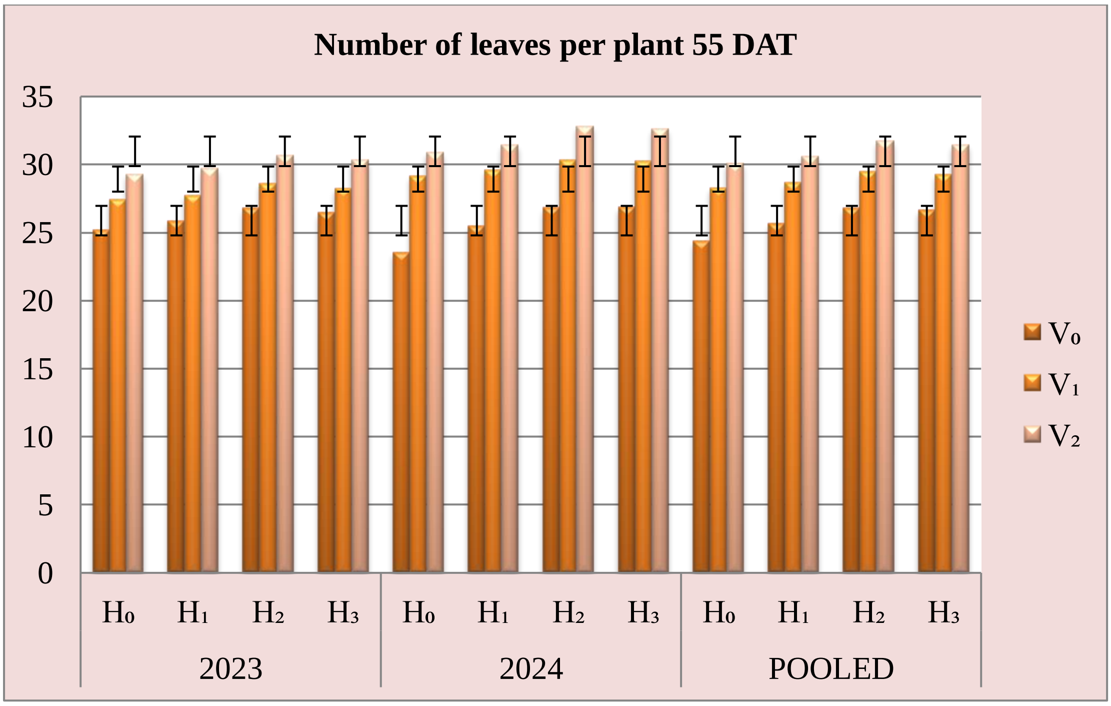


Figure 4.4: Analysis of number of leaves 70 DAT as influenced by hydrogel and AVS

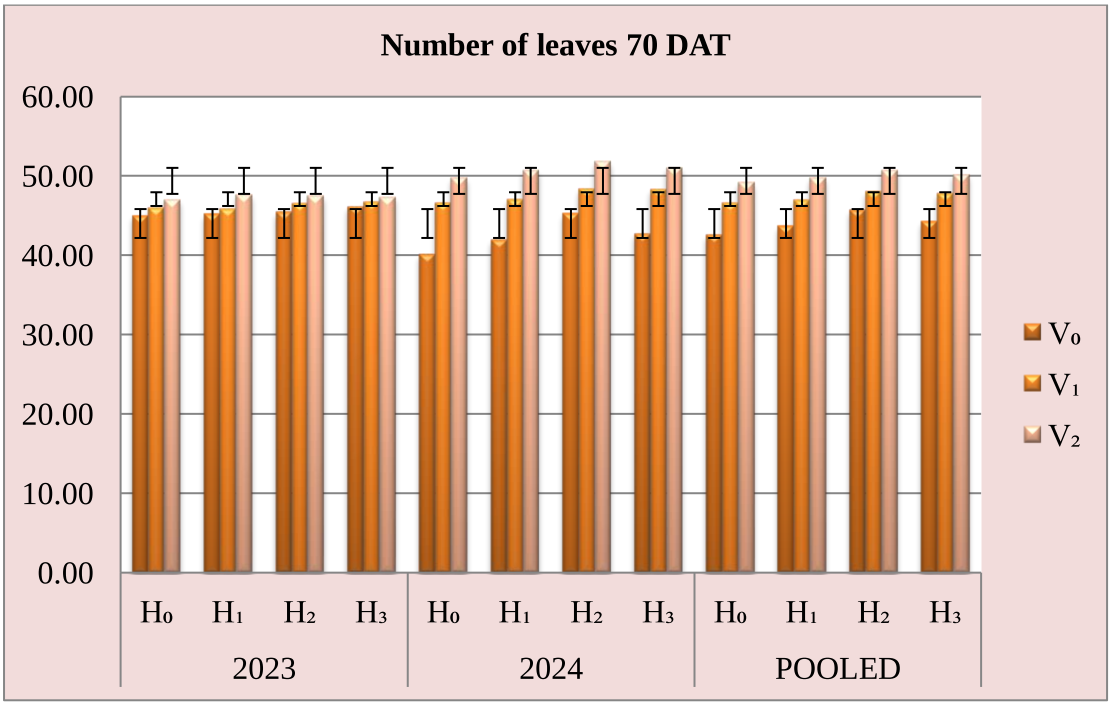


Table 4.2: Analysis of number of leaves per plant as influenced by hydrogel and AVS

2023						2024						POOLED					
55 DAT																	
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	25.19	25.87	26.78	26.46	26.08	**V_0**	23.54	25.49	26.83	26.88	25.69	**V_0**	24.37	25.68	26.81	26.67	25.88
V_1	27.44	27.73	28.64	28.27	28.02	**V_1**	29.16	29.62	30.32	30.28	29.85	**V_1**	28.30	28.68	29.48	29.28	28.94
V_2	29.31	29.73	30.64	30.32	30.00	**V_2**	30.89	31.45	32.83	32.62	31.95	**V_2**	30.10	30.59	31.74	31.47	30.98
Mean	27.31	27.78	28.69	28.35		**Mean**	27.86	28.85	29.99	29.93		**Mean**	27.59	28.32	29.34	29.14	

	V	**H**	**V × H**		**V**	**H**	**V × H**		**V**	**H**	**V × H**
CD (p=0.05)	0.026	0.03	0.051	**CD (p=0.05)**	0.027	0.031	0.054	**CD (p=0.05)**	0.011	0.013	0.022
SE(m) ±	0.051	0.01	0.017	**SE(m) ±**	0.009	0.011	0.018	**SE(m) ±**	0.004	0.004	0.007

70 DAT																	
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	45.00	45.22	45.45	46.10	45.44	**V_0**	40.14	41.95	45.29	42.75	42.53	**V_0**	42.57	43.69	45.71	44.30	44.07
V_1	45.99	45.86	46.56	46.76	46.29	**V_1**	46.63	47.07	48.39	48.34	47.61	**V_1**	46.60	47.03	48.02	47.84	47.37
V_2	47.00	47.64	47.50	47.35	47.37	**V_2**	49.76	50.69	51.83	51.05	50.83	**V_2**	49.16	49.78	50.75	50.14	49.96
Mean	45.99	46.24	46.50	46.74		**Mean**	45.51	46.57	48.50	47.38		**Mean**	46.11	46.83	48.16	47.42	

	V	**H**	**V × H**		**V**	**H**	**V × H**		**V**	**H**	**V × H**
CD (p=0.05)	0.17	0.20	0.34	**CD (p=0.05)**	0.028	0.033	0.057	**CD (p=0.05)**	0.02	0.03	0.05
SE(m) ±	0.05	0.06	0.11	**SE(m) ±**	0.01	0.01	0.019	**SE(m) ±**	0.009	0.001	0.018

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.3 Absolute growth rate (cm/day)

Absolute growth rate showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the observations are shown in **Figure 4.5** and **Table 4.3** and discussed below:

In 2023, the hydrogel treatment at 1.5 kg/acre (H_2) was the most effective resulting in significantly higher absolute growth rate 1.31 cm/day. The control (H_0) had less absolute growth rate 1.20 cm/day. AVS application at 5 g/L (V_2) similarly resulted in maximum absolute growth rate 1.28 cm/day compared to the (V_1) with growth rate of 1.18 cm/day. The combination of V_2-5 g/L + H_2-1.5 kg/acre showed the maximum absolute growth rate with 1.52 cm/day whereas; the least absolute growth rate was found with V_0-0 g/L + H_0-0.0 kg/acre 1.11 cm/day.

In 2024, the hydrogel treatment at 0 kg/acre (H_0) showed superior results with absolute growth rate (1.32 cm/day). The 1.5 kg/acre (H_2) had less absolute growth rate 1.16 cm/day. AVS at (V_0) also led to maximum absolute growth rate 1.37 cm/day compared to 5 g/L (V_2) with growth rate of 1.12 cm/day. The combination of V_0-0 g/L + H_0-0 kg/acre produced the maximum growth rate with average of 1.45 cm/day. The combination of V_2-5 g/L + H_2-1.5 kg/acre resulted in the less growth rate 0.95 cm/day.

Combining data from both the years, hydrogel at 1.5 kg/acre (H_2) resulted in maximum absolute growth rate with average of 1.29 cm/day which was significantly higher than control (H_0) with averages of 1.16 cm/day. The AVS at 5 g/L (V_2) also showed increase in absolute growth rate average 1.25 cm/day in contrast to the control (V_1) which had averages of 1.15 cm/day. The optimal growth combination was V_2-5 g/L + H_2-1.5 kg/acre with average growth rate of 1.45 cm/day. The less absolute growth rates were observed with V_2 + H_0 at 1.08 cm/day.

Hydrogels maintain consistent soil moisture, reducing water stress and sustaining photosynthesis, respiration, and metabolic enzyme activity. They enhance nutrient uptake and assimilation, improve root function, and reduce oxidative stress, providing steady biochemical resources for cell division, elongation, and biomass accumulation**,** which increases the plant's absolute growth rate. The outcomes are consistent with the conclusions of **Abdelghafar *et al.* (2024)** in lettuce, where water absorbing polymers increased water availability and retention for plants. **Chankachang *et al.* (2024)** reported higher nutrient availability and uptake resulting from combining hydrogels with biostimulants led to rise in absolute growth rate.

Figure 4.5: Analysis of absolute growth rate (cm/day) as influenced by hydrogel and AVS

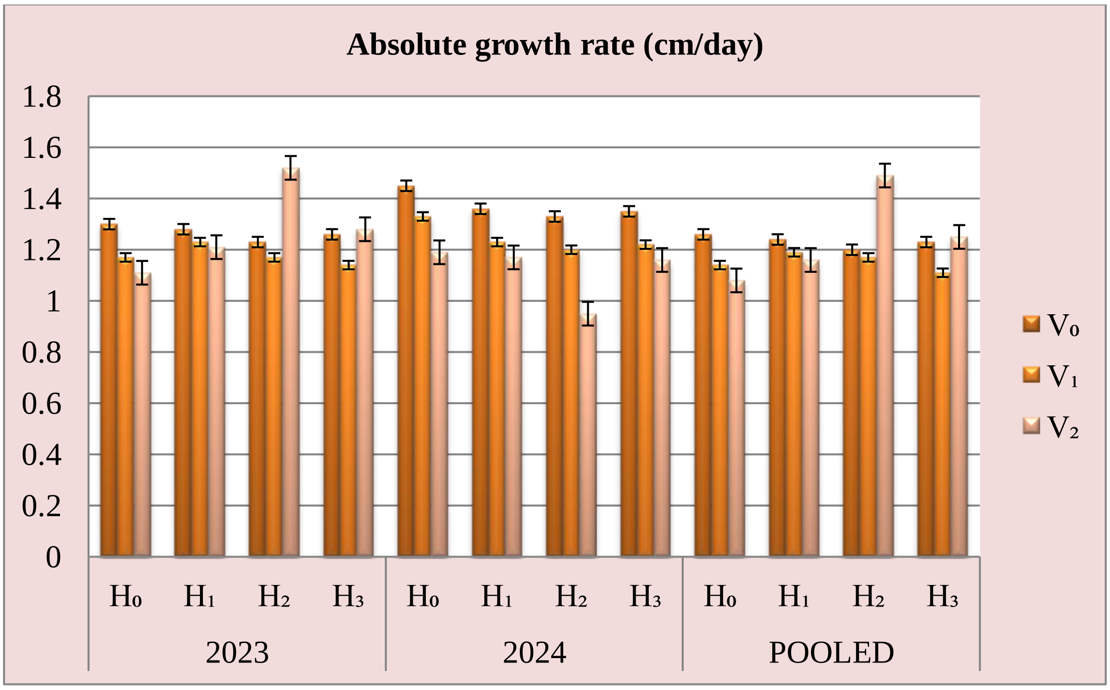


Table 4.3: Analysis of absolute growth rate (cm/day) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.30	1.28	1.23	1.26	1.27
V_1	1.17	1.23	1.17	1.14	1.18
V_2	1.11	1.21	1.52	1.28	1.28
Mean	1.20	1.24	1.31	1.23	
	V		**H**		**V × H**
CD (p=0.05)	0.08		N/A		0.16
SE(m) ±	0.028		0.032		0.055
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**

V_0	1.45	1.36	1.33	1.35	1.37
V_1	1.33	1.23	1.20	1.22	1.25
V_2	1.19	1.17	0.95	1.16	1.12
Mean	1.32	1.25	1.16	1.24	
	V	**H**	**V × H**		
CD (p=0.05)	0.01	0.02	0.03		
SE(m) ±	0.006	0.007	0.013		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.26	1.24	1.20	1.23	1.23
V_1	1.14	1.19	1.17	1.11	1.15
V_2	1.08	1.16	1.49	1.25	1.25
Mean	1.16	1.20	1.29	1.20	
	V	**H**	**V × H**		
CD (p=0.05)	0.041	0.047	0.082		
SE(m) ± ±	0.014	0.016	0.028		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.4 Leaf length (cm)

Leaf length showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the observations are shown in **Figure 4.6, 4.7** and **Table 4.4** and discussed here:

In 2023, hydrogel at 1.5 kg/acre (H_2) was shown to be the most successful with leaf length reaching 12.36 cm, 15.84 cm at 55 and 70 days, respectively. These lengths were significantly greater than those of the control (H_0) which had minimum leaf length of 11.22 cm and 14.79 cm. The biostimulant treatment of 5 g/L (V_2) also significantly improved leaf length to 13.63 cm (55 DAT) and 16.78 cm (70 DAT) compared to the control (V_0) which had leaf length of 10.22 cm (55 DAT) and 13.82 cm (70 DAT). Notable results with V_2 + H_2 (55 DAT) and V_2 + H_2 (70DAT) achieved leaf length of 14.49 cm and 17.31 cm. The combination of V_0 + H_0 showed the lowest length at 9.72 cm and 13.35 cm at both the observations.

In 2024, hydrogel at 2.0 kg/acre (H_3) and 1.5 kg/acre (H_2) again demonstrated a significant positive effect on leaf length with average of 13.48 cm (55 DAT) and 16.85 cm (70 DAT) respectively. The control (H_0) had significantly lower leaf length of 12.73 cm (55 DAT) and 15.62 cm (70 DAT). The biostimulant application of 5 g/L (V_2) resulted in leaf length of 14.49 cm (55 DAT) and 17.76 cm (70 DAT) whereas the control (V_0) showed minimum leaf length of 11.91 cm (55 DAT) and 14.58 cm (70 DAT). V_2 + H_3, V_2 + H_2 led to the highest leaf length with average of 15.12 cm and 18.14 cm. Conversely, the combination of V_0 + H_0 had lowest leaf length measuring 11.61 cm and 13.88 cm at both the observations.

The combined data for 2023 and 2024 showed that hydrogel at 2.0 kg/acre (H_3) and 1.5 kg/acre (H_2) consistently led to the highest leaf length average 12.90 cm (55 DAT) and 16.35 cm (70 DAT). These were significantly higher compared to the control (H_0), with average leaf length of 11.98 cm (55 DAT) and 15.21 cm (70 DAT). The biostimulant at 5 g/L (V_2) also significantly improved leaf length with average of 14.06 cm (55 DAT) and 17.27 cm (70 DAT) compared to the control (V_0) which had lower average of 11.07 cm (55 DAT) and 14.20 cm (70 DAT). The optimal combination was V_2-5 g/L + H_3-2.0 kg/acre and V_2 + H_2 resulting in the highest leaf length of 14.81 cm and 17.73 cm. The lowest average leaf length was noted V_2 + H_0 at 10.67 cm and 13.62 cm at both the observations.

Moisture conservation practice helped to prevent dehydration and water stress both of which can lead to decrease in leaf length. Hydrogel promoted ideal leaf elongation by sustaining a steady water supply. By providing vital minerals like iron, which is necessary the micronutrient therapy improved leaf growth. Increased leaf length was a result of the nutritional availability, which encouraged cellular growth and elongation as reported by **(Tripathi *et al.*, 2015)**.

Dubey *et al*. (2013) observed in chili by using foliar sprays of borox. The combination of appropriate nutrient levels (micronutrients) and sufficient moisture (hydrogels) optimizes photosynthetic efficiency, giving more energy for leaf elongation and development.

Figure 4.6: Analysis of leaf length (cm) 55 DAT as influenced by hydrogel and AVS

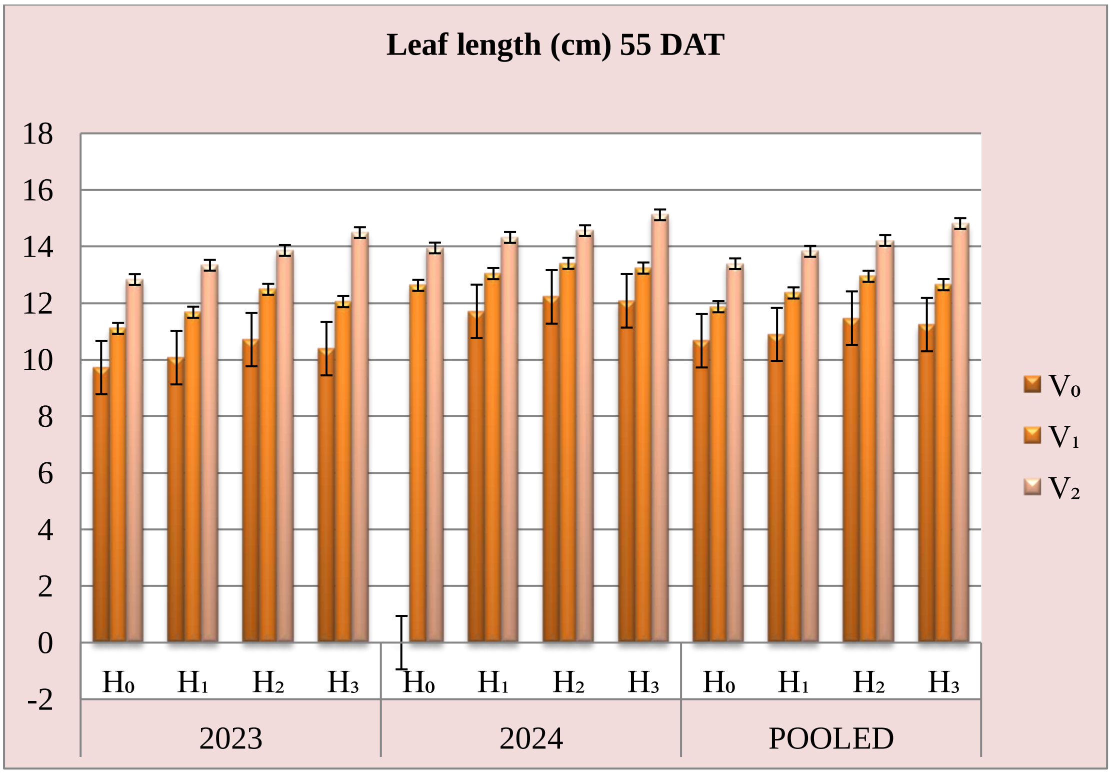


Figure 4.7: Analysis of leaf length (cm) 70 DAT as influenced by hydrogel and AVS

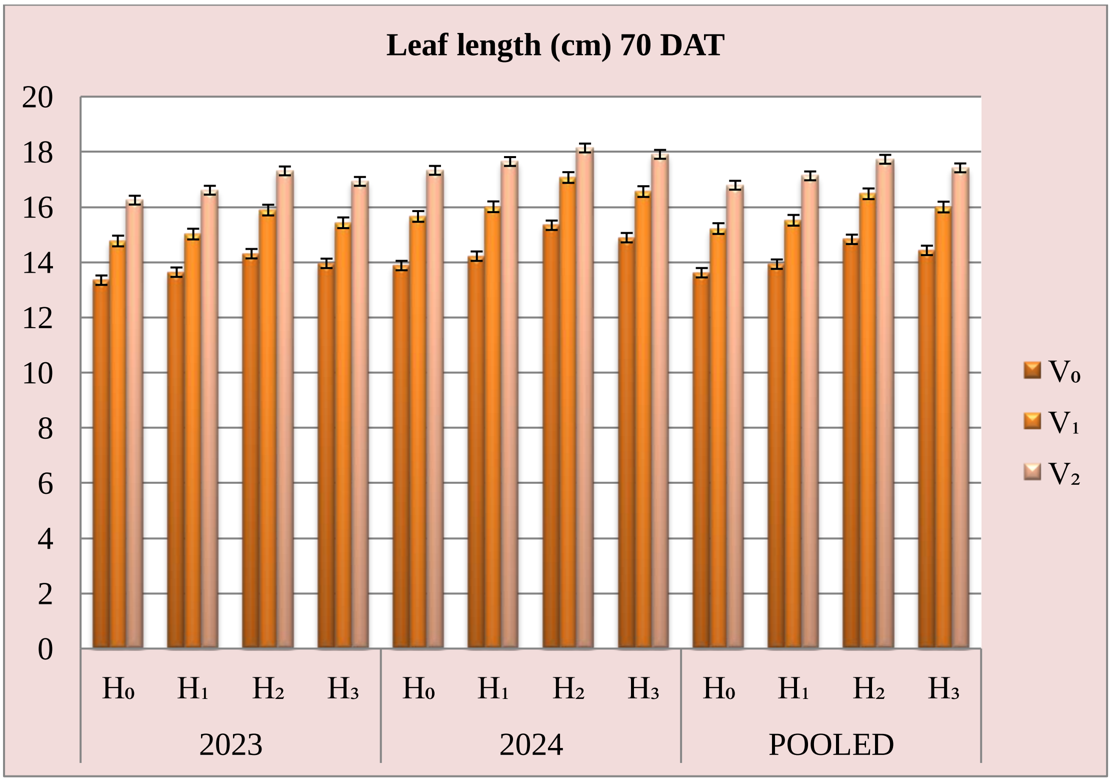


Table 4.4: Analysis of leaf length (cm) as influenced by hydrogel and AVS

2023

T	H_0	H_1	H_2	H_3	Mean
55 DAT					
V_0	9.72	10.07	10.71	10.39	10.22
V_1	11.11	11.68	12.49	12.05	11.83
V_2	12.83	13.34	13.86	14.49	13.63
Mean	11.22	11.70	12.36	12.31	
	V	H	V × H		
CD (p=0.05)	0.007	0.008	0.014		
SE(m) ±	0.002	0.003	0.005		
70 DAT					
V_0	13.35	13.64	14.31	13.96	13.82
V_1	14.77	15.02	15.89	15.43	15.28
V_2	16.25	16.61	17.31	16.93	16.78
Mean	14.79	15.09	15.84	15.44	
	V	H	V × H		
CD (p=0.05)	0.01	0.01	0.01		
SE(m) ±	0.003	0.004	0.007		

2024

T	H_0	H_1	H_2	H_3	Mean
55 DAT					
V_0	11.61	11.71	12.22	12.08	11.91
V_1	12.63	13.04	13.41	13.24	13.08
V_2	13.95	14.32	14.56	15.12	14.49
Mean	12.73	13.02	13.40	13.48	
	V	H	V × H		
CD (p=0.05)	0.011	0.013	0.022		
SE(m) ±	0.004	0.004	0.007		
70 DAT					
V_0	13.88	14.22	15.34	14.89	14.58
V_1	15.66	16.01	17.07	16.56	16.33
V_2	17.33	17.65	18.14	17.91	17.76
Mean	15.62	15.96	16.85	16.46	
	V	H	V × H		
CD (p=0.05)	0.007	0.008	0.015		
SE(m) ±	0.002	0.003	0.005		

POOLED

T	H_0	H_1	H_2	H_3	Mean
55 DAT					
V_0	10.67	10.89	11.47	11.24	11.07
V_1	11.87	12.36	12.95	12.65	12.46
V_2	13.39	13.83	14.21	14.81	14.06
Mean	11.98	12.36	12.88	12.90	
	V	H	V × H		
CD (p=0.05)	0.006	0.007	0.012		
SE(m) ±	0.002	0.002	0.004		
70 DAT					
V_0	13.62	13.93	14.83	14.43	14.20
V_1	15.22	15.52	16.48	16.00	15.81
V_2	16.79	17.13	17.73	17.42	17.27
Mean	15.21	15.53	16.35	15.95	
	V	H	V × H		
CD (p=0.05)	0.014	0.016	0.028		
SE(m) ±	0.005	0.006	0.01		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.5 Leaf width (cm)

Leaf width showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding, the results are shown in **Figure 4.8, 4.9** and **Table 4.5** and presented below:

In the first year of the study 2023, notable differences in leaf width were observed with varying treatments. The application of hydrogel at 1.5 kg/acre (H_2) consistently resulted in the largest leaf width at each measurement interval with leaf width reaching 9.26 cm and 10.27 cm at 55 and 70 days, respectively. This was significantly higher compared to the control (H_0) which recorded leaf width of 8.51 cm and 9.52 cm. Similarly the biostimulant applied at 5 g/L (V_2) led to increased leaf width of 9.87 cm (55 DAT) and 10.88 cm (70 DAT) surpassing the control (V_0), which had lowest leaf width of 7.74 cm (55 DAT) and 8.75 cm (70 DAT). The interaction of V_2 + H_2 proved to be the most effective resulting in the largest leaf width overall leaf growth with measurements of 10.16 cm and 11.17 cm while the least growth was observed with the combination of V_0 + H_0 showing leaf width of 7.28 cm and 8.29 cm at both the observations.

The trends observed in 2023 were consistent in 2024, with hydrogel at 1.5 kg/acre (H_2) again producing the maximum leaf width at 9.46 cm (55 DAT) and 10.56 cm (70 DAT) across the same intervals. The control (H_0) continued to show minimum leaf width recorded at 8.13 cm (55 DAT) and 9.52 cm (70 DAT). The biostimulant treatment at 5 g/L (V_2) maintained its positive impact leaf width of 11.09 cm (55 DAT) and 11.54 cm (70 DAT) whereas the V_0 had reduced leaf width at 7.06 cm and 8.76 cm. The combination of V_2 + H_3 remained the most effective achieving leaf width of 12.33 cm and 12.36 cm while the combination of V_0 + H_0 resulted in the lowest measurements, with leaf width reaching 6.62 cm and 8.29 cm at both the observations.

Across both years, the data consistently demonstrated that hydrogel at 1.5 kg/acre (H_2) was the most effective treatment for enhancing leaf width with combined average of 9.36 cm (55 DAT) and 9.87 cm (70 DAT). These leaf widths were significantly greater than those recorded in the (H_0) which average 8.32 cm (55 DAT) and 8.83 cm (70 DAT). The biostimulant at 5 g/L (V_2) also consistently outperformed the control

(V_0) with average leaf width of 10.45 cm (55 DAT) and 10.98 cm (70 DAT) compared to 7.40 cm and 7.90 cm. The optimal growth conditions were achieved with the V_2 + H_2 combination 10.94 cm and 11.45 cm which produced the highest overall leaf width while the V_0 + H_0 combination resulted in the least growth 6.95 cm and 7.46 cm at both the observations.

Hydrogel reduced drought stress helps maintain higher levels of growth hormones like cytokinins and auxins which stimulate leaf expansion. It also lower oxidative stress and support stronger root growth, enabling better water and nutrient uptake resulting in wider leaves.Plants were able to fully stretch their leaves, producing wider leaves, by using hydrogel to ensure soil hydration. The leaves reached their full breadth because water stress was avoided by providing constant moisture availability **(El Hady *et al.*, 2012)**. Important nutrients from the AVS aided in the development of wider leaves. The growth of broad, robust leaves, which increases the photosynthetic surface area and general vigor of the plant, depends on nutrients like potassium and magnesium. **Pandiyan *et al.* (2018)** and **Goyal *et al*. (2017)** used foliar application of micronutrients Zn, Mn, B and C in onions. The interaction between hydrogels and micronutrients promotes the leaf width of brinjal by ensuring water levels and maximizing nutrient uptake.

Figure 4.8: Analysis of leaf width (cm) 55 DAT as influenced by hydrogel and AVS

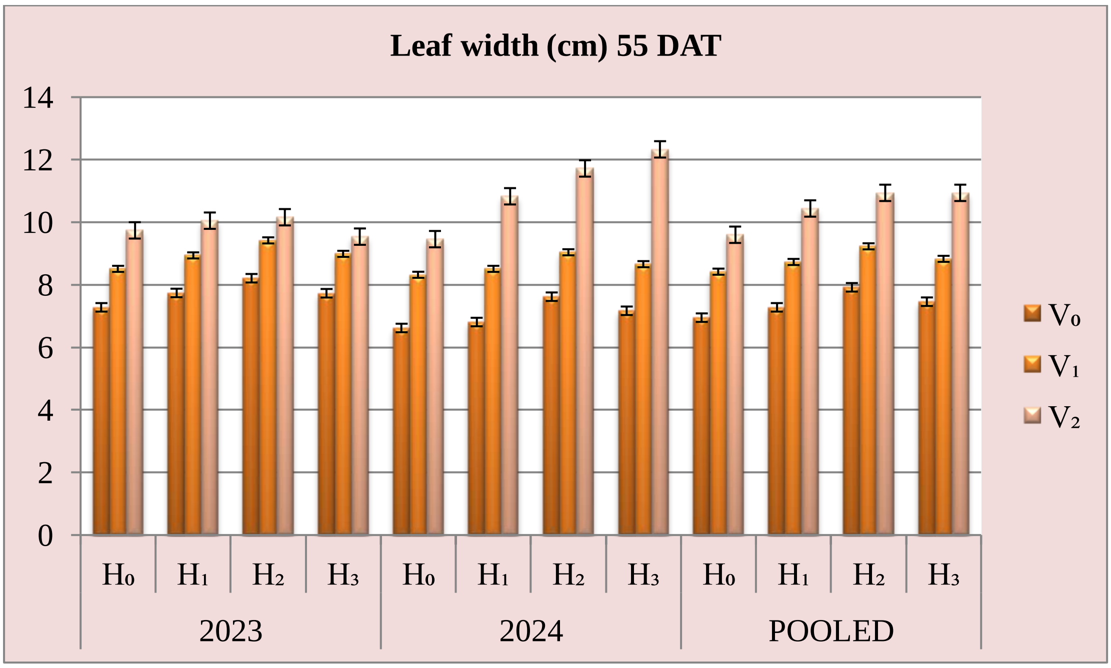


Figure 4.9: Analysis of leaf width (cm) 70 DAT as influenced by hydrogel and AVS

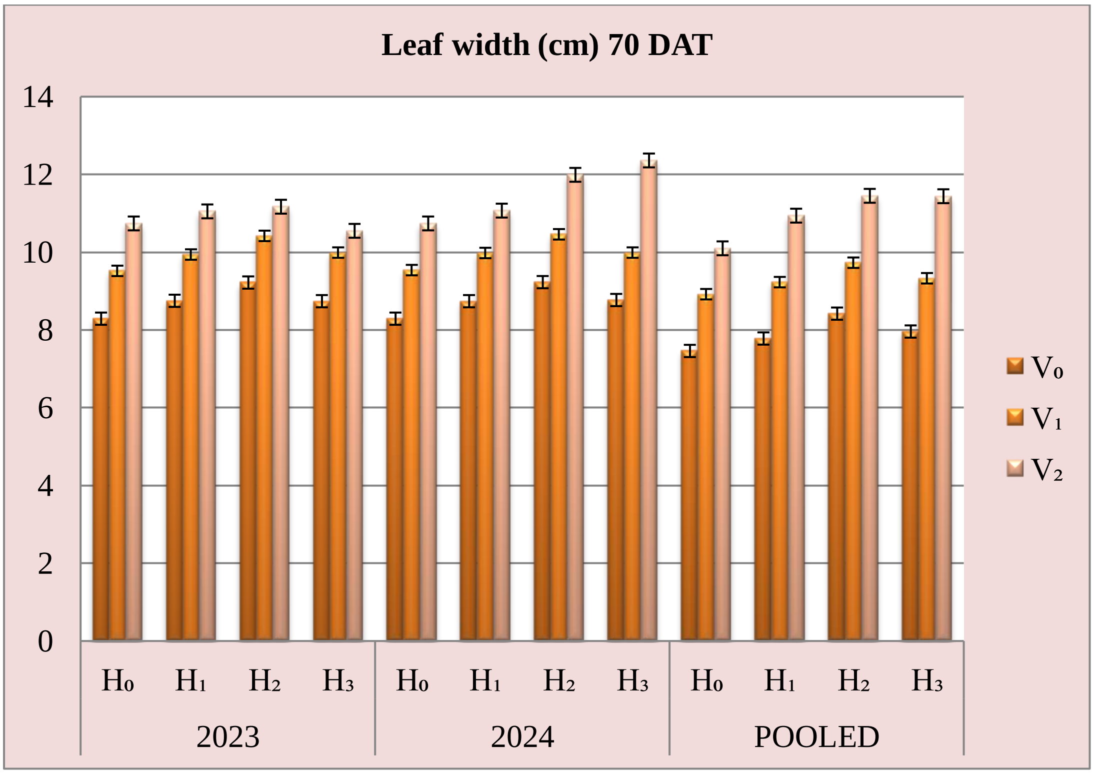


Figure 4.10: Analysis of petiole length (cm) as influenced by hydrogel and AVS

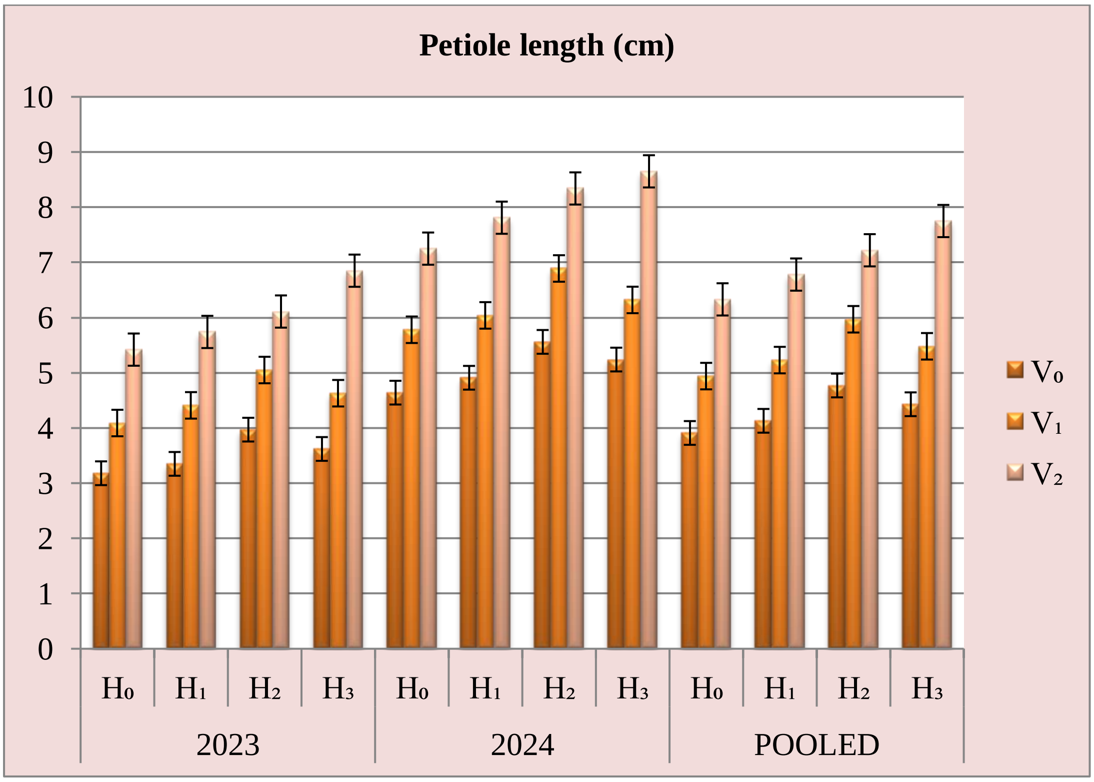


Table 4.5: Analysis of average leaf width (cm) as influenced by hydrogel and AVS

2023						2024						POOLED					
55 DAT																	
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	7.28	7.74	8.21	7.73	7.74	**V_0**	6.62	6.81	7.62	7.17	7.06	**V_0**	6.95	7.28	7.92	7.46	7.40
V_1	8.51	8.94	9.42	8.99	8.97	**V_1**	8.32	8.51	9.04	8.66	8.63	**V_1**	8.42	8.73	9.23	8.83	8.80
V_2	9.74	10.05	10.16	9.54	9.87	**V_2**	9.46	10.83	11.72	12.33	11.09	**V_2**	9.60	10.44	10.94	10.94	10.48
Mean	8.51	8.91	9.26	8.75		**Mean**	8.13	8.72	9.46	9.39		**Mean**	8.32	8.82	9.36	9.07	

	V	**H**	**V × H**		**V**	**H**	**V × H**		**V**	**H**	**V × H**
CD (p=0.05)	0.111	0.128	0.222	**CD (p=0.05)**	0.008	0.009	0.015	**CD (p=0.05)**	0.056	0.064	0.111
SE(m) ±	0.038	0.043	0.075	**SE(m) ±**	0.003	0.003	0.005	**SE(m) ±**	0.019	0.022	0.038

70 DAT																	
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	8.29	8.75	9.22	8.74	8.75	**V_0**	8.29	8.74	9.23	8.77	8.76	**V_0**	7.46	7.78	8.42	7.96	7.90
V_1	9.52	9.94	10.42	9.99	9.97	**V_1**	9.54	9.98	10.46	9.99	9.99	**V_1**	8.92	9.23	9.73	9.33	9.30
V_2	10.74	11.05	11.17	10.55	10.88	**V_2**	10.74	11.07	11.99	12.36	11.54	**V_2**	10.10	10.94	11.45	11.44	10.98
Mean	9.52	9.91	10.27	9.76		**Mean**	9.52	9.93	10.56	10.37		**Mean**	8.83	9.32	9.87	9.58	

	V	**H**	**V × H**		**V**	**H**	**V × H**		**V**	**H**	**V × H**
CD (p=0.05)	0..007	0.008	0.015	**CD (p=0.05)**	0.005	0.006	0.011	**CD (p=0.05)**	0.006	0.006	0.011
SE(m) ±	0.002	0.003	0.005	**SE(m) ±**	0.002	0.002	0.004	**SE(m) ±**	0.002	0.002	0.004

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.6 Petiole length (cm)

Petiole length showed significant variations among the treatments in both the years under study. For easy and comparative understanding the results are shown in **Table 4.6** and **Figure 4.10** and presented underneath:

In 2023, the application of hydrogel and biostimulants significantly influenced petiole length. The use of hydrogel at 1.5 kg/acre (H_2) led to the maximum petiole length of 5.29 cm. In contrast the control (H_0) had the lowest petiole length measuring 4.23 cm. Biostimulant application at 5 g/L (V_2) also showed positive effects with length of 6.03 cm compared to the control (V_0) 3.53 cm. The maximum growth was observed in the V_2 + H_2 combination reaching 6.85 cm while the combination of V_0 + H_0 resulted in the least growth 3.18 cm.

In 2024, the trends remained consistent with hydrogel at 1.5 kg/acre (H_2) producing the highest petiole length 7.03 cm at the same respective growth stages. The controls (H_0) underperform with petiole length at of 5.89 cm. The biostimulant at 5 g/L (V_2) performed better then the control (V_0) with length of 8.01 cm and 5.09 cm. The most effective treatment combination was V_2 + H_3 resulting in petiole length at of 8.65 cm. The least effective was the combination of V_0 + H_0 where petiole length was 4.64 cm.

Overall, considering data from both years the use of hydrogel at 1.5 kg/acre (H_2) provided the maximum petiole length at 6.16 cm significantly outperforming the control (H_0) which average 5.06 cm. The biostimulant at 5 g/L (V_2) also showed superior results compared to the control (V_0) with overall petiole length of 7.02 cm and 4.31 cm. The combination of V_2 +H_3 showed the maximum petiole length 7.75 cm while the combination of V_0 + H_0 resulted in the lowest length 3.91 cm.

With a consistent supply of moisture, plants may grow more quickly and form pedicels. Hydrogel improve soil moisture retention, which can improve overall plant health. Regular hydration may result in longer pedicles. Through enhanced nutrient absorption and general plant health, AVS may encourage the development of longer pedicles. The interaction of hydrogels and micronutrients ensures stable moisture levels and improves nutrient uptake which in turn leads to longer petioles. **Kumar *et al.* (2018)** have also reported similar result in ginger by applying PUSA hydrogel.

Table 4.6: Analysis of petiole length (cm) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	3.18	3.35	3.97	3.62	3.53
V_1	4.09	4.41	5.05	4.63	4.55
V_2	5.42	5.74	6.11	6.85	6.03
Mean	4.23	4.50	5.29	4.79	
	V	**H**	**V × H**		
CD (p=0.05)	0.01	0.01	0.02		
SE(m) ±	0.003	0.004	0.007		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4.64	4.91	5.56	5.24	5.09
V_1	5.78	6.04	6.89	6.32	6.26
V_2	7.25	7.81	8.34	8.65	8.01
Mean	5.89	6.26	7.03	6.63	
	V	**H**	**V × H**		
CD (p=0.05)	0.01	0.012	0.02		
SE(m) ±	0.003	0.004	0.007		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	3.91	4.13	4.77	4.43	4.31
V_1	4.94	5.23	5.97	5.48	5.41
V_2	6.33	6.78	7.22	7.75	7.02
Mean	5.06	5.38	6.16	5.71	
	V	**H**	**V × H**		
CD (p=0.05)	0.012	0.013	0.023		
SE(m) ±	0.004	0.005	0.008		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.7 Average leaf area per plant (cm^2)

The average leaf area per plant (cm^2) as influenced by various hydrogel and AVS treatments in 2023 and 2024 as well as pooled data for both years is shown in **Figure 4.11**, **Figure 4.12**.The numerical values are summarized in **Table 4.7** which also shows how the leaf area varied with each treatment as shown below:

In 2023, the hydrogel treatment at 1.5 kg/acre (H_2) was the most effective resulting in significantly higher average leaf area of 2551.5 cm^2 and 4464.7 cm^2 at 55 and 70 days after transplanting. The control (H_0) had significantly minimum average leaf area of 2501.3 cm^2 and 4380.3 cm^2. Biostimulant application @ 5 g/L (V_2) similarly resulted in maximum average leaf area of 2569.9 cm^2 (55 DAT) and 4456.8 cm^2 (70 DAT) compared to the control (V_0) with leaf area of 2464.3 cm^2 (55 DAT) and 4344.0 cm^2 (70 DAT). The combination of V_2 5 g/L + H_2 1.5 kg/acre showed the highest average leaf area with values of 2578.5 cm^2 and 4520.8 cm^2 whereas, the lowest average leaf area were found with V_0-0 g/L + H_0-0.0 kg/acre is 2415.2 cm^2 and 4292.4 cm^2 at both the observations.

In 2024, the hydrogel treatment at 1.5 kg/acre (H_2) again showed superior results with average leaf area of 2417.7 cm^2 (55 DAT) and 4350.8 cm^2 (70 DAT). The control (H_0) had lower leaf area of 2334.0 cm^2 (55 DAT) and 4278.5 cm^2 (70 DAT). Biostimulant at the rate of 5 g/L (V_2) also led to higher leaf area of 2418.4 cm^2 (55 DAT) and 4355.5 cm^2 (70 DAT) compared to (V_0) with leaf area of 2322.7 cm^2 (55 DAT) and 4241.2 cm^2 (70 DAT). The combination of V_2-5 g/L + H_2-1.5 kg/acre produced the maximum leaf area with average of 2577.7 cm^2 and 4419.6 cm^2. The combination of V_0-0 g/L + H_0-0.0 kg/acre resulted in the lowest leaf area at 2315.3 cm^2 and 4190.6 cm^2 at both the observations.

Combining data from both years, hydrogel at 1.5 kg/acre (H_2) consistently resulted in maximum leaf area with averages of 2484.6 cm^2 (55 DAT) and 4407.8 cm^2 (70 DAT) which were significantly higher than the control (H_0) with average of 2417.7 cm^2 (55 DAT) and 4329.4 cm^2 (70 DAT). The biostimulant at 5 g/L (V_2) also showed a significant increase in average leaf area 2494.1 cm^2 (55 DAT) and 4406.1 cm^2 (70 DAT) in contrast to the control biostimulant (V_0) which had average of 2393.5 cm^2 (55 DAT) and 4292.6 cm^2 (70 DAT). The optimal growth combination was V_2-5 g/L +

H_2-1.5 kg/acre with average leaf area of 2578.1 cm^2 and 4470.2 cm^2. The minimum leaf areas were observed with V_0-0 g/L + H_0-0.0 kg/acre, at 2365.2 cm^2 and 4241.5 cm^2 at both the observations.

The turgidity (internal pressure) of plant cells is maintained by adequate water from hydrogels and this is necessary for cell expansion and leaf growth. This leads to larger leaves with greater surface area. Photosynthesis the main energy generating mechanism that increase leaf area depends on Arka Vegetable Special contains micronutrients. Larger leaves are the result of more effective photosynthesis. Hydrogels maintains a steady moisture supply for the plant while micronutrients facilitate the metabolic processes essential for photosynthesis, cell division and elongation. Combining effects provide ideal conditions for increased leaf growth and a larger leaf area. These findings align with previous research conducted by **Afrin *et al.*, 2024** in brinjal working with zinc and boron. **Bisht *et al.* (2018)** discovered that cell elongation in the mature petiole of the brinjal plant system may be the cause of the plant's increased leaf area. As the concentration of nutrients increase the area of the leaves.

Figure 4.11: Analysis of average leaf area (cm^2) 55 DAT influenced by hydrogel and AVS

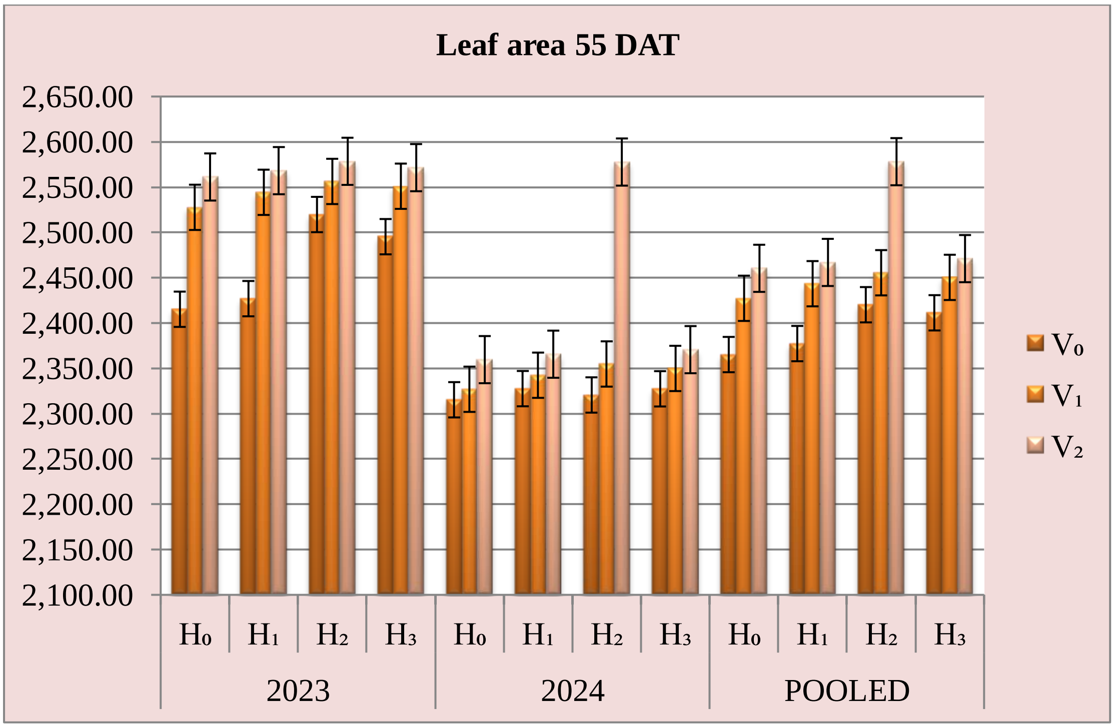


Table 4.7: Analysis of average leaf area per plant (cm²) influenced by hydrogel and AVS

2023						2024						POOLED					
55 DAT																	
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	2,415.2	2,426.9	2,519.8	2,495.3	2,464.3	**V_0**	2,315.3	2,327.6	2,320.6	2,327.4	2,322.7	**V_0**	2,365.2	2,377.3	2,420.2	2,411.3	2,393.5
V_1	2,527.7	2,544.3	2,556.3	2,551.0	2,544.8	**V_1**	2,326.9	2,342.4	2,354.8	2,349.9	2,343.5	**V_1**	2,427.3	2,443.4	2,455.5	2,450.4	2,444.2
V_2	2,561.2	2,568.2	2,578.5	2,571.5	2,569.9	**V_2**	2,359.6	2,365.6	2,577.7	2,370.6	2,418.4	**V_2**	2,460.4	2,466.9	2,578.1	2,471.1	2,494.1
Mean	2,501.3	2,513.1	2,551.5	2,539.2		**Mean**	2,334.0	2,345.2	2,417.7	2,349.3		**Mean**	2,417.7	2,429.2	2,484.6	2,444.3	
		V	**H**		**V × H**			**V**	**H**		**V × H**			**V**	**H**		**V × H**
CD (p=0.05)		14.13	16.32		28.27	**CD (p=0.05)**		0.51	0.59		1.02	**CD (p=0.05)**		7.07	8.16		14.13
SE(m) ±		4.78	5.52		9.57	**SE(m) ±**		0.17	0.20		0.34	**SE(m) ±**		2.39	2.76		4.79
70 DAT						70 DAT						70 DAT					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**	**T**	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4,292.4	4,321.3	4,413.9	4,348.5	4,344.0	**V_0**	4,190.6	4,218.6	4,309.5	4,246.2	4,241.2	**V_0**	4,241.5	4,270.0	4,361.7	4,297.3	4,292.6
V_1	4,419.4	4,423.3	4,459.4	4,422.7	4,431.2	**V_1**	4,316.4	4,319.9	4,323.4	4,318.7	4,319.6	**V_1**	4,367.9	4,371.6	4,391.4	4,370.7	4,375.4
V_2	4,429.2	4,436.1	4,520.8	4,440.9	4,456.8	**V_2**	4,328.4	4,335.4	4,419.6	4,338.6	4,355.5	**V_2**	4,378.8	4,385.8	4,470.2	4,389.8	4,406.1
Mean	4,380.3	4,393.6	4,464.7	4,404.0		**Mean**	4,278.5	4,291.3	4,350.8	4,301.2		**Mean**	4,329.4	4,342.4	4,407.8	4,352.	
		V	**H**		**V × H**			**V**	**H**		**V × H**			**V**	**H**		**V × H**
CD (p=0.05)		14.07	16.25		28.14	**CD (p=0.05)**		3.39	3.92		6.79	**CD (p=0.05)**		6.90	7.97		13.80
SE(m) ±		4.76	5.50		9.53	**SE(m) ±**		1.15	1.32		2.3	**SE(m) ±**		2.33	2.70		4.67

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

Figure 4.12: Analysis of average leaf area (cm^2) 70 DAT influenced by hydrogel and AVS

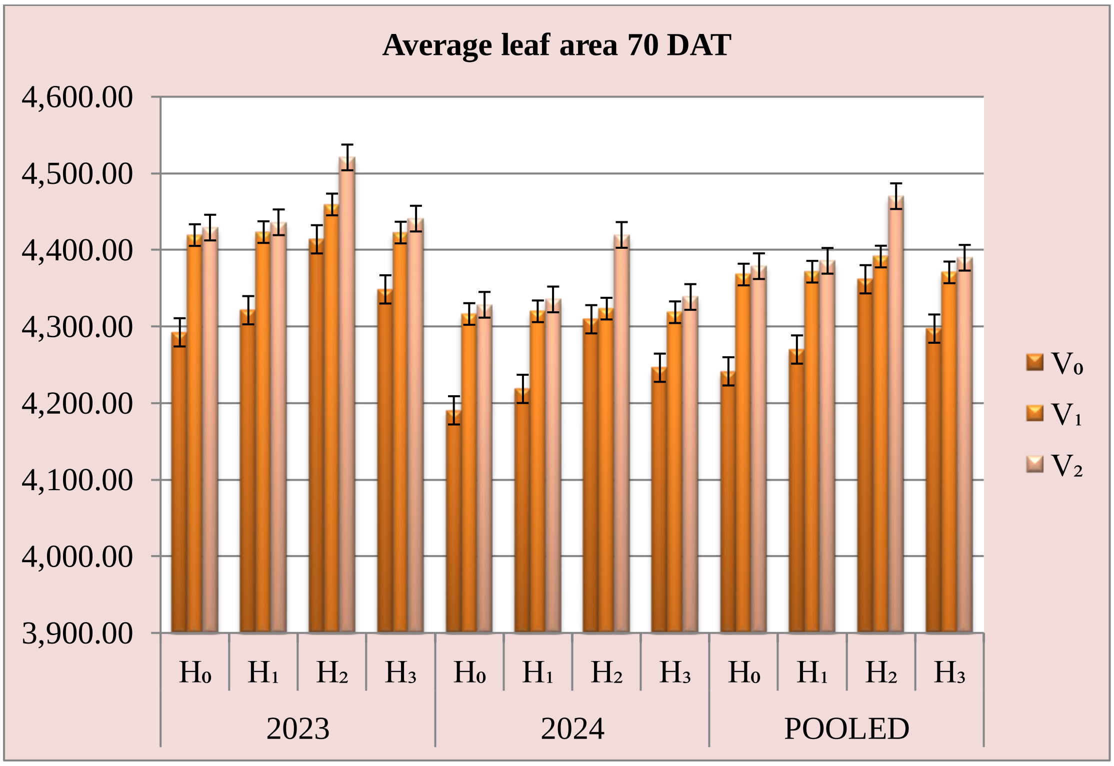
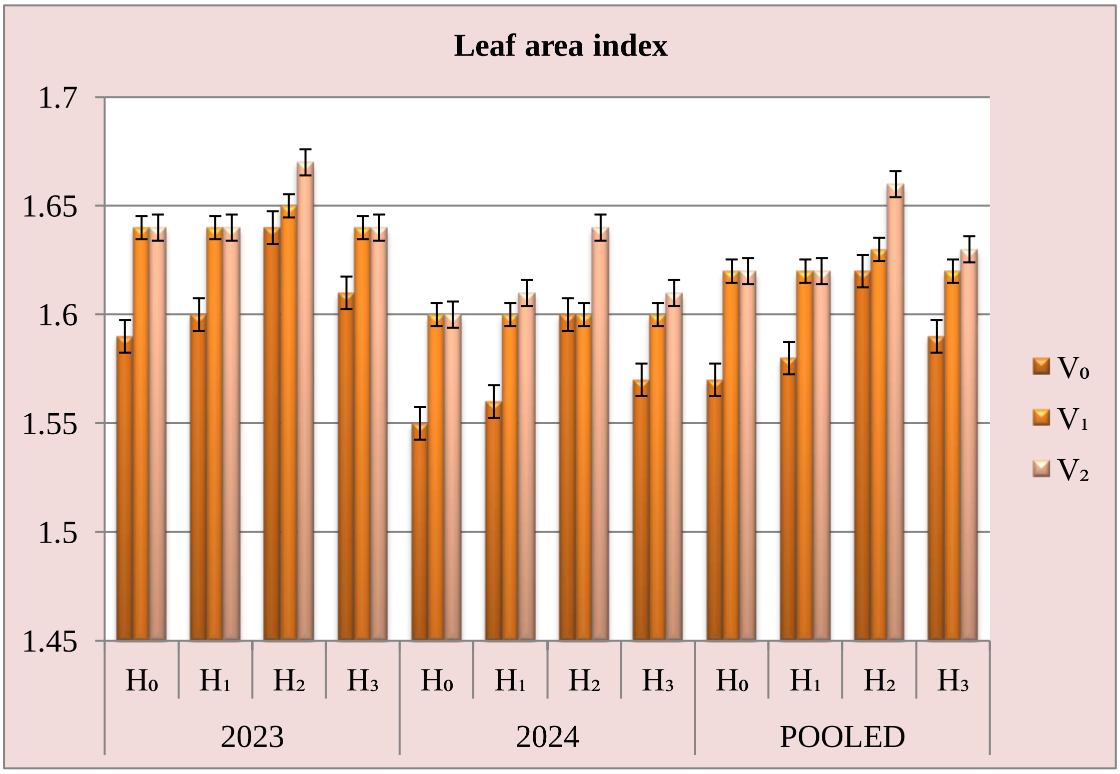


Figure 4.13: Analysis of leaf area index influenced by hydrogel and AVS



4.8 Leaf area index

Leaf area index showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the results are shown in **Table 4.8** and **Figure 4.13** and presented beneath:

In 2023, the hydrogel treatment at 1.5 kg/acre (H_2) was the most effective resulting in significantly higher leaf area index 1.65 at 70 days after transplanting. The control (H_0) had significantly minimum leaf area index 1.62. Biostimulant application at 5 g/L (V_2) similarly resulted in maximum leaf area index of 1.65 compared to the control (V_0) with leaf area index 1.61. The combination of V_2 5 g/L + H_2 1.5 kg/acre shows the greatest leaf area index with values of 1.67 whereas the lowest leaf area index were found with V_0-0 g/L + H_0-0.0 kg/acre is 1.59.

In 2024, the hydrogel treatment at 1.5 kg/acre (H_2) again showed superior results with leaf area index 1.61. The control (H_0) had lower leaf area index 1.58. Biostimulant at 5 g/L (V_2) also led to higher leaf area 1.62 compared to (V_0) with leaf area index 1.59. The combination of V_2-5 g/L + H_2 1.5 kg/acre produced the maximum leaf area index 1.64. The combination of V_0-0 g/L + H_0-0.0 kg/acre resulted in the lowest leaf area index 1.55.

Combining data from both years, hydrogel at 1.5 kg/acre (H_2) consistently resulted in maximum leaf area index 1.64 which were significantly higher than the control (H_0) 1.60. The biostimulant at 5 g/L (V_2) also showed a significant increase in leaf area index 1.63 m^2m^{-2} compare to control (V_0) 1.57. The optimal growth combination was V_2-5 g/L + H_2-1.5 kg/acre with leaf area index 1.66. The minimum leaf area index observed with V_0-0 g/L + H_0-0.0 kg/acre 1.57.

Hydrogel helped boost the LAI by preserving soil moisture which encouraged healthy leaf growth and expansion. The consistent moisture conditions supported the development of a denser canopy resulting in a higher LAI. The enhanced nutrient availability resulted in a larger leaf area boosting the plant's photosynthetic efficiency. When combined these two factors help the plant maximize LAI reduce water stress and increase overall growth and yield. **Saha *et al*., 2020** studied that by adding super absorbent hydrogel may increase plant access to water boost leaf area index and promote general development.

Table 4.8: Analysis of leaf area index influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.59	1.60	1.64	1.61	1.61
V_1	1.64	1.64	1.65	1.64	1.64
V_2	1.64	1.64	1.67	1.64	1.65
Mean	1.62	1.63	1.65	1.63	
	V		**H**	**V × H**	
CD (p=0.05)	0.006		0.007	0.011	
SE(m) ±	0.002		0.002	0.004	
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.55	1.56	1.60	1.57	1.57
V_1	1.60	1.60	1.60	1.60	1.60
V_2	1.60	1.61	1.64	1.61	1.62
Mean	1.58	1.59	1.61	1.59	
	V		**H**	**V × H**	
CD (p=0.05)	0.001		0.001	0.002	
SE(m) ±	0.001		0.001	0.002	
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.57	1.58	1.62	1.59	1.59
V_1	1.62	1.62	1.63	1.62	1.62
V_2	1.62	1.62	1.66	1.63	1.63
Mean	1.60	1.61	1.64	1.61	
	V		**H**	**V × H**	
CD (p=0.05)	0.003		0.003	0.006	
SE(m) ±	0.001		0.001	0.002	

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.9 Days to fruit initiation

The impact of hydrogel and AVS treatments on the number of days until fruit initiation in 2023, 2024 and as pooled data across both years is shown below. The assessment of treatment wise performance is given in **Table 4.9** which shows significant variations in the time required for fruit initiation. These changes are graphically depicted in **Figure 4.14** which also demonstrates how specific hydrogel and Arka Vegetable Special combinations considerably shortened the time to fruit initiation. Using hydrogel and Arka Vegetable Special together can encourage earlier fruiting most likely as a result of better nutrient availability and moisture in soil.

In 2023, hydrogel at 2.0 kg/acre (H_3) proved to be the most effective treatment with days to fruit initiation reaching 55.44 days respectively. These days were significantly less than those of the (H_0) which had maximum days to fruit initiation of 58.89 days. The biostimulant treatment of 2 g/L (V_1) also significantly improved days to fruit initiation to 56.83 days compared to the (V_2) which had days to fruit initiation of 57.71 days. The most notable results were V_2 + H_3 achieving days to fruit initiation of 53.92 days. The combination of V_0 + H_0-0.0 resulted in the maximum 62.33 days.

In 2024, hydrogel at 2.0 kg/acre (H_3) again demonstrated a significant positive effect on days to fruit initiation with average of 55.14 days. The control (H_0) had significantly higher days to fruit initiation of 57.97. The biostimulant application of 2 g/L (V_1) resulted in fruit initiation after 56.23 days, whereas, V_2 showed maximum days to fruit initiation (56.94 days). The combination of V_2-5 g/L + H_3- 2.0 kg/acre led to the minimum days to fruit initiation with averages of 54.00 days. Conversely, the combination of V_0-0 g/L + H_0-0.0 kg/acre had the maximum days to fruit initiation 61.08 days.

The combined data for 2023 and 2024 show that hydrogel at 2.0 kg/acre (H_3) consistently led to the lowest days to fruit initiation 55.29 days. These were significantly less compared to H_0 with average days to fruit initiation of 58.43 days. The biostimulant at 2 g/L (V_1) also significantly improved days to fruit initiation 56.53 days compared to V_2 which had maximum averages of 57.33 days. The optimal combination was $V_2 + H_3$ resulting the minimum days to fruit initiation of 53.96 days. The maximum average days to fruit initiation was noted $V_0 + H_0$ at 61.71 days.

The application of hydrogel accelerated fruit initiation by maintaining proper moisture levels which are crucial for reproductive stages. As a result, fruit initiation occurred earlier leading to a shorter time to market maturity and enabling faster harvests. The use of Arka Vegetable Special facilitated earlier fruit initiation and shortened the time to market maturity by improving the plant's physiological functions. Using hydrogel and AVS together enhances plant development and improves the initiation of fruiting. When combined they enhance plant establishment resulting in earlier fruit initiation in brinjal. This integrated method speeds up physiological processes including blooming and fruit initiation Because of this plants go into the reproductive phase faster, which shortens the time needed for fruiting. **Uikey *et al.* (2018)** studied that this might be because boron plays a part in fruit abscission, pollen germination, flower growth and fertilization.

Figure 4.14: Analysis of days to fruit initiation influenced by hydrogel and AVS

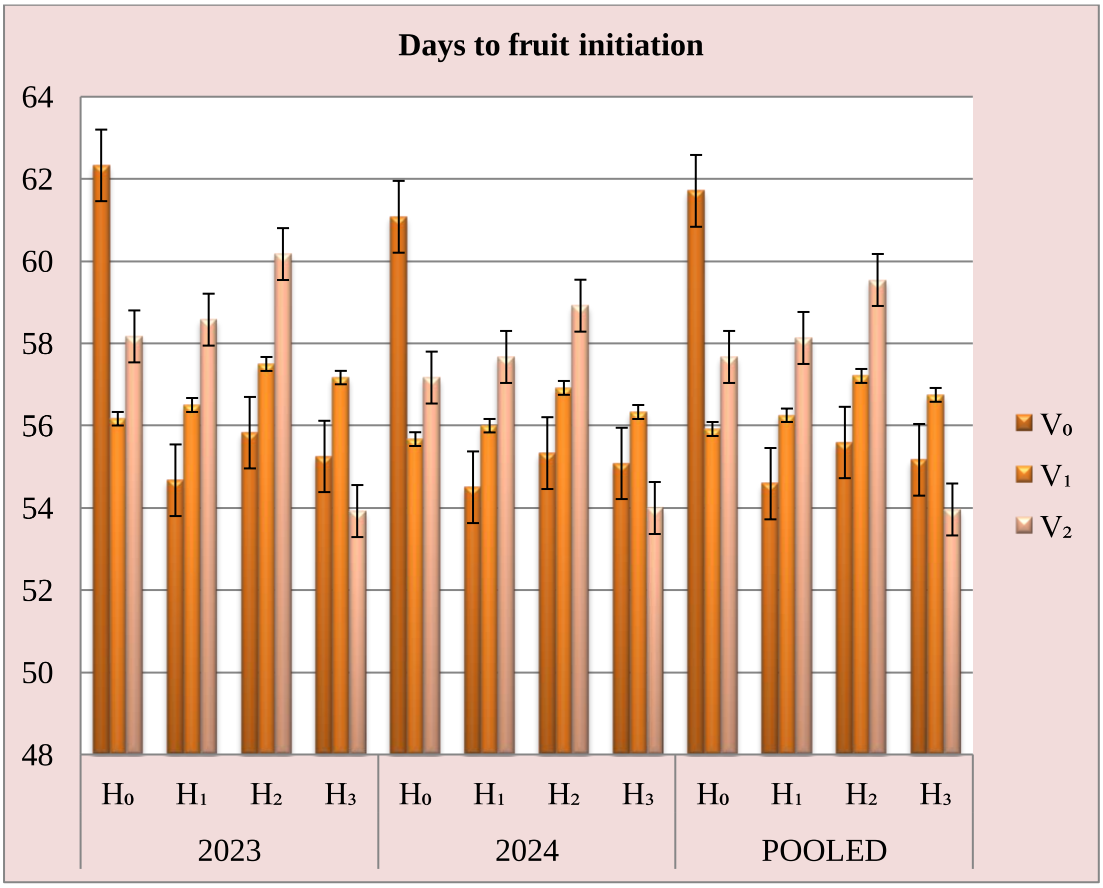


Table 4.9: Analysis of days to fruit initiation influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	62.33	54.67	55.83	55.25	57.02
V_1	56.17	56.50	57.50	57.17	56.83
V_2	58.17	58.58	60.17	53.92	57.71
Mean	58.89	56.58	57.83	55.44	
	V		**H**	**V × H**	
CD (p=0.05)	0.1		0.1	0.2	
SE(m) ±	0.03		0.03	0.06	
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	61.08	54.50	55.33	55.08	56.50
V_1	55.67	56.00	56.92	56.33	56.23
V_2	57.17	57.67	58.92	54.00	56.94
Mean	57.97	56.06	57.06	55.14	
	V		**H**	**V × H**	
CD (p=0.05)	0.11		0.12	0.22	
SE(m) ±	0.03		0.04	0.07	
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	61.71	54.59	55.59	55.17	56.76
V_1	55.92	56.25	57.21	56.75	56.53
V_2	57.67	58.13	59.54	53.96	57.33
Mean	58.43	56.32	57.45	55.29	
	V		**H**	**V × H**	
CD (p=0.05)	0.07		0.08	0.14	
SE(m) ±	0.02		0.02	0.04	

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.10 Days to marketable maturity

In 2023, hydrogel at 2.0 kg/acre (H_3) proved to be the most effective treatment with days to marketable maturity reaching 65.44 days respectively. These days were significantly minimum than those of the H_0 which required maximum days for the fruit to reach marketable maturity (70.22 days). At control condition *i.e.*, V_0 also significantly improved days taken to marketable maturity to 67.48 days compared to V_2 which had higher number of days to marketable maturity (69.06 days). The most notable results V_2 + H_3 achieved days to marketable maturity of 62.75 days. The combination of V_0 + H_0 resulted in the maximum days 72.83.

In 2024, hydrogel at 2.0 kg/acre (H_3) demonstrated a significant positive effect on days to marketable maturity with average 66.33 days. H_0 had significantly higher days to marketable maturity (70.89 days). The biostimulant application V_0 resulted in 68.54 days to marketable maturity, whereas, V_2 showed maximum days to reach marketable maturity (70.33 days). The combination of V_2 + H_3 led to the minimum days to marketable maturity 63.33 days. Conversely, V_0 + H_0 had the maximum days to marketable maturity *i.e.*, 73.75 days.

The combined data for 2023 and 2024 show that hydrogel at 2.0 kg/acre (H_3) consistently led to the lowest days to marketable maturity that is 65.89 days. These were significantly less compared to the (H_0) with average days to marketable maturity of 70.56 days. The biostimulant at 0 g/L also significantly improved days to marketable maturity (68.01 days) compared to the V_2 which had maximum averages of 69.70 days. The optimal combination was V_2 + H_3 resulting in the fewer days to marketable maturity of 63.04 days. The maximum average days to marketable maturity were noted V_0 + H_0-0.0 at 73.29 days.

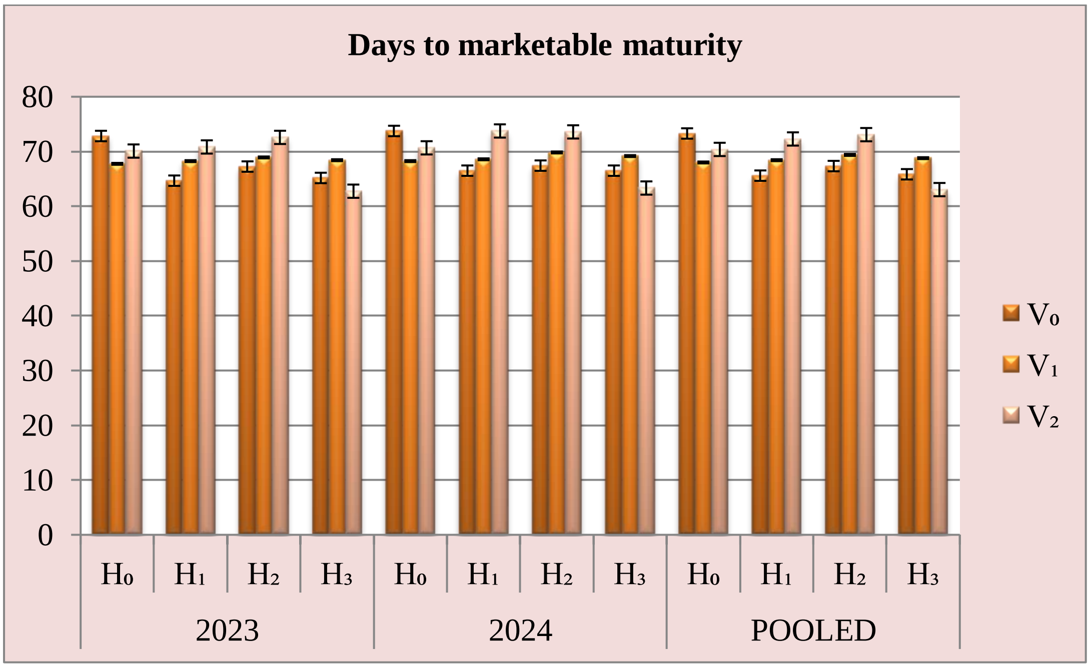
Hydrogels can absorb and hold nutrients releasing them gradually to the plant roots as needed increasing nutrient availability and decreasing nutrient leaching AVS encourages strong plant development improves nutrient uptake and improves stress tolerance. This phenomenon shows similarities to **Jyothi *et al.* (2019)** in brinjal who suggest that such treatments can influence the timing of days to fruit maturation and **Madramootoo *et al.* (2023)** also observed the same with waste paper based hydrogel in tomato.

Table 4.10: Analysis of days to marketable maturity as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	72.83	64.67	67.25	65.17	67.48
V_1	67.75	68.25	68.92	68.42	68.33
V_2	70.08	70.83	72.58	62.75	69.06
Mean	70.22	67.92	69.58	65.44	
	V	**H**	**V × H**		
CD (p=0.05)	0.09	0.10	0.18		
SE(m) ±	0.03	0.03	0.06		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	73.75	66.50	67.42	66.50	68.54
V_1	68.25	68.58	69.83	69.17	68.96
V_2	70.67	73.75	73.58	63.33	70.33
Mean	70.89	69.61	70.28	66.33	
	V	**H**	**V × H**		
CD (p=0.05)	0.12	0.14	0.25		
SE(m) ±	0.04	0.05	0.08		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	73.29	65.59	67.34	65.84	68.01
V_1	68.00	68.42	69.38	68.79	68.65
V_2	70.38	72.29	73.08	63.04	69.70
Mean	70.56	68.77	69.93	65.89	
	V	**H**	**V × H**		
CD (p=0.05)	0.05	0.06	0.11		
SE(m) ±	0.01	0.02	0.03		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

Figure 4.15: Analysis of days to marketable maturity as influenced by hydrogel and AVS



4.11 Average marketable fruit weight (g)

Average marketable fruit weight showed significant variations among the treatments in both the years 2023 and 2024. The compiled results are depicted in **Figure 4.16** and **Table 4.11** and discussed below.

In 2023, hydrogel at 1.5 kg/acre (H_2) proved to be the most effective treatment with average marketable fruit weight measuring 73.32 g. These weights were significantly greater than those of H_0 (64.29 g). The biostimulant treatment of 5 g/L (V_2) also significantly improved fruit weight to 79.41 g compared to the control which had average fruit weight of 59.61 g. The most notable results V_2 + H_2 achieved fruit weight 85.40 g. V_2 + H_0 shows lowest fruit weight 57.50 g.

In 2024, hydrogel at 1.5 kg/acre (H_2) demonstrated a significant positive effect on fruit weight with average of 74.44 g. The control (H_0) had significantly less weight of fruit 66.20 g. The biostimulant application of 5 g/L (V_2) resulted in fruit weight of 80.22 g whereas the (V_0) showed less fruit weight of 64.74 g. The combination of V_2- + H_2 led to the maximum fruit weight with average of 86.23 g. Conversely, the combination of V_0-0 g/L + H_0-0.0 kg/acre had the least fruit weight 61.94 g.

The combined data for 2023 and 2024 show that hydrogel at 1.5 kg/acre (H_2) consistently led to the maximum fruit weight 73.88 g. These were significantly higher compared to the H_0 with average fruit weight of 65.25 g. The biostimulant at 5 g/L also significantly improved fruit weight (79.82 g) compared to the control (V_0) which had lesser fruit weight *i.e*., 62.18 g. The optimal combination was V_2-5 g/L + H_2-1.5 kg/acre resulting in the maximum weight of fruit of 85.82 g. The lowest average fruit weight was noted V_0 + H_0 at 59.72 g.

The application of hydrogel helped boost the weight of individual marketable fruits by preventing water stress which can increase fruit size and quality. The Arka Vegetable Special treatment enhanced the weight of individual marketable fruits by supplying the essential nutrients needed for optimal growth and development. The balanced nutrient supply allowed the fruits to achieve their maximum size and weight increasing their marketability. Hydrogel and Arka Vegetable Special interaction optimize nutrient availability and maintain constant growing conditions which can result in higher marketable fruit weight. The findings are similar to **Manjunath (2018)** who studied the use of Arka Vegetable Special among farmers and noticed improvements in fruit weight **Pahlevanyan *et al.* (2023)** also used Aquasource hydrogel to enhance the fruit weight in musk melon crop.

Figure 4.16: Analysis of average marketable fruit weight (g) as influenced by hydrogel and AVS

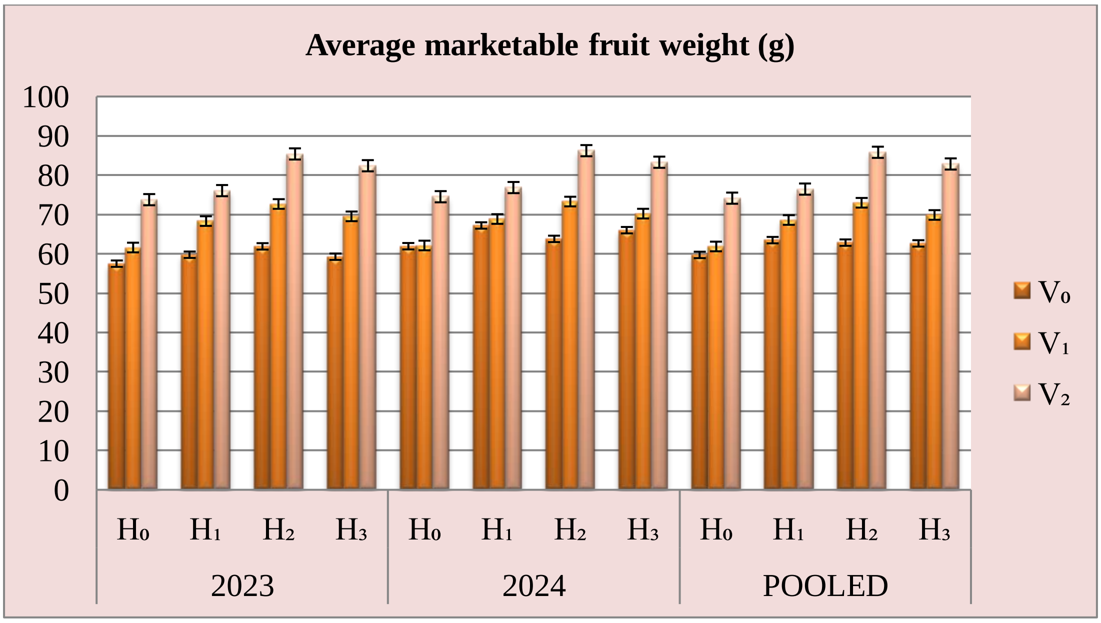


Table 4.11: Analysis of average marketable fruit weight (g) influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	57.50	59.77	61.90	59.27	59.61
V_1	61.60	68.33	72.67	69.53	68.03
V_2	73.77	76.07	85.40	82.40	79.41
Mean	64.29	68.06	73.32	70.40	
	V	**H**	**V × H**		
CD (p=0.05)	1.08	1.24	2.15		
SE(m) ±	0.36	0.42	0.73		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	61.94	67.21	63.80	66.02	64.74
V_1	62.12	68.85	73.29	70.22	68.62
V_2	74.52	76.85	86.23	83.29	80.22
Mean	66.20	70.97	74.44	73.18	
	V	**H**	**V × H**		
CD (p=0.05)	1.30	1.50	2.60		
SE(m) ±	0.44	0.51	0.88		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	59.72	63.49	62.85	62.65	62.18
V_1	61.87	68.60	72.98	69.88	68.33
V_2	74.15	76.46	85.82	82.85	79.82
Mean	65.25	69.52	73.88	71.79	
	V	**H**	**V × H**		
CD (p=0.05)	0.91	1.06	1.83		
SE(m) ±	0.31	0.35	0.62		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.12 Fruit length (cm)

During 2023, the hydrogel treatment at H_2 was the most uniform resulting in significantly highest fruit length 15.18 cm. The control H_0 had significantly lowest fruit length 13.61 cm. Biostimulant application at 5 g/L (V_2) resulted in highest fruit length *i.e.*, 15.42 cm compared to the control (13.41 cm). The combination of V_2 + H_2 shows highest fruit length with values of 16.88 cm, whereas, the shortest fruits were found in V_0-0 g/L + H_0-0.0 kg/acre (12.05 cm).

In 2024, the hydrogel treatment at 1.5 kg/acre (H_2) shows longest fruit (17.09 cm). The control (H_0) had smallest fruit length 15.34 cm. Biostimulant at 5 g/L (V_2) shows highest fruit length 17.62 cm compared to V_0 with length 14.90 cm. The combination of V_2-5 g/L + H_2-1.5 kg/acre found longest fruit length with average of 19.11 cm. The combination of V_0-0 g/L + H_0-0.0 kg/acre resulted in the shortest length of fruit 13.38 cm.

Combine data from both years, hydrogel at 1.5 kg/acre (H_2) consistently resulted in fruit length 16.13 cm which were significantly longest than the control (H_0) 14.48 cm. The biostimulant at 5 g/L (V_2) also showed a significant increase in fruit length 16.52 cm in contrast to the control (V_0) 14.16 cm. The combination of V_2-5 g/L + H_2-1.5 kg/acre found longest fruit length 18.00 cm. The less fruit length was observed with V_0-0 g/L + H_0-0.0 kg/acre is 12.72 cm.

Hydrogel ability to retain moisture ensured the fruit received sufficient water during key growth stages leading to longer fruits. By preventing water stress it supported consistent fruit elongation resulting in increased fruit length. The use of micronutrients such as potassium and calcium promoted the growth of longer fruits by improving cell division and expansion. The nutrients supplied by the Arka Vegetable Special were crucial in achieving the optimal fruit length. The combination of Arka Vegetable Special with hydrogel probably increased water and nutrient availability which enhances brinjal fruit development and length. A comparable phenomenon was also reported in mango **by (Alshallash *et al.*, 2022)** wherein hydrogel application improved growth parameters. **Ali *et al.* (2024)** noticed marked enhancement in fruit qualities such as fruit length and vegetative growth in tomato by using micronutrient based biostimulants.

Table 4.12: Analysis of fruit length (cm) influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	12.05	13.66	14.15	13.78	13.41
V_1	14.15	14.27	14.49	14.39	14.33
V_2	14.62	15.01	16.88	15.17	15.42
Mean	13.61	14.31	15.18	14.45	
	V		**H**	**V × H**	
CD (p=0.05)	0.46		0.53	0.92	
SE(m) ±	0.15		0.18	0.31	
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	13.38	15.08	15.66	15.46	14.90
V_1	15.91	16.14	16.48	16.41	16.24
V_2	16.71	17.13	19.11	17.52	17.62
Mean	15.34	16.12	17.09	16.47	
	V		**H**	**V × H**	
CD (p=0.05)	0.12		0.14	0.025	
SE(m) ±	0.06		0.07	0.12	
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	12.72	14.37	14.91	14.62	14.16
V_1	15.04	15.21	15.49	15.41	15.29
V_2	15.67	16.07	18.00	16.35	16.52
Mean	14.48	15.22	16.13	15.46	
	V		**H**	**V × H**	
CD (p=0.05)	0.24		0.28	0.49	
SE(m) ±	0.08		0.09	0.16	

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.13 Fruit diameter (cm)

Fruit diameter showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the results are shown in **Table 4.13** and **Figure 4.17** and presented beneath.

In 2023, hydrogel at 1.0 kg/acre (H_1) proved to be the most effective treatment with fruit diameter 4.79 cm. These diameters were significantly greater than H_3 which recorded minimum fruit diameter of 4.60 cm. The biostimulant treatment of 5 g/L (V_2) also significantly improved fruit diameter to 5.06 cm compared to control (V_0) which had fruit diameter of 4.48 cm. The combination of V_2-5 g/L + H_2-1.5 kg/acre resulted in thicker fruits *i.e.*, 5.27 cm. The combination of V_0-0 g/L + H_3-2.0 kg/acre resulted in the lowest diameter at 4.08 cm.

In 2024, hydrogel at 1.5 kg/acre (H_2) demonstrated a significant positive effect on fruit diameter with average of 5.66 cm. The control (H_0) had significantly lower fruit diameter of 5.38 cm. The biostimulant application of 5 g/L (V_2) resulted in fruit diameter of 5.97 cm, whereas, the control (V_0) showed minimum fruit diameter of 4.81 cm. The combination of V_2-5 g/L + H_2-1.5 kg/acre led to the highest fruit diameter 6.11 cm. The control had the lowest fruit diameter 4.94 cm.

The combined data for 2023 and 2024 showed that hydrogel at 1.5 kg/acre (H_2) recorded the highest fruit diameter 5.20 cm. These were significantly higher compared to the control (H_0) 5.01 cm. The biostimulant at 5 g/L (V_2) also significantly improved fruit diameter with average of 5.52 compared to the control (V_0) 4.81 cm. The optimal combination was V_2-5 g/L + H_2-1.5 kg/acre resulting in the highest fruit diameter of 5.69 cm. The lowest average fruit diameter was is V_0H_3.

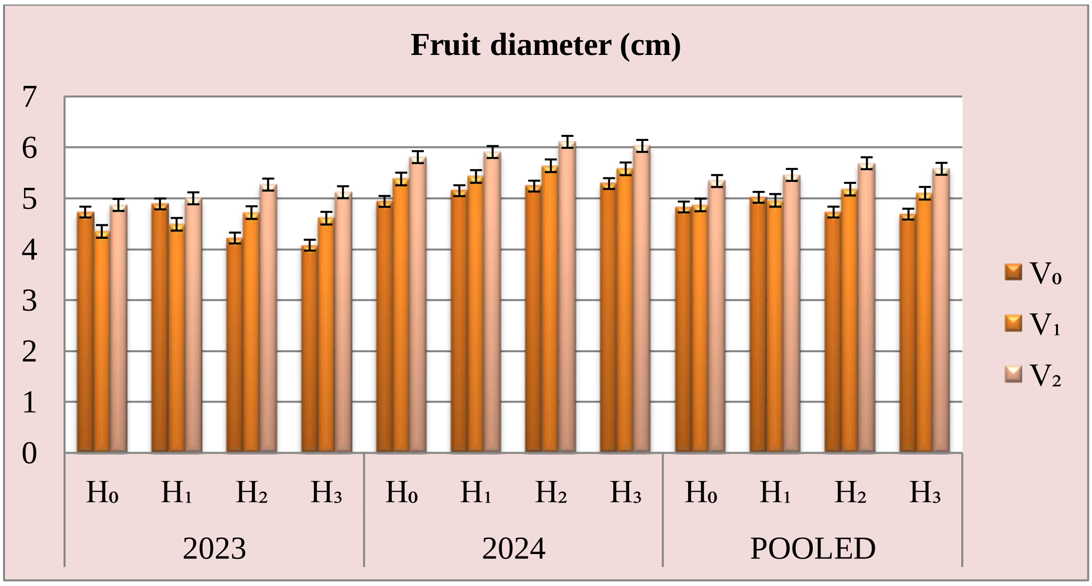
Adequate hydration is crucial for cell enlargement which directly impacts fruit size. The treatment of micronutrients promoted the longevity of larger fruits by supplying key nutrients that support cellular growth and expansion. In combination the hydrogel provides the plant with water availability allowing it to reach the ideal fruit diameter while the biostimulant improves nutrient use. A corresponding phenomenon was observed in capsicum after using Zn and B which resulted in increased fruit diameter **(Ahmed *et al.*, 2017)**.

Table 4.13: Analysis of fruit diameter (cm) influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4.73	4.89	4.22	4.08	4.48
V_1	4.35	4.49	4.72	4.61	4.54
V_2	4.87	5.00	5.27	5.12	5.06
Mean	4.65	4.79	4.74	4.60	
	V	**H**	**V × H**		
CD (p=0.05)	0.01	0.01	0.02		
SE(m) ±	0.03	0.04	0.07		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4.94	5.15	5.24	5.29	5.16
V_1	5.38	5.43	5.64	5.58	5.51
V_2	5.81	5.91	6.11	6.03	5.97
Mean	5.38	5.50	5.66	5.63	
	V	**H**	**V × H**		
CD (p=0.05)	0.01	0.01	0.02		
SE(m) ±	0.03	0.04	0.07		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4.83	5.02	4.73	4.69	4.81
V_1	4.87	4.96	5.18	5.10	5.03
V_2	5.34	5.46	5.69	5.58	5.52
Mean	5.01	5.15	5.20	5.12	
	V	**H**	**V × H**		
CD (p=0.05)	0.006	0.007	0.012		
SE(m) ±	0.002	0.002	0.004		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

Figure 4.17: Analysis of fruit diameter (cm) as influenced by hydrogel and AVS



4.14 Pedicle length (cm)

Pedicle length showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the results are shown in **Figure 4.18** and **Table 4.14** and presented below:

In the first year of the study 2023, notable differences in pedicle length were observed with varying treatments. The application of hydrogel at 1.5 kg/acre (H_2) resulted in the largest pedicle length (4.72 cm), which was significantly higher compared to the control (3.81 cm). Similarly, the biostimulant applied at 5 g/L (V_2) led to increased pedicle length of 5.61 cm surpassing the control (V_0) which had lowest pedicle length of 2.53 cm. The interaction of V_2 + H_2 proved to be the most effective resulting in the largest pedicle length overall leaf growth 6.48 cm while the least growth was observed with the combination of V_0 + H_0 1.97 cm.

In the second year of the study 2024, with hydrogel at 1.5 kg/acre (H_2) shows the highest pedicle length 5.84 cm. The control (H_0) shows minimum pedicle length 5.22 cm. The biostimulant treatment at 5 g/L (V_2) maintained its positive impact with pedicle length 6.09 cm whereas the V_0 group had reduced pedicle length at 4.92 cm. The combination of V_2 + H_2 remained the most effective achieving pedicle length of 6.91 cm while the combination of V_0 + H_0 resulted in the lowest measurements 4.62 cm.

Across both years, the data consistently demonstrated that hydrogel at 2.0 kg/acre (H_2) was the most effective treatment for enhancing pedicle length (5.28 cm). These pedicle lengths were significantly greater than those recorded in the control (H_0) 4.34 cm. The biostimulant at 5 g/L (V_2) also consistently outperformed the control (V_0) with average pedicle length of 5.86 cm compared to 3.72 cm. The V_2 + H_2 combination (6.70 cm) produced the highest overall pedicle length, while the V_0 + H_0 combination resulted in the least growth (3.30 cm).

Hydrogels increase brinjal pedicle length by improving soil moisture retention, which maintains higher turgor pressure and promotes cell expansion in pedicel tissues. They enhance nutrient availability especially K, Ca, and B supporting vascular development and elongation. Longer pedicles in the treated plants are the result of the constant water supply preventing stress that could impede pedicle growth **(Narjary *et al.*, 2012)**.

Figure 4.18: Analysis of pedicle length (cm) as influenced by hydrogel and AVS

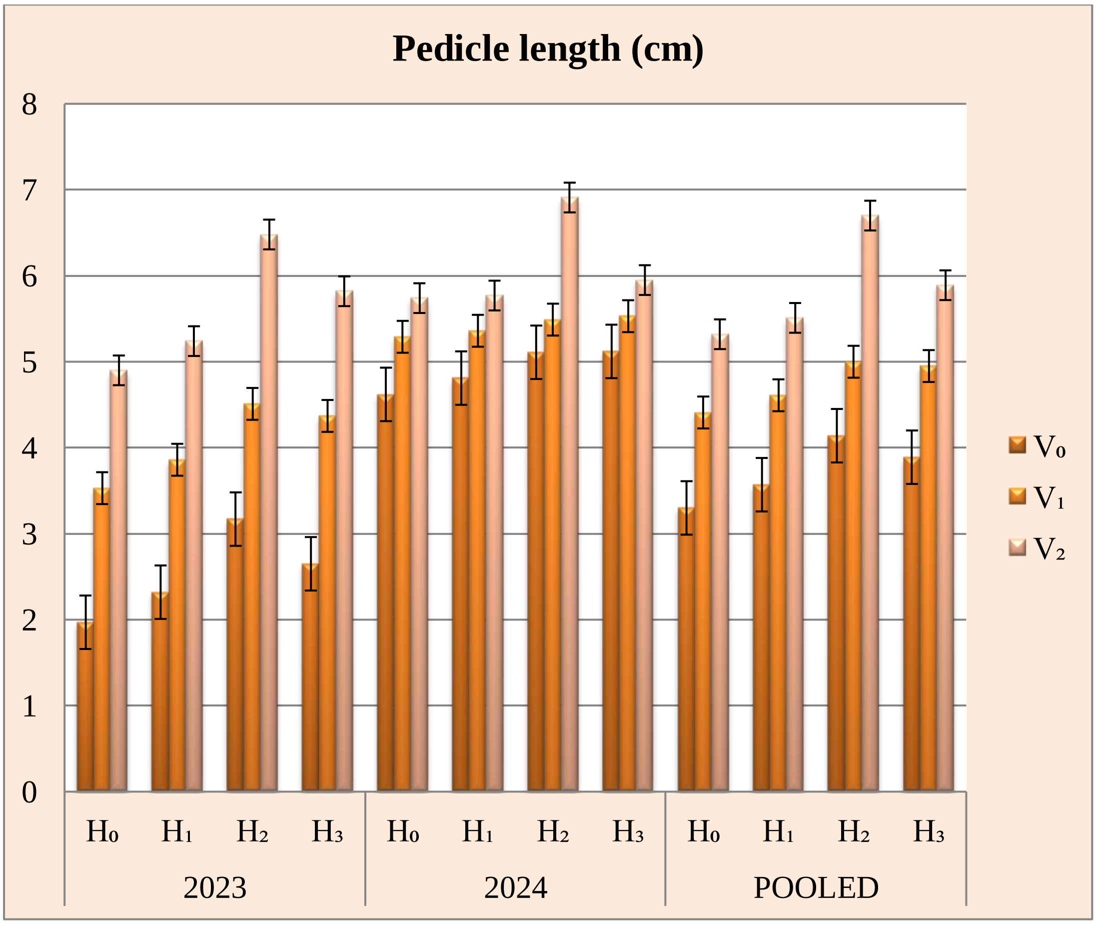


Table 4.14: Analysis of pedicle length (cm) influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.97	2.32	3.17	2.65	2.53
V_1	3.53	3.86	4.51	4.37	4.07
V_2	4.90	5.24	6.48	5.82	5.61
Mean	3.47	3.81	4.72	4.28	
	V		**H**		**V × H**
CD (p=0.05)	0.01		0.012		0.021
SE(m) ±	0.003		0.003		0.007
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4.62	4.81	5.11	5.12	4.92
V_1	5.29	5.36	5.49	5.53	5.42
V_2	5.74	5.77	6.91	5.95	6.09
Mean	5.22	5.32	5.84	5.53	
	V		**H**		**V × H**
CD (p=0.05)	0.009		0.01		0.017
SE(m) ±	0.003		0.003		0.006
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	3.30	3.57	4.14	3.89	3.72
V_1	4.41	4.61	5.00	4.95	4.75
V_2	5.32	5.51	6.70	5.89	5.86
Mean	4.34	4.56	5.28	4.91	
	V		**H**		**V × H**
CD (p=0.05)	0.007		0.008		0.014
SE(m) ±	0.002		0.003		0.005

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

YIELD PARAMETERS

4.15 Number of fruits per plant

In 2023, hydrogel @ 1.5 kg/acre (H_2) proved to be the most effective treatment with number of fruits per plant 28.19. These were significantly maximum than those of the control which had less number of fruits per plant 26.56. The treatment 5 g/L (V_2) also significantly improved number of fruits per plant 31.15 compared to the control which had individual number of fruits per plant 24.48. The maximum number of fruits per plant was observed with the combination of V_2 + H_2 *i.e.*, 32.50 and V_0 + H_0 resulted in the lowest number of fruits (22.92).

In 2024, hydrogel at 1.5 kg/acre (H_2) demonstrated a significant positive effect on number of fruit per plant with average of 37.53. The control had significantly less number of fruit per plant (35.86). The application of 2 g/L (V_1) AVS resulted in higher number of fruit per plant *i.e.*, 37.48, whereas, the control plants bore an average of 35.46 fruits. The combination of V_2-5 g/L + H_2-1.5 kg/acre resulted in production of maximum number of fruit per plant (38.50). The combination of V_0-0 g/L + H_0-0.0 kg/acre had minimum number of fruit per plant (33.83).

The combined data for 2023 and 2024 showed that hydrogel at 1.5 kg/acre (H_2) recorded the maximum number of fruit per plant (32.86). These were significantly higher compared to the control (31.21). The biostimulant at 5 g/L (V_2) also significantly improved number of fruit per plant with average of 34.15 fruits compared to control *i.e.*, 29.97. The combination V_2 + H_2 showed the maximum number of fruit per plant (35.50). The less number of fruit per plant was noted with the combination of V_0 + H_0 *i.e.*, 28.38.

The stable moisture conditions helped prevent flower and fruit drop thereby increasing the overall fruit number. Plants treated with Arka Vegetable Special produced a greater number of fruits per plant highlighting the importance of nutrient availability in fruit production. By improving general plant health expanding nutrient uptake and ensuring steady water availability the interaction is probably going to increase the number of fruits per plant in brinjal. A similar occurrence was observed in tomato by using combination of $B_{2.0}Zn_{3.0}$ kg ha^{-1} **(Ahmed *et al.*, 2017)**. **Chirino *et al.* (2011)** reported higher cork yield in cork oak by using PUSA hydrogel.

Table 4.15: Analysis of number of fruit per plant as influenced by hydrogel and AVS

2023

T	H_0	H_1	H_2	H_3	Mean
V_0	22.92	24.08	25.83	25.08	24.48
V_1	26.42	26.67	26.25	26.58	26.48
V_2	30.33	30.50	32.50	31.25	31.15
Mean	26.56	27.08	28.19	27.64	

	V	H	V × H
CD (p=0.05)	0.65	0.75	1.30
SE(m) ±	0.22	0.25	0.44

2024

T	H_0	H_1	H_2	H_3	Mean
V_0	33.83	35.08	36.83	36.08	35.46
V_1	37.42	37.67	37.25	37.58	37.48
V_2	36.33	36.50	38.50	37.25	37.15
Mean	35.86	36.42	37.53	36.97	

	V	H	V × H
CD (p=0.05)	0.64	0.74	1.28
SE(m) ±	0.21	0.25	0.43

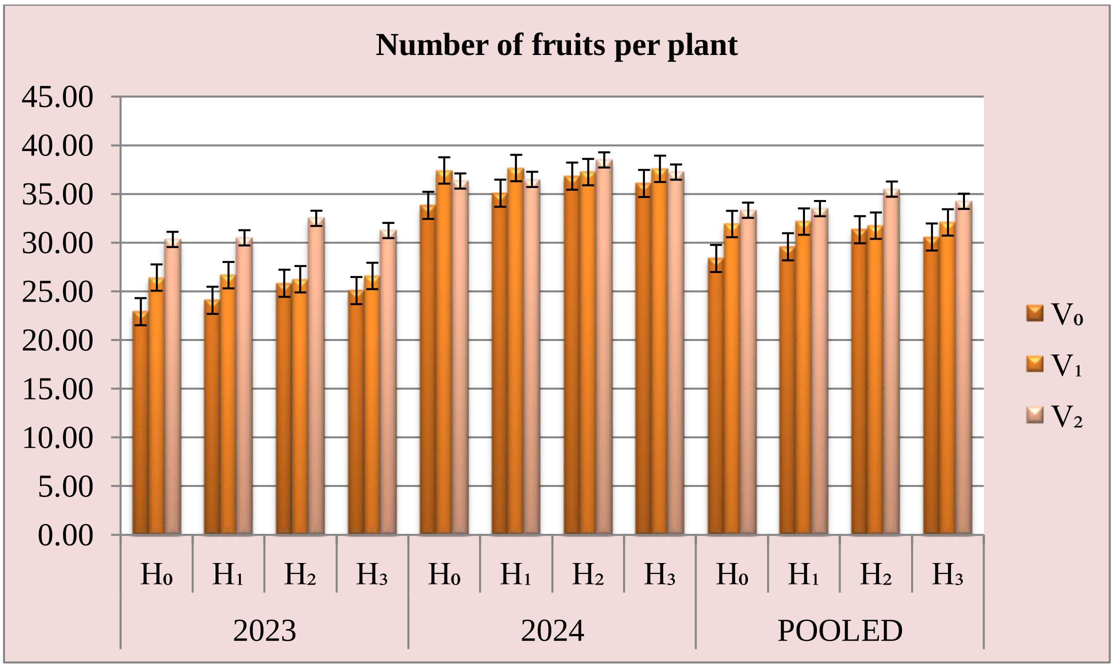
Pooled

T	H_0	H_1	H_2	H_3	Mean
V_0	28.38	29.58	31.33	30.58	29.97
V_1	31.92	32.17	31.75	32.08	31.98
V_2	33.33	33.50	35.50	34.25	34.15
Mean	31.21	31.75	32.86	32.31	

	V	H	V × H
CD (p=0.05)	0.64	0.74	1.29
SE(m) ±	0.21	0.25	0.43

H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

Figure 4.19: Analysis of number of fruit per plant as influenced by hydrogel and AVS



4.16 Fruit yield per plant (kg/plant)

Fruit yield/plant showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the results are shown in **Figure 4.20** and **Table 4.16** and discussed

In 2023, hydrogel at 1.5 kg/acre (H_2) proved to be the most effective treatment with 2.05 kg fruits/plant. These are significantly higher than control which had produced only 1.60 kg/plant. The biostimulant treatment of 5 g/L (V_2) also significantly improved fruit yield per plant (2.47 kg/plant) compared to the control (1.22 kg/plant). The combination V_2-5 g/L + H_2-1.5 kg/acre achieved fruit yield per plant to the tune of 2.72 kg/plant which was the highest among the 12 combinations. The combination of V_0-0 g/L + H_0-0.0 kg/acre resulted in the minimum fruit yield per plant *i.e.*, 1.02 kg/plant.

In 2024, hydrogel at 1.5 kg/acre (H_2) demonstrated a significant positive effect on individual fruit weight with average of 2.83 kg/plant. The control (H_0) had significantly less fruit yield per plant *i.e.*, 2.42 kg/plant. The biostimulant application of 5 g/L (V_2) resulted in fruit yield per plant of 3.36 kg/plant, whereas, the control (V_0) showed less fruit yield per plant of 1.84 kg/plant. The combination of V_2-5 g/L +

H_2-1.5 kg/acre led to the maximum plant fruit yield per plant with average of 3.44 kg/plant. The combination of V_0-0 g/L + H_0-0.0 kg/acre had the less fruit yield per plant 1.67 kg/plant.

The combined data of both 2023 and 2024 year show that hydrogel at 1.5 kg/acre (H_2) maximum fruit yield per plant average 2.44 kg/plant. These were significantly higher compared to control (H_0) with average fruit yield per plant of 2.01 kg/plant. The biostimulant @ 5 g/L (V_2) also significantly improved with average of 2.92 kg/plant compared to the control 1.53 kg/plant. The combination V_2-5 g/L + H_2-1.5 kg/acre resulted in the maximum fruit yield per plant *i.e.*, 3.08 kg/plant. The lowest average fruit yield per plant was noted in control 1.35 kg/plant.

Hydrogel greatly enhanced fruit yield/plant by ensuring optimal soil moisture, crucial for fruit development and maturation. The use of AVS further increased fruit yield by supplying vital nutrients such as boron and zinc that support fruit development and quality. Plants treated with it produced a larger quantity of marketable fruits resulting in a higher overall yield per plant.

Figure 4.20: Analysis of fruit yield per plant (kg/plant) as influenced by hydrogel and AVS

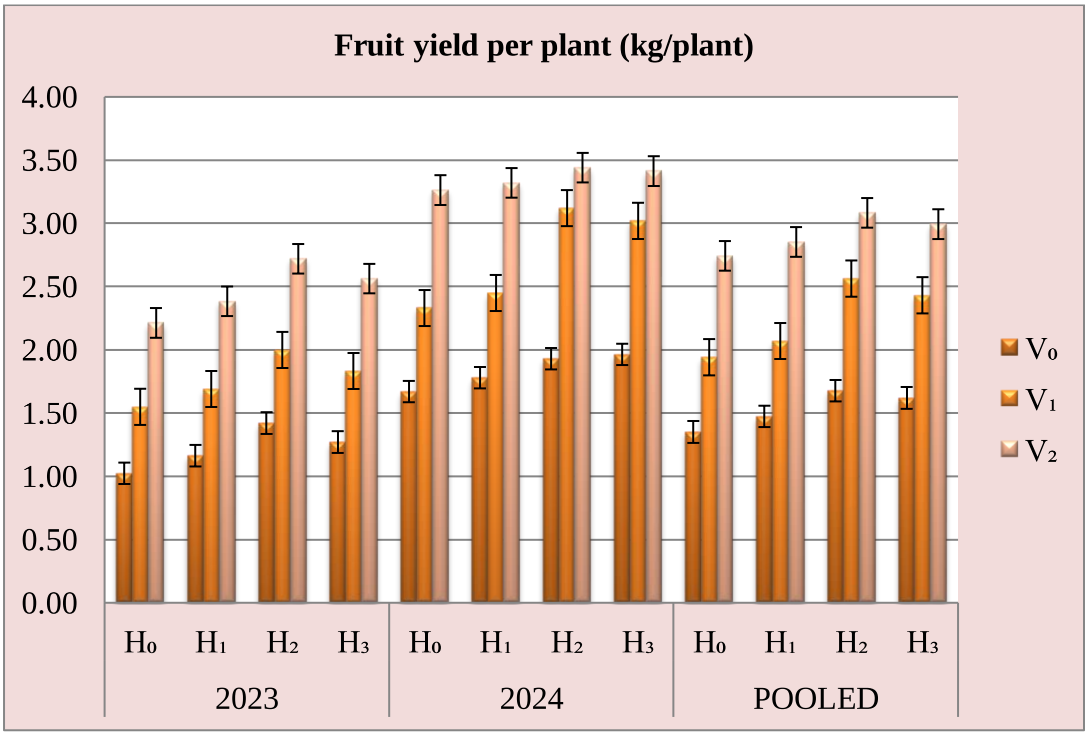


Table 4.16: Analysis of fruit yield per plant (kg/plant) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.02	1.16	1.42	1.27	1.22
V_1	1.55	1.69	2.00	1.83	1.77
V_2	2.21	2.38	2.72	2.56	2.47
Mean	1.60	1.75	2.05	1.89	
	V	**H**	**V × H**		
CD (p=0.05)	0.015	0.017	0.03		
SE(m) ±	0.005	0.006	0.01		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.67	1.78	1.93	1.96	1.84
V_1	2.33	2.45	3.12	3.02	2.73
V_2	3.26	3.32	3.44	3.41	3.36
Mean	2.42	2.52	2.83	2.80	
	V	**H**	**V × H**		
CD (p=0.05)	0.009	0.011	0.019		
SE(m) ±	0.003	0.004	0.006		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	1.35	1.47	1.68	1.62	1.53
V_1	1.94	2.07	2.56	2.43	2.25
V_2	2.74	2.85	3.08	2.99	2.92
Mean	2.01	2.13	2.44	2.35	
	V	**H**	**V × H**		
CD (p=0.05)	0.008	0.009	0.016		
SE(m) ±	0.003	0.003	0.005		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.17 Fruit yield per plot (kg/plot)

Fruit yield per plot showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the results are shown in **Table 4.17** and **Figure 4.21** and presented below

In 2023, hydrogel @ 1.5 kg/acre (H_2) proved to be the most effective treatment with fruit yield per plot 52.45 kg. These were significantly greater than control which had less fruit yield per plot 43.09 kg. The biostimulant treatment of 5 g/L (V_2) also significantly improved fruit yield per plot to 62.56 kg compared to the control which had fruit yield per plot 32.25 kg. The most notable results V_2 + H_3 achieved fruit yield per plot 65.91 kg. The combination of V_0 + H_0 resulted in the lowest fruit yield per plot *i.e.*, 27.79 kg.

In 2024, hydrogel @ 1.5 kg/acre (H_2) demonstrated a significant positive effect on fruit yield per plot 76.77 kg. The control had significantly less fruit yield per plot 64.92 kg. The application of 5 g/L (V_2) resulted in fruit yield per plot of 89.63 kg whereas the control showed less fruit yield per plot 49.14 kg. The combination of V_2 + H_3 led to the maximum fruit yield 91.73 kg. The combination of V_0 + H_0 had the less yield 44.23 kg.

The combined data for 2023 and 2024 show that hydrogel @ 1.5 kg/acre (H_2) maximum fruit yield per plot 64.61 kg. These were significantly higher compared to the control 54.00 kg. The AVS application @ 5 g/L (V_2) also significantly improved fruit yield per plot with average of 76.10 kg, compared to the control which had less yield 40.70 kg. The optimal combination was V_2-5 g/L + H_3-2.0 kg/acre resulted in the maximum fruit yield of plot 78.83 kg. The lowest fruit yield per plot was noted with the combination V_2-5 g/L + H_0-0.0 kg/acre is 36.01 kg.

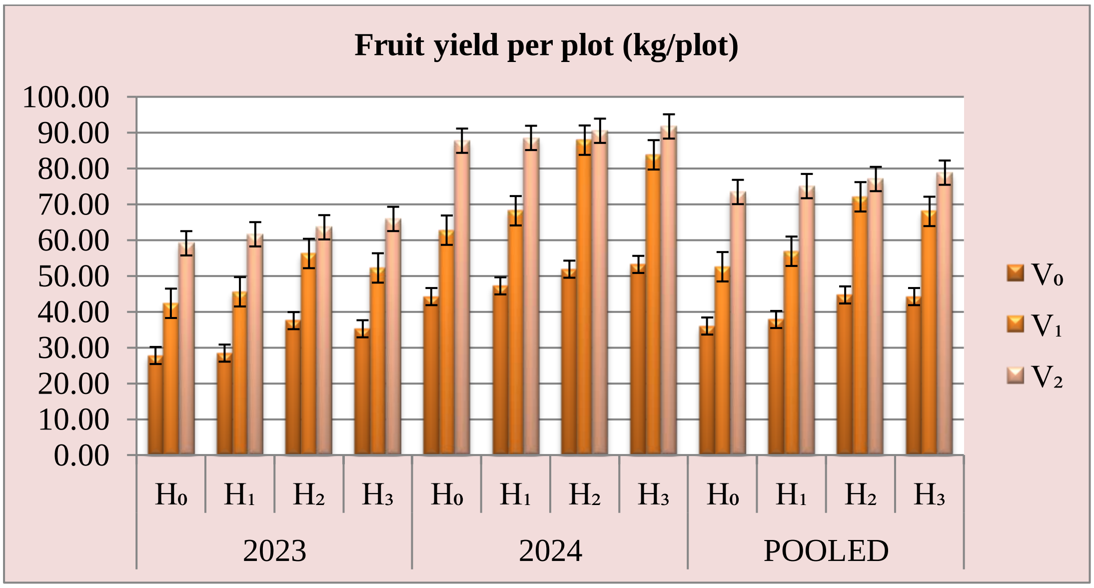
Hydrogel led to improved fruit development throughout the plot, thereby increasing the overall yield. The use of AVS also helped increase fruit weight per plot by improving the plants nutritional status. The combined effect of better nutrition and steady moisture resulted in a significant boost in the total fruit weight harvested per plot. Similar findings observed were **Pandiyan *et al.*, 2018** showed the maximum fruit yield per plot in tomato by foliar spray of Boric acid.

Table 4.17: Analysis of fruit yield per plot (kg/plot) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	27.79	28.45	37.52	35.25	32.25
V_1	42.36	45.58	56.26	52.23	49.11
V_2	59.11	61.63	63.58	65.91	62.56
Mean	43.09	45.22	52.45	51.13	
	V		**H**	**V × H**	
CD (p=0.05)	0.55		0.64	1.17	
SE(m) ±	0.18		0.21	0.37	
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	44.23	47.23	51.88	53.21	49.14
V_1	62.77	68.20	87.90	83.81	75.67
V_2	87.75	88.53	90.52	91.73	89.63
Mean	64.92	67.99	76.77	76.25	
	V		**H**	**V × H**	
CD (p=0.05)	0.54		0.62	1.09	
SE(m) ±	0.18		0.21	0.36	
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	36.01	37.84	44.70	44.23	40.70
V_1	52.57	56.89	72.09	68.02	62.39
V_2	73.43	75.08	77.06	78.83	76.10
Mean	54.00	56.61	64.61	63.69	
	V		**H**	**V × H**	
CD (p=0.05)	0.36		0.41	0.71	
SE(m) ±	0.12		0.14	0.24	

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

Table 4.21: Analysis of fruit yield per plot (kg/plot) as influenced by hydrogel and AVS



4.18 Fruit yield (t/acre)

Fruit yield showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the results are shown in **Figure 4.23** and **Table 4.18** and presented following

In 2023, the hydrogel treatment @ 1.5 kg/acre (H_2) was the most effective, which resulted in significantly maximum fruit yield 17.48 t/acre. The control had significantly less fruit yield that is 14.36 t/acre The application of biostimulant @ 5 g/L (V_2) resulted in maximum fruit yield 20.85 compared to the control 10.75 t/acre. The combination of V_2H_3 showed the maximum fruit yield (21.97 t/acre) and less fruit yield was found with V_0H_0 (9.26 t/acre).

In 2024 the hydrogel treatment at 1.5 kg/acre (H_2) showed superior results with fruit yield 25.59 t/acre. The control had less fruit yield 21.64 t/acre. AVS @ 5 g/L (V_2) also led to maximum fruit yield 29.88 t/acre compared to control 16.38 t/acre the combination of V_2H_3 produced the maximum fruit yield 30.58 t/acre. The combination of V_0H_0 found the less yield 14.74 t/acre.

Combining data from both years, hydrogel @ 1.5 kg/acre (H_2) resulted in maximum fruit yield with average of 21.54 t/acre which were significantly higher than control with average *i.e.*, 18.00 t/acre. The biostimulant at 5 g/L (V_2) also showed a significant increased in fruit yield 25.37 t/acre compared to control *i.e.*, 13.57 t/acre. The combination V_2-5 g/L + H_3-2.0 kg/acre shows maximum yield 26.28 t/acre and less fruit yield were observed with control 12.00 t/acre.

The fruit yield of brinjal plants is significants increased when Arka Vegetable Special and hydrogel are applied together. While hydrogel improve the root growth, nutrient uptake and stress resilience, Arka Vegetable Special offers a balanced nutrition supply that promotes plant growth and fruit development. Their combination results in better flowering, fruiting, healthier plants and higher yields per plant. Crops' productivity can be increased sustainably and effectively using this integrated approach particularly as results of changing environmental conditions. The findings align closely with previous research conducted and documented in comprehensive study by **Singh *et al.* (2024)** where they found that maximum fruit yield was achieved by applying a solution containing 2.0 kg B ha^{-1} at the maximum vegetative development stage and another at the flower initiation stage in tomato.

Figure 4.22: Analysis of fruit yield (t/acre) as influenced by hydrogel and AVS

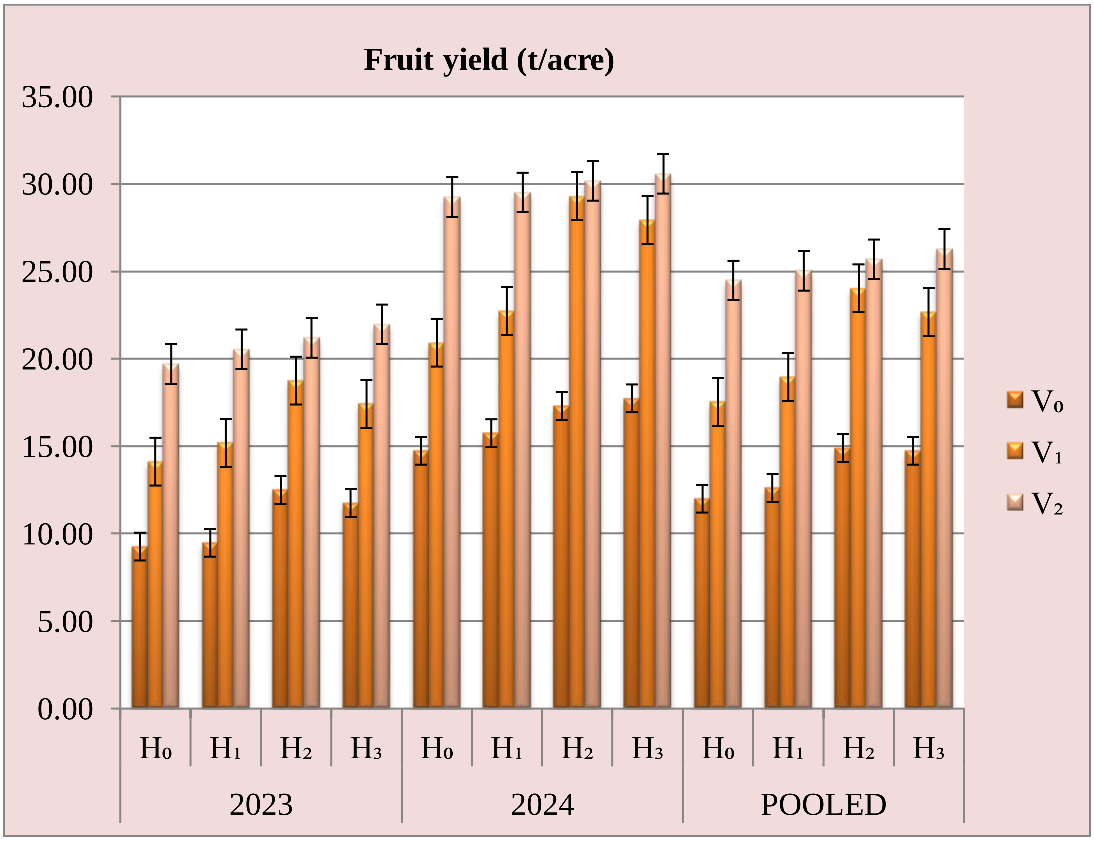


Table 4.18: Analysis of fruit yield (t/acre) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	9.26	9.48	12.51	11.75	10.75
V_1	14.12	15.19	18.75	17.41	16.37
V_2	19.70	20.54	21.19	21.97	20.85
Mean	14.36	15.07	17.48	17.04	
	V	**H**	**V × H**		
CD (p=0.05)	0.18	0.21	0.37		
SE(m) ±	0.06	0.07	0.12		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	14.74	15.74	17.29	17.74	16.38
V_1	20.92	22.73	29.30	27.93	25.22
V_2	29.25	29.51	30.17	30.58	29.88
Mean	21.64	22.66	25.59	25.42	
	V	**H**	**V × H**		
CD (p=0.05)	0.18	0.21	0.36		
SE(m) ±	0.06	0.07	0.12		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	12.00	12.62	14.90	14.74	13.57
V_1	17.52	18.96	24.03	22.67	20.80
V_2	24.48	25.03	25.69	26.28	25.37
Mean	18.00	18.87	21.54	21.23	
	V	**H**	**V × H**		
CD (p=0.05)	0.11	0.13	0.23		
SE(m) ±	0.04	0.04	0.08		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

<u>SOIL MOISTURE ANALYSIS</u>

4.19 Number of irrigations

The **Table 4.19** and **4.20** shows several combinations of treatments for diffferent dates of irrigation. A (0=irrigation applied) or (1=irrigation not applied) is used to indicate each element in the table. The total number of times irrigation was not applied for each treatment combination is shown in the sum row at the bottom.

During 2023, sum of 0 indicates that 16 irrigations (at regular intervals) were applied to the V_0H_0, V_1H_0 and V_2H_0 combinations for the whole period. However, V_0H_3 combination was irrigated 12 times, V_0H_3 combination irrigated 12 times. Irrigation was applied on 13, 14 and 13 times for the V_1H_1, V_1H_2 and V_1H_3 combinations. In V_1H_2 irrigation was applied 12 times. The V_2H_1 and V_2H_3 combinations were irrigated 11 times each, whereas the V_2H_2 combination was irrigated 10 times only. These demonstrate the frequency of irrigation varied among the various treatment combinations with some irrigated at regular intervals and others requiring lesser irrigations.

During 2024, V_0H_0, V_1H_0 and V_2H_0 each required 16 irrigations in their entire crop duration. V_0H_2 was irrigated 11 times. The combination V_0H_1 was irrigated 12 times. Irrigation was applied 10 times to the V_0H_3 combination. For V_1H_1 and V_1H_2 13 and 12 irrigations were required respectively. V_1H_3 proved to be water economical as it required only 10 irrigations. Best combination was V_2H_2 which required 8 lesser irrigations as compared to control.

Hydrogel functions as a water-retaining polymer that absorbs and stores a lot of water in the root zone. This stored water is then gradually released over time. It drastically lowers the frequency of irrigations needed for crop (brinjal) cultivation. Applying hydrogel to the soil causes it to absorb water and swell during the availability of water and retain it like a sponge. Hydrogel helps prevent water stress and supports consistent development while lowering overall water usage. Moreover, the application of hydrogel not only reduces the dependency on frequent irrigation but also helps conserve water resources. It can also improve soil structure by reducing surface runoff and soil erosion. Similar findings are observed by **Deenavarman *et al.* (2018)** in

Syngonium podophyllum by using PUSA hydrogel it reduces the frequency of watering and increases the availability of water for plants.

Table 4.19: Analysis of number of irrigations as influenced by hydrogel and AVS

	Treatment combinations											
Irrigation dates	V_0H_0	V_0H_1	V_0H_2	V_0H_3	V_1H_0	V_1H_1	V_1H_2	V_1H_3	V_2H_0	V_2H_1	V_2H_2	V_2H_3
1st May	0	0	0	0	0	0	0	0	0	0	0	0
5th May	0	0	0	0	0	0	0	0	0	0	0	0
10th May	0	0	0	0	0	0	0	0	0	0	0	0
17th May	0	0	0	0	0	0	0	0	0	0	0	0
23rd May	0	0	0	0	0	0	0	0	0	0	0	0
1st June	0	**1**	**1**	**1**	0	**1**	**1**	**1**	0	**1**	**1**	**1**
8th June	0	0	0	0	0	0	0	0	0	0	0	0
13th June	0	0	**1**	0	0	0	**1**	**1**	0	**1**	**1**	0
20th June	0	0	0	0	0	0	0	0	0	0	0	0
28th June	0	0	0	**1**	0	**1**	0	0	0	0	**1**	**1**
5th July	0	0	0	0	0	0	0	0	0	0	0	0
12th July	0	0	**1**	**1**	0	0	0	0	0	**1**	**1**	**1**
15th July	0	0	0	0	0	0	0	0	0	0	0	0
18th July	0	**1**	0	**1**	0	**1**	**1**	**1**	0	**1**	**1**	**1**
23rd July	0	0	0	0	0	0	0	0	0	0	0	0
6th August	0	0	0	0	0	0	**1**	0	0	**1**	**1**	**1**
Sum	0	2	3	4	0	3	4	3	0	5	6	5
Irrigations applied	16	14	13	12	16	13	12	13	16	11	10	11

*0=Irrigation applied, 1=Irrigation not applied, Sum=Total number of irrigation not applied

Table 4.20: Analysis of number of irrigations as influenced by hydrogel and AVS

	Treatment combinations											
Irrigation dates	V_0H_0	V_0H_1	V_0H_2	V_0H_3	V_1H_0	V_1H_1	V_1H_2	V_1H_3	V_2H_0	V_2H_1	V_2H_2	V_2H_3
1st May	0	0	0	0	0	0	0	0	0	0	0	0
5th May	0	0	0	0	0	0	0	0	0	0	0	0
10th May	0	0	0	0	0	0	0	0	0	0	0	0
17th May	0	0	0	0	0	0	0	0	0	0	0	0
23rd May	0	0	0	0	0	0	0	0	0	0	0	0
1st June	0	0	0	**1**	0	0	0	**1**	0	**1**	**1**	0
8th June	0	0	0	0	0	0	0	0	0	0	0	0
13th June	0	**1**	**1**	**1**	0	0	**1**	**1**	0	**1**	**1**	0
20th June	0	0	0	0	0	0	0	0	0	0	0	0
28th June	0	0	0	0	0	0	0	0	0	0	**1**	**1**
5th July	0	**1**	**1**	**1**	0	**1**	**1**	**1**	0	**1**	**1**	**1**
12th July	0	**1**	**1**	**1**	0	**1**	0	**1**	0	**1**	**1**	**1**
15th July	0	0	0	0	0	0	0	0	0	0	0	0
18th July	0	0	**1**	**1**	0	**1**	**1**	**1**	0	**1**	**1**	**1**
23rd July	0	0	0	0	0	0	0	0	0	0	**1**	0
6th August	0	**1**	**1**	**1**	0	**1**	**1**	**1**	0	**1**	**1**	**1**
Sum	0	4	5	6	0	3	4	6	0	6	8	5
Irrigations applied	16	12	11	10	16	13	12	13	16	10	08	11

*0=Irrigation applied, 1=Irrigation not applied, Sum=Total number of irrigation not applied

QUALITY PARAMETERS

4.20 Total soluble solid (°Brix)

Total soluble solid showed significant variations among the treatments in both the years 2023 and 2024. For easy and comparative understanding the results are shown in **Figure 4.23** and **Table 4.21** and presented below:

In 2023, hydrogel at 1.5 kg/acre (H_2) proved to be the most effective treatment with total soluble solid 5.60°Brix. These total soluble solids were significantly greater than those of the control (5.16°Brix). The biostimulant treatment of 5 g/L (V_2) also significantly improved total soluble solid to 6.15°Brix compared to the control 4.73°Brix. V_2 + H_3 shows highest total soluble solid of 6.45°Brix and V_0 + H_0 resulted lowest total soluble solid 4.56°Brix.

In 2024, hydrogel @ 2.0 kg/acre (H_3) demonstrated a significant positive effect on total soluble solid 4.83°Brix. The control had significantly lower total soluble solid 4.33°Brix. The application of 5 g/L (V_2) resulted in highest total soluble solid 4.93°Brix whereas, the control showed lowest total soluble solid (4.33°Brix). The combination V_2 + H_3 led to the highest total soluble solid with average of 5.48°Brix and the combination of V_0 + H_0 had the lowest total soluble solid 3.61°Brix.

The pooled data for 2023 and 2024 showed that hydrogel at 2.0 kg/acre (H_3) highest total soluble solid 5.18°Brix. These were significantly higher compared to the control *i.e.*, 4.74°Brix. The biostimulant @ 5 g/L (V_2) also significantly improved total soluble solid with average of 5.54°Brix compared to the control which had lowest average 4.53°Brix. The optimal combination was V_2 + H_3 showed maximum total soluble solid of 5.97°Brix. The lowest average total soluble solid was noted V_0 + H_0 *i.e.*, 4.09°Brix.

A steady supply of water by using hydrogel ensures that the plant can perform physiological functions such as sugar production more effectively this may result in increased TSS levels in fruits. Fruits with greater TSS are typically produced by nutrient rich plants because healthy nutrition aids in the synthesis of sugars and other substances that raise TSS. Its interaction can result in a higher fruit output, good size and increased taste. Similar phenomenon was observed by **Elwan *et al.*, 2015** showed boron application improved the plant's overall absorption of nutrients leading to a rise in TSS content. This is due to the fact that these micronutrients are essential for the activation of enzymes and effective metabolic processes associated with the production of carbohydrates.

Figure 4.23: Analysis of total soluble solid (°Brix) as influenced by hydrogel and AVS

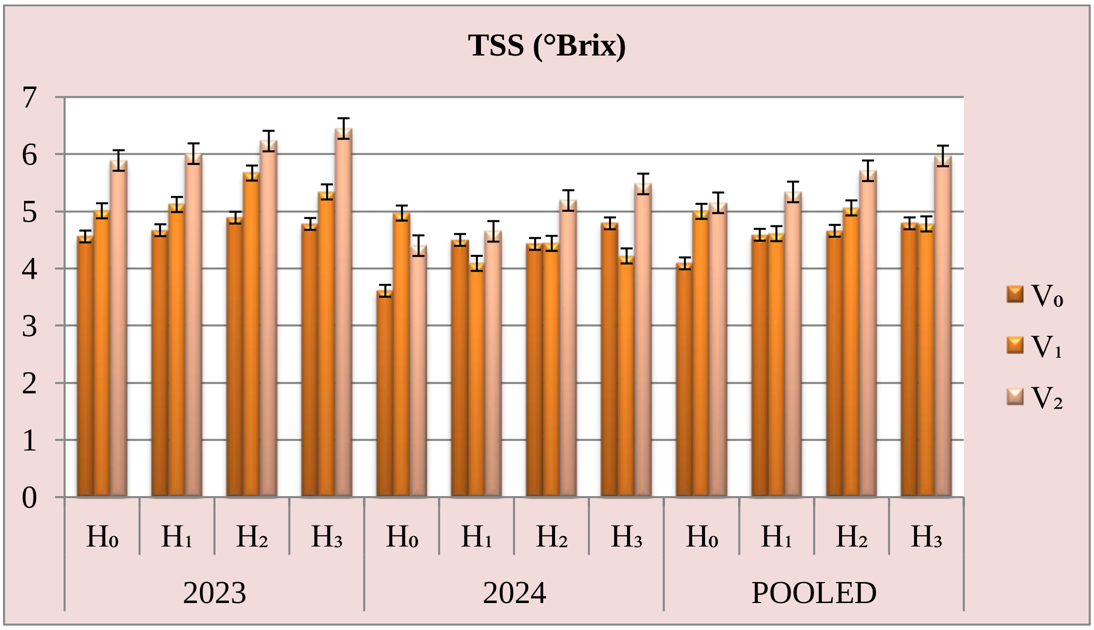


Figure 4.24: Analysis of moisture content of fruit (%) as influenced by hydrogel and AVS

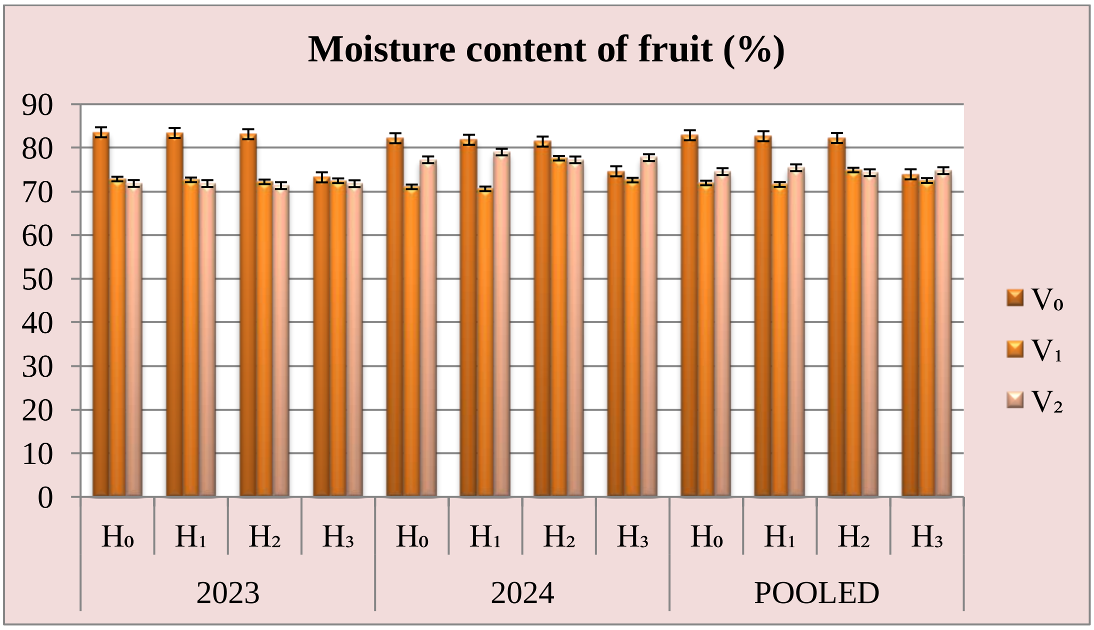


Table 4.21: Analysis of total soluble solid (°Brix) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4.56	4.67	4.89	4.78	4.73
V_1	5.01	5.12	5.67	5.34	5.29
V_2	5.89	6.01	6.23	6.45	6.15
Mean	5.16	5.27	5.60	5.52	

	V	**H**	**V × H**
CD (p=0.05)	0.012	0.014	0.024
SE(m) ±	0.004	0.005	0.008

2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	3.61	4.50	4.43	4.79	4.33
V_1	4.97	4.09	4.44	4.22	4.43
V_2	4.40	4.65	5.19	5.48	4.93
Mean	4.33	4.42	4.69	4.83	

	V	**H**	**V × H**
CD (p=0.05)	0.205	0.237	0.41
SE(m) ±	0.07	0.08	0.13

Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	4.09	4.59	4.66	4.79	4.53
V_1	5.00	4.61	5.06	4.78	4.86
V_2	5.15	5.34	5.71	5.97	5.54
Mean	4.74	4.85	5.14	5.18	

	V	**H**	**V × H**
CD (p=0.05)	0.101	0.117	0.203
SE(m) ±	0.03	0.04	0.06

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.21 Moisture content of fruit (%)

Analysis of moisture content of fruit (%) as influenced by hydrogel and AVS for the year 2023, 2024 and pooled over the different treatment illustrated in **Table 4.22** and **Figure 4.24**.

In 2023, maximum moisture content in hydrogel is in control 76.08%. This moisture content of fruits in H_0 was greater than fruits of 2.0 kg/acre (H_3) which had minimum moisture content in fruits (72.48%). The biostimulant treatment of 0 g/L (V_0) resulted in 80.83% content in fruits which was significantly greater as compared to the 5 g/L (V_2) *i.e.*, 71.69%. The V_0H_0 resulted in 83.55% moisture content of fruit and combination V_2-5 g/L + H_2-1.5 kg/acre resulted in the lowest value (71.33%).

In 2024, moisture content in hydrogel is maximum in 1.5 kg/acre (H_2) 78.77%. This moisture content of fruits was significantly maximum than those of the 2.0 kg/acre (H_3) which had minimum moisture content of fruit of 74.98%. The biostimulant treatment of V_0 *i.e.*, 80.02% is maximum compared to the 5 g/L (V_1) 72.96%. The combination of V_0-0 g/L + H_0-0.0 kg/acre achieved moisture content of fruit 82.19%. In combination V_1-2 g/L + H_0-0.0 kg/acre is lowest 71.04%.

The combined data for 2023 and 2024, shows that moisture content in hydrogel is maximum in H_0 *i.e.*, 76.46%. This moisture content of fruits was significantly maximum than those of the 2.0 kg/acre (H_3) which had minimum moisture content of fruit 73.73%. The treatment V_0 is highest 80.43% compared to the 5 g/L (V_1) 72.75%. The combination of V_0-0 g/L + H_0-0.0 kg/acre achieved moisture content of fruit of 82.87%. In combination V_1-2 g/L + H_1-1.0 kg/acre is lowest 71.62%.

Brinjal moisture content can be maintained throughout its growing phase with the use of Arka Vegetable Special and hydrogel resulting in healthier fruits and optimum moisture content. The fruits without using Arka Vegetable Special and hydrogel may deteriorate more quickly in storage because they are more prone to spoiling, microbial activity and rapid moisture loss. By enhancing moisture retention and improving overall plant health, Arka Vegetable Special and hydrogel not only boost the shelf life of brinjal but also help in maintaining its nutritional value.

Table 4.22: Analysis of moisture content of fruit (%) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	83.55	83.43	83.11	73.22	80.83
V_1	72.85	72.65	72.18	72.44	72.53
V_2	71.85	71.82	71.33	71.77	71.69
Mean	76.08	75.97	75.54	72.48	
	V	**H**	**V × H**		
CD (p=0.05)	0.074	0.086	0.148		
SE(m) ±	0.025	0.029	0.05		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	82.19	81.86	81.43	74.60	80.02
V_1	71.04	70.58	77.63	72.61	72.96
V_2	77.25	79.03	77.24	77.75	77.82
Mean	76.82	77.16	78.77	74.98	
	V	**H**	**V × H**		
CD (p=0.05)	1.104	1.275	2.209		
SE(m) ±	0.374	0.432	0.748		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	82.87	82.65	82.27	73.91	80.43
V_1	71.94	71.62	74.91	72.53	72.75
V_2	74.55	75.43	74.29	74.76	74.76
Mean	76.46	76.56	77.16	73.73	
	V	**H**	**V × H**		
CD (p=0.05)	0.553	0.639	1.107		
SE(m) ±	0.187	0.216	0.375		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.22 Dry matter content (%)

Analysis of Dry matter content of fruit (%) as influence by hydrogel and AVS for the year 2023, 2024 and pooled over the different treatment illustrated in **Table 4.22** and **Figure 4.25**.

In 2023, hydrogel @ 2.0 kg/acre (H_3) proved to be the most effective treatment with dry matter content (27.52%). These dry matter content were highest than those of the H_0 (23.92%). The treatment of 5 g/L (V_2) also significantly improved dry matter content (28.31%) compared to the control (19.17%). The most notable results $V_2 + H_2$ achieved dry matter content of (28.67%). The combination of control showed lowest dry matter content *i.e.*, 16.45%.

In 2024, hydrogel @ 2.0 kg/acre (H_3) demonstrated a positive effect on dry matter content (25.02%). The H_2 had significantly lower dry matter content *i.e.*, 21.23%. The AVS application of 2 g/L (V_1) resulted in dry matter content of (27.04%) whereas, the control showed lowest dry matter content *i.e.*, 19.98%. The combination $V_1 + H_1$ resulted to the highest dry matter content with average of 29.42%. Conversely, the combination of V_0-0 g/L + H_0-0.0 kg/acre showed the lowest dry matter content (17.81%).

The combined data for 2023 and 2024 show that hydrogel @ 2.0 kg/acre (H_3) consistently led to the highest dry matter content (26.27%). These were significantly higher compared to the 1.5 kg/acre (H_2) with average dry matter content of (22.85%). The biostimulant @ 2 g/L (V_1) also significantly improved with average of 27.25% compared to control (19.58%). The optimal combination was $V_1 + H_1$ resulted in the maximum dry matter content of 28.38%. The lowest dry matter content was observed with the combination of control (17.13%).

Brinjal nutrient profile and growth potential are improved with Arka Vegetable Special, which may raise the dry matter content. By increasing water availability hydrogel helps plants avoid stress and make better use of nutrients which raises their dry matter content. Hydrogel and Arka Vegetable Special combined together to enhance the growing circumstances of brinjal plants. The hydrogel keeps the plant continuously moist while the Arka Vegetable Special ensures nutrient rich growth.

These elements can enhance plant development and resource efficiency which can raise the dry matter content of fruit. Comparable result were noted in **(Javed *et al.*, 2023)** in okra by using zinc sulphate, ammonium molybdate, copper sulphate, ferrous sulphate, manganese sulphate mixture without boric acid.

Figure 4.25: Analysis of dry matter content of fruit (%) as influenced by hydrogel and AVS

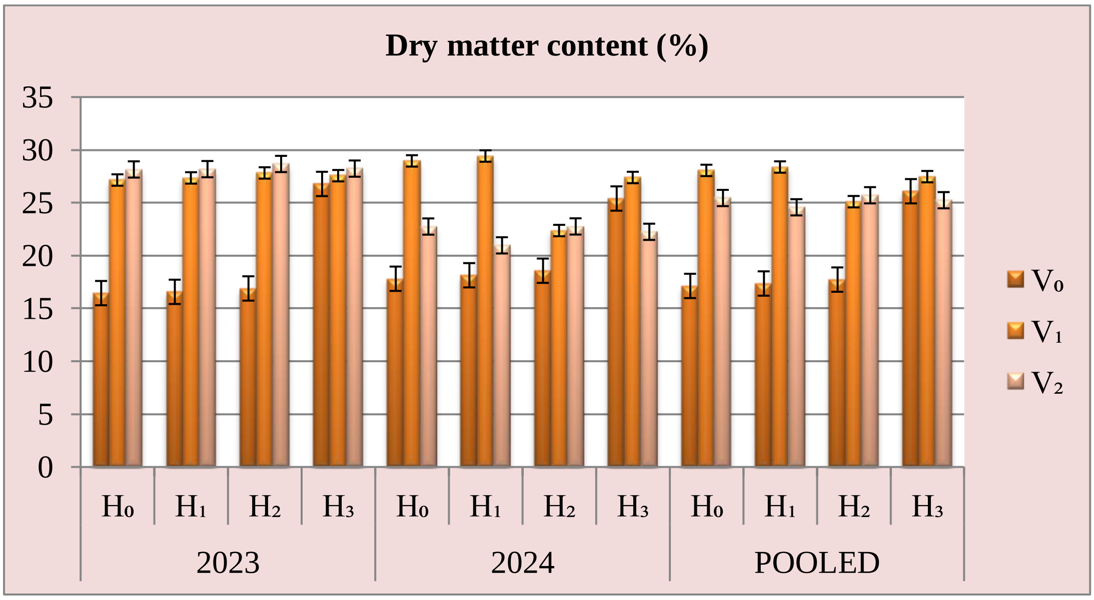


Figure 4.26: Analysis of ash content (% on dry weight basis) as influenced by hydrogel and AVS

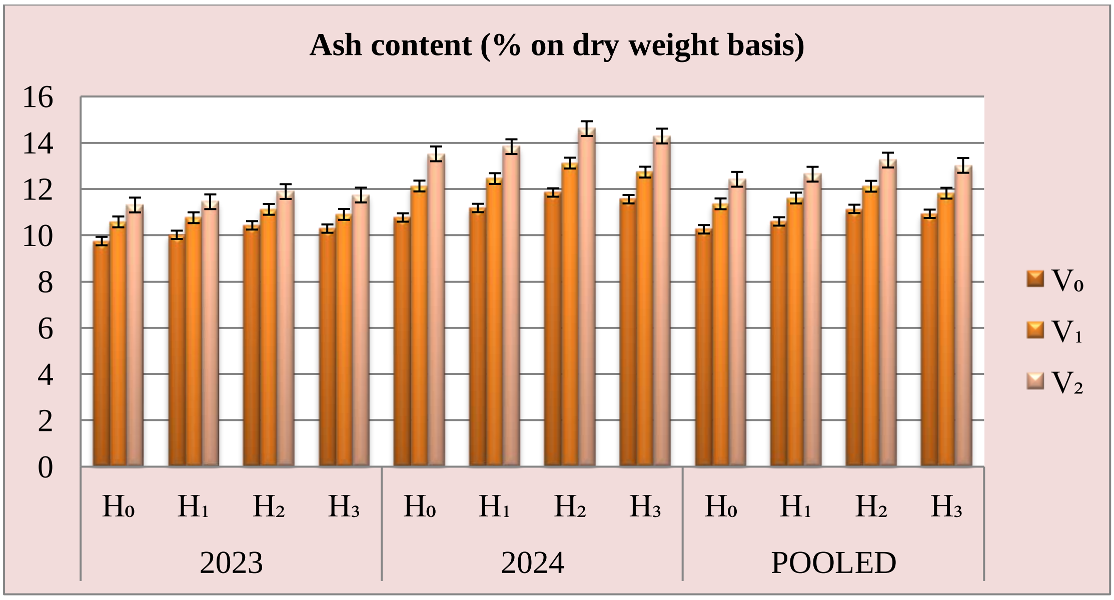


Table 4.23: Analysis of dry matter content of fruit (%) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	16.45	16.57	16.89	26.78	19.17
V_1	27.15	27.35	27.82	27.56	27.47
V_2	28.15	28.18	28.67	28.23	28.31
Mean	23.92	24.03	24.46	27.52	
	V	**H**	**V × H**		
CD (p=0.05)	0.05	0.05	0.10		
SE(m) ±	0.017	0.02	0.034		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	17.81	18.14	18.57	25.40	19.98
V_1	28.96	29.42	22.37	27.39	27.04
V_2	22.75	20.97	22.76	22.25	22.18
Mean	23.18	22.84	21.23	25.02	
	V	**H**	**V × H**		
CD (p=0.05)	1.104	1.27	2.20		
SE(m) ±	0.37	0.43	0.74		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	17.13	17.36	17.73	26.09	19.58
V_1	28.06	28.38	25.10	27.47	27.25
V_2	25.45	24.57	25.71	25.24	25.25
Mean	23.55	23.44	22.85	26.27	
	V	**H**	**V × H**		
CD (p=0.05)	0.55	0.64	1.10		
SE(m) ±	0.18	0.21	0.37		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

4.23 Ash content (% on dry weight basis)

Analysis of ash content (%) as influenced by hydrogel and AVS for the year 2023, 2024 and pooled over the different treatments is illustrated in **Table 4.24** and **Figure 4.26**.

In 2023, hydrogel @ 1.5 kg/acre (H_2) proved to be the most effective treatment with ash content 11.15%. This was significantly highest than those of the H_0 *i.e.*, 10.55%. The biostimulant treatment of 5 g/L (V_2) also improved ash content to 11.60% compared to the control (10.12%). The most notable results V_2 + H_2 achieved ash content 11.89% and V_0 + H_0 resulted in the lowest ash content (9.75%).

In 2024, hydrogel @ 1.5 kg/acre (H_2) demonstrated a significant positive effect on ash content 13.19%. The control had significantly lower ash content of 12.14%. The biostimulant application of 5 g/L (V_2) resulted in highest ash content of 14.06% whereas, the control showed lowest ash content (11.34%). The combination V_2 + H_2 resulted to the highest ash content with averages of 14.61%. Conversely, the combination of V_0 + H_0 resulted the lowest (10.77%) ash content.

The combined data for 2023 and 2024 show that hydrogel @ 1.5 kg/acre (H_2) led to the highest ash content 12.17%. These were significantly higher compared to the control with average ash content of 11.35%. The biostimulant @ 5 g/L (V_2) also significantly improved with average of 12.83% compared to the control which had lower averages of 10.73%. The combination V_2 + H_2 showed the maximum ash content of 13.25% and lowest average ash content was observed in V_0 + H_0 *i.e.*, 10.26%.

By enhancing nutrient uptake biostimulants can raise the ash level of brinjal and consequently the fruit mineral content. Steady supply of water, lowering water stress and promoting improved root development, by adding hydrogel to the soil, can also indirectly raise the ash content through improved nutrient absorption. Synergistic impact ensures proper hydration and nutrient availability. Similar findings are observed by **EI Hady *et al.* (2012)** in tomato when hydrogel was added to the growing media improved nutrient absorption, which may have an impact on the mineral content of fruits particularly their ash level.

Table 4.24: Analysis of ash content (% on dry weight basis) as influenced by hydrogel and AVS

2023					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	9.75	10.02	10.43	10.29	10.12
V_1	10.58	10.76	11.12	10.90	10.84
V_2	11.31	11.45	11.89	11.74	11.60
Mean	10.55	10.74	11.15	10.98	
	V	**H**	**V × H**		
CD (p=0.05)	0.01	0.01	0.02		
SE(m) ±	0.003	0.004	0.007		
2024					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	10.77	11.18	11.85	11.56	11.34
V_1	12.13	12.45	13.12	12.73	12.61
V_2	13.52	13.83	14.61	14.29	14.06
Mean	12.14	12.49	13.19	12.86	
	V	**H**	**V × H**		
CD (p=0.05)	0.007	0.008	0.014		
SE(m) ±	0.002	0.003	0.005		
Pooled					
T	**H_0**	**H_1**	**H_2**	**H_3**	**Mean**
V_0	10.26	10.60	11.14	10.93	10.73
V_1	11.36	11.61	12.12	11.82	11.73
V_2	12.42	12.64	13.25	13.02	12.83
Mean	11.35	11.62	12.17	11.92	
	V	**H**	**V × H**		
CD (p=0.05)	0.007	0.008	0.014		
SE(m) ±	0.002	0.003	0.005		

*H_0-0.0 kg/acre, H_1-1.0kg/acre, H_2-1.5 kg/acre, H_3-2.0 kg/acre, V_0-0 g/L, V_1-2 g/L, V_2-5 g/L; H=hydrogel, V=Arka Vegetable Special

ECONOMIC ANALYSIS

This research took into account the current market pricing of all the inputs and the revenue generated from selling the produce. The goal of this analysis was to determine the cost of cultivation (₹/acre), gross returns (₹/acre), net return (₹/acre) and benefit:cost ratio. It was calculated treatment-wise and the data gathered according to treatments is shown in **Table 4.25 and 4.26**.

4.24 Cost of cultivation (₹/ha)

Data on the cost of cultivation during 2023 of various treatment applications on brinjal reported with a fixed cost of cultivation of (₹ per ha), the highest total cost of cultivation (₹ 93,505.00) was recorded in V_1H_3 (2 g/L + 2.0 kg/acre) whereas, the least total cost of cultivation (₹ 90,115.00) was recorded in treatments V_0H_0 (0 g/L + 0 kg/acre).

During 2024 of various treatment applications on brinjal reported with a fixed cost of cultivation of (₹ per ha), highest total cost of cultivation (₹ 93,250.00) was recorded in V_2H_3 (5 g/L + 2.0 kg/acre) whereas, least total cost of cultivation (₹ 90,115.00) was recorded in treatments V_0H_0 (0 g/L + 0 kg/acre).

4.25 Gross returns (₹/ha)

The maximum gross return during 2023 was obtained higher (₹ 4,43,816.44) with treatment V_2H_3 (5 g/L + 2.0 kg/acre) and lowest gross return (₹ 1,87,096.89) was obtained with treatment V_0H_0 (0 g/L + 0 kg/acre).

During 2024 the maximum gross return was obtained higher (₹ 1,87,808.71) with treatment V_2H_3 (5 g/L + 2.0 kg/acre) and lowest gross return (₹ 90,560.38) was obtained with treatment V_0H_0 (0 g/L + 0 kg/acre).

4.26 Net returns (₹/ha)

The maximum net returns during 2023 was obtained (₹ 3,50,566.44) with treatment V_2H_3 (5 g/L + 2.0 kg/acre) and the lowest net returns (₹ 96,981.89) was obtained with treatment V_0H_0 (0 g/L + 0 kg/acre).

During 2024 the maximum net return was obtained higher (₹ 94,558.71) with treatment V_2H_3 (5 g/L + 2.0 kg/acre) and the lowest net return (₹ 445.38) was obtained with treatment V_0H_0 (0 g/L + 0 kg/acre).

Table 4.25: Benefit cost analysis for brinjal crop production in 2023 using different treatments

Treatment name	Total cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit cost ratio
V_0H_0 0 g/L + 0 kg/acre	90,115.00	1,87,096.89	96,981.89	1.08
V_0H_1 0 g/L + 1.0 kg/acre	92,035.00	1,91,563.33	99,528.33	1.08
V_0H_2 0 g/L + 1.5 kg/acre	92,295.00	2,52,634.67	1,60,339.67	1.74
V_0H_3 0 g/L + 2.0 kg/acre	92,555.00	2,37,327.56	1,44,772.56	1.56
V_1H_0 2 g/L + 0 kg/acre	90,825.00	2,85,201.56	1,94,376.56	2.14
V_1H_1 2 g/L + 1.0 kg/acre	92,505.00	3,06,882.89	2,14,377.89	2.32
V_1H_2 2 g/L + 1.5 kg/acre	92,765.00	3,78,839.78	2,86,074.78	3.08
V_1H_3 2 g/L + 2.0 kg/acre	93,505.00	3,51,659.56	2,58,154.56	2.76
V_2H_0 5 g/L + 0 kg/acre	91,050.00	3,98,029.78	3,06,979.78	3.37
V_2H_1 5 g/L + 1.0 kg/acre	91,770.00	4,14,952.89	3,23,182.89	3.52
V_2H_2 5 g/L + 1.5 kg/acre	92,510.00	4,28,105.33	3,35,595.33	3.63
V_2H_3 5 g/L + 2.0 kg/acre	93,250.00	4,43,816.44	3,50,566.44	3.76

Table 4.26: Benefit cost analysis for brinjal crop production in 2024 using different treatments

Treatment name	Total cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit cost ratio
V_0H_0 0 g/L + 0 kg/acre	90,115.00	90,560.38	445.38	0.00
V_0H_1 0 g/L + 1.0 kg/acre	91,555.00	96,702.38	5147.38	0.06
V_0H_2 0 g/L + 1.5 kg/acre	91,815.00	1,06,215.65	14,400.65	0.16
V_0H_3 0 g/L + 2.0 kg/acre	92,075.00	1,08,945.43	16,870.43	0.18
V_1H_0 2 g/L + 0 kg/acre	90,825.00	1,28,511.11	37,686.11	0.41
V_1H_1 2 g/L + 1.0 kg/acre	92,505.00	1,39,621.31	47,116.31	0.51
V_1H_2 2 g/L + 1.5 kg/acre	92,765.00	1,79,967.42	87,202.42	0.94
V_1H_3 2 g/L + 2.0 kg/acre	92,785.00	1,71,580.18	78,795.18	0.85
V_2H_0 5 g/L + 0 kg/acre	91,050.00	1,79,646.68	88,596.68	0.97
V_2H_1 5 g/L + 1.0 kg/acre	92,010.00	1,81,250.42	89,240.42	0.97
V_2H_2 5 g/L + 1.5 kg/acre	92,030.00	1,85,331.44	93,301.44	1.01
V_2H_3 5 g/L + 2.0 kg/acre	93,250.00	1,87,808.71	94,558.71	1.01

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted in field of LPU during 2023 and 2024. The salient findings were observed as follow:

- Plant height was observed highest in hydrogel 1.5 kg/acre (H_2) 36.14 cm (55 DAT), 55.40 cm (70 DAT) and lowest in control 34.62 cm (55 DAT), 52.62 cm (70 DAT). The tallest plants in AVS 5 g/L (V_2) 37.25 cm (55 DAT), 56.22 cm (70 DAT) and smallest in control 33.41 cm (55 DAT), 51.88 cm (70 DAT). In combination highest in V_2 + H_2 was 38.11 cm (55 DAT), 60.40 cm and lowest in V_0 + H_0 with heights 32.60 cm (55 DAT), 51.47 cm (70 DAT).
- Number of leaves per plant: Maximum in hydrogel 1.5 kg/acre (H_2) 29.34 (55 DAT), 48.16 (70 DAT) and the minimum in control 27.59 (55 DAT), 46.11 (70 DAT). The maximum in AVS 5 g/L (V_2) 30.98, 49.96 (70 DAT) and minimum in control 25.88 (55 DAT), 44.07 (70 DAT). The maximum in combination V_2-5 g/L + H_2-1.5 kg/acre was 31.74 (55 DAT), 50.75 (70 DAT) and minimum in V_0-0 g/L + H_0-0.0 kg/acre with number of leaves 24.37 (55 DAT), 42.57 (70 DAT).
- Absolute growth rate: Maximum in hydrogel 1.5 kg/acre (H_2) 1.29 and minimum in control 1.16. The maximum in AVS at 5 g/L (V_2) 1.25 and minimum in V_1 *i.e.*, 1.15. The maximum in combination was (1.45) V_2-5 g/L + H_2-1.5 kg/acre and minimum in V_2-5 g/L + H_0 0.0 kg/acre at 1.08.
- Leaf length: Highest in hydrogel 2.0 kg/acre (H_3) and 1.5 kg/acre (H_2) 12.90 cm (55 DAT), 16.35 cm (70 DAT) and lowest in control 11.98 cm (55 DAT), 15.21 cm (70 DAT). The highest AVS 5 g/L (V_2) 14.06 cm (55 DAT), 17.27 cm (70 DAT) and lowest in control 11.07 cm (55 DAT), 14.20 cm (70 DAT). The highest in combination V_2+ H_3-2.0 kg/acre, V_2 + H_2 was 14.81 cm (55 DAT), 17.73 cm (70 DAT) and lowest V_0-0 g/L + H_0-0.0 kg/acre in 10.67 cm (55 DAT), 13.62 cm (70 DAT).

- Leaf width: Highest in hydrogel 1.5 kg/acre (H_2) 9.36 cm (55 DAT), 9.87 cm (70 DAT) and lowest in control 8.32 cm (55 DAT), 8.83 cm (70 DAT). The highest in biostimulant 5 g/L (V_2) 10.45 cm (55 DAT), 10.98 cm (70 DAT) and lowest control 7.40 cm (55 DAT), 7.90 cm (70 DAT). The highest in combination V_2-5 g/L + H_2-1.5 kg/acre 10.94 cm, 11.45 cm and lowest V_0-0 g/L + H_0-0.0 kg/acre with width 6.95 cm (55 DAT), 7.46 cm (70 DAT).
- Petiole length: Highest in hydrogel 1.5 kg/acre (H_2) 6.16 cm and lowest in control 5.89 cm. The highest in biostimulant 5 g/L (V_2) 7.02 cm and lowest in control 4.31 cm. The highest in combination V_2-5 g/L + H_3 2.0 g/L *i.e.*, 7.75 cm and lowest V_0-0 g/L + H_0-0.0 kg/acre with length 3.91 cm.
- Leaf area: Highest in hydrogel 1.5 kg/acre (H_2) 2484.6 cm^2 (55 DAT), 4407.8 cm^2 (70 DAT) and lowest in control 2417.7 cm^2 (55 DAT) and 4392.4 cm^2 (70 DAT). The highest in biostimulant 5 g/L (V_2) 2494.1 cm^2 (55 DAT), 4406.1 cm^2 (70 DAT) and lowest in control 2393.5 cm^2 (55 DAT), 4292.6 cm^2 (70 DAT). The highest in combination V_2-5 g/L + H_2-1.5 kg/acre was 2578.1 cm^2 (55 DAT), 4470.2 cm^2 (70 DAT) and lowest in V_0-0 g/L + H_0-0.0 kg/acre withy leaf area 2365.2 cm^2 (55 DAT) and 4241.5 cm^2 (70 DAT).
- Leaf area index: Highest in hydrogel H_0 1.11, 1.39 at 55 and 70 DAT and lowest in H_2 1.00 and 1.23. The biostimulant applied @ 0 g/L led to increased leaf area index 1.18, 1.46 then the 2.0 kg/acre (V_2) which had lowest leaf area index 0.90, 1.16. The interaction of V_0 + H_0 shows largest leaf area index 1.24, 1.54 and lowest V_2 + H_2 showing leaf area index of 1.00, 1.23.
- Days to fruit initiation: Minimum in hydrogel 2.0 kg/acre (H_3) 55.29 days and maximum in control 58.43 days. The minimum in biostimulant 2 g/L (V_1) 56.53 days and maximum in control 57.33 days. The minimum in combination V_2-5 g/L + H_3-2.0 kg/acre was 53.96 days and maximum V_0-0 g/L + H_0-0.0 kg/acre at 61.71 days.
- Days to marketable maturity: Minimum in hydrogel 2.0 kg/acre (H_3) 65.89 days and maximum in control 70.56 days. The minimum in biostimulant 0 g/L (V_0) 68.01 days and maximum in control 69.70 days. The minimum in combination was V_2-5 g/L + H_3-2.0 was 63.04 days and maximum V_0-0 g/L + H_0-0.0 kg/acre at 73.29 days.

- Average fruit weight: Maximum in hydrogel 1.5 kg/acre (H_2) 73.88 g and minimum in control 65.25 g. The biostimulant maximum in 5 g/L (V_2) 79.82 g and minimum in control 62.18 g. The maximum in combination V_2-5 g/L + H_2-1.5 kg/acre was 85.82 g and minimum V_0-0 g/L + H_0-0.0 kg/acre 59.72 g.
- Fruit length: Longest in hydrogel 1.5 kg/acre (H_2) 16.13 cm and lowest in control 14.48 cm. The highest in biostimulant 5 g/L (V_2) 6.52 cm and lowest in control 14.16 cm. The longest in combination of V_2-5 g/L + H_2-1.5 kg/acre was 18.00 cm and lowest V_0-0 g/L + H_0-0.0 kg/acre was 12.72 cm
- Fruit diameter: Highest in hydrogel 1.5 kg/acre (H_2) 5.20 and lowest in control 5.01 cm. The highest in biostimulant 5 g/L (V_2) 5.52 and lowest in control 4.81 cm. The highest in combination V_2-5 g/L + H_2-1.5 kg/acre was 5.69 cm and lowest V_2-5 g/L + H_3-2.0 kg/acre was 4.69 cm.
- Pedicle length: Highest in hydrogel 1.0 kg/acre (H_1) 5.53 cm and lowest in control 4.95 cm. The highest in biostimulant at 5 g/L (V_2) and lowest in control 4.73 cm. The highest in combination V_2 + H_3 was 6.50 cm and lowest V_0 + H_0 *i.e.*, 4.47 cm.
- Number of fruits: Maximum in hydrogel 1.5 kg/acre (H_2) 35.50 and minimum in control 31.21. The maximum number of fruits in biostimulant 2 g/L (V_1) 31.98 and minimum in control 29.97. The combination was V_2-5 g/L + H_2-1.5 kg/acre resulting in the maximum number of fruits 35.50 and lowest was noted with the combination of V_0-0 g/L + H_0-0.0 kg/acre was 28.38.
- Fruit yield per plant: Hydrogel at 1.5 kg/acre (H_2) shows maximum fruit yield per plant 2.44 kg/plant and minimum in control 2.01 kg/plant. The biostimulant 5 g/L (V_2) 2.92 kg/plant was maximum compared to the control 1.53 kg/plant. The maximum in combination V_2+ H_2 was 3.08 kg/plant and minimum V_0 + H_0 was 1.35 kg/plant.
- Fruit yield per plot shows maximum in hydrogel 1.5 kg/acre (H_2) 64.61 kg and minimum in control 54.00 kg. The biostimulant maximum in 5 g/L (V_2) 76.10 kg and less in control 40.70 kg. The combination V_2-5 g/L + H_3-2.0 kg/acre resulting in the maximum fruit yield of plot 78.83 kg and lowest in V_2-5 g/L + H_0-0.0 kg/acre was 36.01 kg.

- Fruit yield was highest in hydrogel 1.5 kg/acre (H_2) 21.54 t/acre and lowest in control 18.00 t/acre. The yield highest in biostimulant 5 g/L (V_2) 25.37 t/acre comparing to in control 13.57 t/acre. The highest in combination was V_2-5 g/L + H_3-2.0 kg/acre with average yield 26.28 t/acre and less fruit yield were observed with V_0-0 g/L + H_0-0.0 kg/acre was 12.00 t/acre
- Fruit TSS: Hydrogel 2.0 kg/acre (H_3) 5.18°Brix produced higher TSS compared to the control 4.74°Brix. The biostimulant highest in 5 g/L (V_2) 5.54°Brix and lowest in control 4.53°Brix. The highest in combination V_2-5 g/L + H_3-2.0 kg/acre was 5.97°Brix and lowest in V_0-0 g/L +H_0-0.0 kg/acre was 4.09°Brix.
- Fruit moisture content: In hydrogel was highest @ 0.0 kg/acre (H_0), with a value of 76.46% and lowest at 2.0 kg/acre (H_3) with a minimum moisture content of 73.73% in the fruit. The biostimulant treatment in control has the highest moisture content at 80.43% compared to 5 g/L (V_1), which has a value of 72.75%. The highest moisture content occurs in the combination of V_0 + H_0 82.87% while the lowest was found in the combination of V_1 + H_1 *i.e.*, 71.62%.
- Dry matter content: Highest in hydrogel at 2.0 kg/acre (H_3) 26.27% and lowest in 1.5 kg/acre (H_2) 22.85%. The biostimulant highest in 2 g/L (V_1) 27.25% and lowest in control 19.58%. The highest in combination was V_2 + H_1 *i.e.*, 28.38% and lowest in V_0 + H_0 at 17.13%.
- Ash content: Highest in hydrogel 1.5 kg/acre (H_2) 12.17% and lowest (H_0) 11.35%. The highest in biostimulant 5 g/L (V_2) 12.83% and lowest was control 10.73%. The highest in combination V_2+ H_2 was 13.25 % and lowest V_0 + H_0 was 10.26%.

Conclusion

The growth, yield and quality characteristics of brinjal (*Solanum melongena* L.) were greatly improved by the combined application of AVS and hydrogel. The most promising results were obtained with a treatment combination of 5 g/L biostimulant + 1.5 kg/acre hydrogel (V_2H_2).

Important SDGs including SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) are supported by this study by encouraging increased production with less water input. In water stressed agricultural areas the method provides an accurate model for resource efficient vegetable cultivation, enhancing food security and protecting natural resources.

To determine their wider applicability across various agro-climatic zones, the effectiveness of Arka Vegetable Special and hydrogel can be evaluated on other vegetable and horticulture crops.

This provides farmers with an effective method to increase brinjal yield while conserving water. Hydrogel and biostimulants together can improve crop quality, lower irrigation requirements and increase crops tolerance to climate stress. This approach can be expanded to other crops with more testing and assistance, assisting farmers in more effectively managing their resources and generating more revenue in a sustainable manner.

Scope for future studies

The combined use of Arka Vegetable Special and hydrogel across different agro-climatic regions to confirm their broader applicability Studies should also test this approach on other vegetable and horticultural crops to establish crop-specific recommendations. Further work is needed to assess long-term soil health effects, optimize doses for different soils and irrigation systems and analyze the economic benefits for farmers. Research on how this combination influences drought tolerance, nutrient-use efficiency and climate resilience will help develop more sustainable, water-efficient cultivation practices.

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ANNEXURE 1

1. ANNOVA TABLE

1.1 ANOVA for plant height 55 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F-value	Significance
Replication	2	0.011			
Factor A	2	88.852	44.426	1,27,505.47	0
Factor B	3	11.732	3.911	11,223.69	0
Interaction A × B	6	0.155	0.026	74.313	0
Error	22	0.008	0		

1.2 ANOVA for plant height 70 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F-value	Significance
Replication	2	0.111			
Factor A	2	120.741	60.37	115.898	0
Factor B	3	40.814	13.605	26.118	0
Interaction A × B	6	41.762	6.96	13.363	0
Error	22	11.46	0.521		

1.3 ANOVA for absolute growth rate (cm/day)

Source of Variation	DF	Sum of Square	Mean Squares	F-value	Significance
Replication	2	0.001			
Factor A	2	0.061	0.031	13.295	< 0.001
Factor B	3	0.08	0.027	11.505	< 0.001
Interaction A × B	6	0.225	0.037	16.202	< 0.001
Error	22	0.051	0.002		

1.4 ANOVA for number of leaves per plant 55 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F value	Significance
Replication	2	0.018			
Factor A	2	157.643	78.822	4,80,720.40	0
Factor B	3	17.454	5.818	35,483.56	0
Interaction A × B	6	1.841	0.307	1,871.42	0
Error	22	0.004	0		

1.5 ANOVA for number of leaves per plant 70 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	-0.004			
Factor A	2	209.105	104.553		
Factor B	3	20.42	6.807	6,791.22	
Interaction A × B	6	2.964	0.494	492.818	< 0.001
Error	22	0.022	0.001		

1.6 ANOVA for leaf length 55 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.019			
Factor A	2	53.79	26.895	5,75,282.12	0
Factor B	3	5.312	1.771	37,874.94	0
Interaction A × B	6	0.972	0.162	3,464.23	0
Error	22	0.001	0		

1.7 ANOVA for leaf length 70 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.011			
Factor A	2	56.462	28.231	1,02,193.18	0
Factor B	3	6.645	2.215	8,018.54	0
Interaction A × B	6	0.153	0.026	92.567	0
Error	22	0.006	0		

1.8 ANOVA for leaf width 55 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.008			
Factor A	2	56.982	28.491	6,677.11	< 0.001
Factor B	3	5.249	1.75	410.047	< 0.001
Interaction A × B	6	0.816	0.136	31.864	< 0.001
Error	22	0.094	0.004		

1.9 ANOVA for leaf width 70 DAT

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.001			
Factor A	2	36.089	18.045		
Factor B	3	3.685	1.228	31,492.75	< 0.001
Interaction A × B	6	0.17	0.028	727.519	
Error	22	0.001	0		

1.10 ANOVA for petiole length

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.02			
Factor A	2	44.529	22.265	1,21,868.55	0
Factor B	3	5.996	1.999	10,940.43	0
Interaction A × B	6	0.285	0.047	259.648	0
Error	22	0.004	0		

1.11 ANOVA for average leaf area per plant

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	200.627			
Factor A	2	60,731.23	30,365.62	441.138	< 0.001
Factor B	3	23,045.34	7,681.78	111.598	< 0.001
Interaction A × B	6	12,980.42	2,163.40	31.429	< 0.001
Error	22	1,514.36	68.835		

1.12 ANOVA for leaf area index

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.656			
Factor A	2	380.292	190.146	448.907	
Factor B	3	62.915	20.972	49.511	< 0.001
Interaction A × B	6	129.305	21.551	50.878	< 0.001
Error	22	9.319	0.424		

1.13 ANOVA for days to fruit initiation

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.027			
Factor A	2	3.992	1.996	287.198	< 0.001
Factor B	3	50.086	16.695	2,402.21	< 0.001
Interaction A × B	6	103.309	17.218	2,477.40	< 0.001
Error	22	0.153	0.007		

1.14 ANOVA for days to marketable maturity

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.089			
Factor A	2	17.45	8.725	1,980.97	< 0.001
Factor B	3	115.588	38.529	8,747.95	< 0.001
Interaction A × B	6	193.206	32.201	7,311.14	
Error	22	0.097	0.004		

1.15 ANOVA for average marketable fruit weight

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.462			
Factor A	2	1,923.34	961.668	828.253	< 0.001
Factor B	3	369.727	123.242	106.145	< 0.001
Interaction A × B	6	119.011	19.835	17.083	< 0.001
Error	22	25.544	1.161		

1.16 ANOVA for average non marketable fruit weight

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.671			
Factor A	2	303.614	151.807	113.866	< 0.001
Factor B	3	30.158	10.053	7.54	0.001
Interaction A × B	6	489.279	81.546	61.166	< 0.001
Error	22	29.331	1.333		

1.17 ANOVA for fruit length

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.129			
Factor A	2	33.584	16.792	196.591	< 0.001
Factor B	3	12.625	4.208	49.27	< 0.001
Interaction A × B	6	5.84	0.973	11.394	< 0.001
Error	22	1.879	0.085		

1.18 ANOVA for fruit diameter

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.021			
Factor A	2	5.398	2.699	58,639.75	0
Factor B	3	0.648	0.216	4,692.93	0
Interaction A × B	6	0.016	0.003	57.72	0
Error	22	0.001	0		

1.19 ANOVA for pedicle length

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.128			
Factor A	2	5.527	2.763	188.242	0
Factor B	3	1.745	0.582	39.62	0
Interaction A × B	6	1.41	0.235	16.003	0
Error	22	0.323	0.015		

1.20 ANOVA for number of fruits per plant

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	3.031			
Factor A	2	104.675	52.338	91.128	< 0.001
Factor B	3	13.657	4.552	7.926	0.001
Interaction A × B	6	10.152	1.692	2.946	0.029
Error	22	12.635	0.574		

1.21 ANOVA for fruit yield per plant

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.021			
Factor A	2	11.571	5.785	66353.4	< 0.001
Factor B	3	1.043	0.348	3,987.05	< 0.001
Interaction A × B	6	0.133	0.022	254.467	< 0.001
Error	22	0.002	0		

1.22 ANOVA for fruit yield per plot

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	2.745			
Factor A	2	7,647.45	3,823.73	21,462.34	
Factor B	3	738.911	246.304	1,382.49	
Interaction A × B	6	243.706	40.618	227.984	< 0.001
Error	22	3.92	0.178		

1.23 ANOVA for fruit yield

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.307			
Factor A	2	849.719	424.86	21,938.06	< 0.001
Factor B	3	82.112	27.371	1,413.31	< 0.001
Interaction A × B	6	27.047	4.508	232.77	
Error	22	0.426	0.019		

1.24 ANOVA for total soluble solid

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.02			
Factor A	2	6.345	3.173	223.737	< 0.001
Factor B	3	1.261	0.42	29.651	< 0.001
Interaction A × B	6	1.183	0.197	13.901	< 0.001
Error	22	0.312	0.014		

1.25 ANOVA for moisture content of fruit

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.691			
Factor A	2	380.249	190.125	450.981	
Factor B	3	63.043	21.014	49.846	< 0.001
Interaction A × B	6	129.363	21.56	51.142	< 0.001
Error	22	9.275	0.422		

1.26 ANOVA for ash content

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.016			
Factor A	2	26.464	13.232	2,01,712.16	0
Factor B	3	3.465	1.155	17,607.31	0
Interaction A × B	6	0.045	0.008	115.569	0
Error	22	0.001	0		

1.27 ANOVA for dry matter content

Source of Variation	DF	Sum of Square	Mean Squares	F- value	Significance
Replication	2	0.656			
Factor A	2	380.292	190.146	448.907	
Factor B	3	62.915	20.972	49.511	< 0.001
Interaction A × B	6	129.305	21.551	50.878	< 0.001
Error	22	9.319	0.424		

Table 2.1: Monthly meteorological observations during crop season May 2023

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-05-2023	32	21	83	33	19	2.3	10
02-05-2023	33	19	71	32	20	0.5	11
03-05-2023	29	19	78	60	19	1.2	8
04-05-2023	37	21	71	34	10	0.2	8
05-05-2023	36	21	51	43	14	1.5	8
06-05-2023	38	23	59	48	7	0	6
07-05-2023	39	22	52	42	12	0	11
08-05-2023	39	24	58	48	26	0	13
09-05-2023	40	23	56	44	7	0	8.6
10-05-2023	41	23	54	45	13	0	10
11-05-2023	42	24	53	42	4	0	10.5
12-05-2023	42	26	36	25	3	0	10.2
13-05-2023	41	21	38	24	11	0	8.6
14-05-2023	41	23	39	22	17	0	9.2
15-05-2023	46	27	52	58	6	0	10.5
16-05-2023	46	28	50	56	9	0	10
17-05-2023	47	29	71	30	7	0	8
18-05-2023	43	28	85	58	8	7.6	2
19-05-2023	37	21	82	32	9	0	10
20-05-2023	40	22	78	24	7	0	7
21-05-2023	41	21	82	20	8	0	7
22-05-2023	43	22	79	18	5	0	12
23-05-2023	41	27	76	21	8	0	10
24-05-2023	36	24	71	34	9	0	7.3
25-05-2023	30	20	85	63	15	12.2	0
26-05-2023	32	20	82	51	20	2	4
27-05-2023	34	22	81	42	7	0	8
28-05-2023	37	20	82	27	6	0	5
29-05-2023	31	22	81	56	9	1	12
30-05-2023	33	21	82	43	6	4.1	2
31-05-2023	26	19	91	69	7	23.3	0

Table 2.2: Monthly meteorological observations during crop season June 2023

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-06-2023	32	20	90	49	5	9.8	0
02-06-2023	31	21	87	49	4	1.2	0
03-06-2023	34	20	86	46	4	0	6
04-06-2023	36	23	86	40	5	0	6
05-06-2023	38	22	84	35	7	0	8
06-06-2023	38	20	58	30	8	22.8	8
07-06-2023	32	20	82	41	9	0.4	0
08-06-2023	38	20	90	32	3	0	3.4
09-06-2023	40	24	80	33	2	0	9
10-06-2023	41	26	76	31	3	0.4	6
11-06-2023	34	23	83	47	4	12	3.6
12-06-2023	38	24	87	41	2	0	12
13-06-2023	39	27	83	40	4	0	5
14-06-2023	38	21	78	44	4	23	8
15-06-2023	32	21	84	60	4	6.2	0
16-06-2023	35	25	87	49	3	0	0
17-06-2023	38	25	89	40	4	0	6
18-06-2023	37	27	85	50	2	0	8
19-06-2023	39	26	75	42	6	0	7
20-06-2023	39	26	82	40	2	0	10
21-06-2023	40	29	72	49	2	0	7
22-06-2023	36	27	84	66	2	16.2	6
23-06-2023	37	29	83	56	2	0	0
24-06-2023	37	29	85	58	2	0	5.4
25-06-2023	34	28	81	66	5	0	5.2
26-06-2023	33	27	81	62	3	0.2	5.8
27-06-2023	37	27	85	49	2	0	3.2
28-06-2023	35	27	81	57	3	2.2	5.5
29-06-2023	38	27	87	51	2	0	2.5
30-06-2023	37	27	83	54	2	0	6

Table 2.3: Monthly meteorological observations during crop season July 2023

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-07-2023	36	26	81	54	1	0	5
02-07-2023	37	27	82	52	1	0	4.2
03-07-2023	38	29	83	54	2	0	5.1
04-07-2023	34	25	84	60	2	5.4	6
05-07-2023	30	24	92	77	2	70	0
06-07-2023	32	23	89	74	2	14	0
07-07-2023	34	25	86	64	2	0	0
08-07-2023	30	24	91	78	10	63.8	0
09-07-2023	28	24	91	80	12	8.2	0
10-07-2023	30	24	85	72	9	0.2	2
11-07-2023	36	25	92	60	2	0	3
12-07-2023	36	28	89	63	7	0	3.6
13-07-2023	34	24	88	64	8	3	2.9
14-07-2023	34	28	84	66	5	0	7.4
15-07-2023	37	28	90	58	6	0	8.3
16-07-2023	34	26	86	74	5	14.8	5.2
17-07-2023	37	26	89	60	7	8.6	0
18-07-2023	34	29	87	77	6	0.2	1.6
19-07-2023	32	28	84	73	7	0	4.9
20-07-2023	38	29	76	60	3	0	1.4
21-07-2023	37	29	90	63	6	0.4	5.1
22-07-2023	30	25	93	83	6	26.2	5.3
23-07-2023	35	27	89	63	4	0	0
24-07-2023	34	26	93	74	6	40.8	3.6
25-07-2023	34	28	90	80	3	1.6	0
26-07-2023	32	27	90	76	6	0	2.4
27-07-2023	34	27	90	68	2	0	2.7
28-07-2023	33	27	92	77	5	17.6	2.1
29-07-2023	33	27	92	71	4	0	1.7
30-07-2023	34	28	92	66	6	4.2	0.8
31-07-2023	35	28	92	66	7	0	4

Table 2.4: Monthly meteorological observations during crop season August 2023

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-08-2023	36	28.1	92	70	4	0	1.2
02-08-2023	37	28	92	72	5	0	0.9
03-08-2023	36	26	86	64	5	9.8	6.2
04-08-2023	35	28	90	73	7	6	1.6
05-08-2023	35	27	92	70	5	14.2	0.8
06-08-2023	35	28	89	65	5	0	3.2
07-08-2023	34	26	87	75	5	0	5

Table 2.5: Monthly meteorological observations during crop season May 2024

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-05-2024	29.6	12.8	87	32	9.4	0	6.0
02-05-2024	34.6	13.6	82	24	9.7	0	6.3
03-05-2024	36.3	14.5	81	22	8.3	0	8.0
04-05-2024	38.9	23.1	58	22	8.3	0	6.2
05-05-2024	38.6	20.8	61	25	11.5	0	7.1
06-05-2024	39.4	19.2	80	22	10.1	0	7.7
07-05-2024	41.0	19.5	74	17	7.6	0	8.8
08-05-2024	40.3	19.9	62	22	5.4	0	9.7
09-05-2024	38.4	27.0	66	36	12.4	0	9.8
10-05-2024	38.6	26.3	69	39	12.2	0	8.0
11-05-2024	33.8	23.0	68	41	8.6	0	7.5
12-05-2024	34.4	21.6	78	37	11.2	0	8.0
13-05-2024	38.7	18.0	83	21	7.9	0	8.8
14-05-2024	39.2	17.5	79	24	7.2	0	9.1
15-05-2024	38.8	19.3	78	19	5.4	0	9.1
16-05-2024	41.7	22.7	71	24	8.3	0	9.1
17-05-2024	42.6	24.2	74	31	6.5	0	9.5
18-05-2024	42.9	24.0	74	22	12.7	0	8.8
19-05-2024	42.6	23.5	63	23	10.4	0	9.3
20-05-2024	42.7	24.3	73	23	8.6	0	8.8
21-05-2024	42.1	22.8	66	27	12.6	0	9.6
22-05-2024	42.4	27.4	68	33	13.0	0	9.6
23-05-2024	40.6	29.7	69	39	12.7	0	10.4
24-05-2024	41.9	29.3	70	39	12.2	0	9.5
25-05-2024	41.0	23.0	73	33	12.2	0	10.3
26-05-2024	42.8	23.4	74	24	11.2	0	10.5
27-05-2024	43.8	22.2	80	19	10.4	0	9.0
28-05-2024	45.1	23.1	75	16	7.9	0	9.5
29-05-2024	45.4	22.8	74	15	7.9	0	10.0
30-05-2024	43.8	29.7	48	18	9.4	0	6.6
31-05-2024	44.5	22.8	72	21	4.3	0	8.2

Table 2.6: Monthly meteorological observations during crop season June 2024

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-06-2024	42.9	24.8	73	21	9.72	0	12
02-06-2024	40.8	25.8	69	32	9	0	10.6
03-06-2024	42.9	24.7	73	27	12.24	0	12
04-06-2024	41.3	23.1	74	27	7.2	7.6	7.8
05-06-2024	41.4	26.5	73	28	8.64	1.7	9.4
06-06-2024	36.2	22.3	85	40	4.68	0	10
07-06-2024	38.2	22.6	74	35	8.64	0	12
08-06-2024	38.2	24.9	78	30	11.16	0	13.4
09-06-2024	41.6	21.0	79	18	12.6	0	13
10-06-2024	41.8	22.3	69	22	9	0	10.5
11-06-2024	43.2	24.0	75	23	8.64	0	10.7
12-06-2024	43.6	23.6	74	22	11.16	0	11.5
13-06-2024	44.2	25.4	71	25	13.33	0	14
14-06-2024	43.4	24.5	61	23	9.72	0	14
15-06-2024	42.7	26.5	72	31	15.84	0	13.8
16-06-2024	43.5	28.1	71	29	14.76	0	13.2
17-06-2024	43.0	27.5	74	34	13.68	0	12.9
18-06-2024	42.1	27.2	69	37	12.24	0	13
19-06-2024	42.3	28.8	74	38	16.56	0	12.5
20-06-2024	36.8	25.8	62	44	12.6	0	12
21-06-2024	35.5	26.1	72	46	9.36	0	12.6
22-06-2024	39.8	24.6	83	39	5.4	0	13.2
23-06-2024	40.6	28.8	73	38	7.56	0	14.2
24-06-2024	41.9	28.2	75	36	7.2	0	14
25-06-2024	40.5	28.6	78	45	5.76	0	14.6
26-06-2024	39.0	31.2	74	51	11.16	0	14
27-06-2024	33.7	23.1	94	76	9.72	2.8	10.5
28-06-2024	37.4	28.0	89	57	7.92	0	12
29-06-2024	37.6	28.9	86	55	4.68	0	13
30-06-2024	33.9	24.2	92	67	6.48	0	13.2

Table 2.7: Monthly meteorological observations during crop season July 2024

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-07-2024	34.1	29.3	88	73	9.72	0	6
02-07-2024	36.9	29.3	86	63	7.92	0	3.2
03-07-2024	33.9	24.9	88	77	11.16	1	4.8
04-07-2024	32.7	26.0	90	74	12.6	1.4	3.1
05-07-2024	34.1	28.0	92	69	9	1.4	3
06-07-2024	31.8	21.9	88	66	12.6	0	4.5
07-07-2024	33.9	26.9	86	69	7.92	0	3.5
08-07-2024	35.2	28.5	92	65	8.64	0	6.5
09-07-2024	36.7	27.7	87	64	4.32	0	7.2
10-07-2024	39.2	29.1	91	59	4.68	0	4.1
11-07-2024	38.3	28.5	91	55	5.04	0	5.8
12-07-2024	32.2	23.5	88	75	11.52	0	4.2
13-07-2024	35.0	25.5	92	61	4.68	0	7.1
14-07-2024	35.8	27.0	93	61	3.6	0	7.5
15-07-2024	37.7	28.3	89	63	3.96	0	7
16-07-2024	37.0	30.0	89	61	4.68	0	7.3
17-07-2024	37.2	29.2	86	70	6.48	0	3.8
18-07-2024	35.8	26.6	87	64	5.76	0	4.5
19-07-2024	37.1	28.9	91	70	3.6	0	3.5
20-07-2024	38.7	27.9	87	63	5.04	1.4	6.2
21-07-2024	38.2	28.5	87	62	4.68	0	7.2
22-07-2024	36.0	24.8	89	65	5.76	0	5.7
23-07-2024	35.2	26.5	85	74	6.84	0	5.9
24-07-2024	36.6	27.9	89	70	4.32	0	6
25-07-2024	35.8	27.5	90	74	6.48	0	4.7
26-07-2024	36.3	27.8	92	71	3.96	0	4.2
27-07-2024	31.8	28.1	90	78	3.96	0	4.5
28-07-2024	36.4	29.7	92	73	2.88	0	7.1
29-07-2024	36.2	27.1	93	72	2.88	0	6.3
30-07-2024	35.9	29.8	93	80	3.6	3	3.2

Table 2.8: Monthly meteorological observations during crop season August 2024

Date	Max Temp (°C)	Min Temp (°C)	RH (%)	RH (%)	Wind speed (km/hr)	Rain (mm)	Evaporation (mm)
01-08-2024	36.7	27.1	93	85	4.32	6.7	2.5
02-08-2024	34.0	27.4	95	63	4.32	1	5.2
03-08-2024	35.0	28.4	92	75	8.64	0	4.8
04-08-2024	35.3	27.8	90	83	5.76	0	5
05-08-2024	36.5	29.2	93	69	5.76	0	5.1
06-08-2024	32.6	27.4	90	66	4.68	0	4.7
07-08-2024	34.3	26.6	90	78	7.56	2.4	4.3

ANNEXURE 3

Table 3.1: Cost of cultivation (per acre) for treatment V_0H_0 0 g/L + 0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonne/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	0 kg/acre	-	-
10.	Labour	-	-	-
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (15 times)	4 hours/day	60/hour	3,600.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	2 L/day	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		90,115.00

Table 3.2: Cost of cultivation (per acre) for treatment V_0H_1 0 g/L + 1.0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonne/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.0 kg/acre	1,000/kg	1,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (13 times)	4 hours/day	60/hour	3,120.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	-	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,035.00

Table 3.3: Cost of cultivation (per acre) for treatment V_0H_2 0 g/L + 1.5 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.5 kg/acre	1,000/kg	1,500.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (12 times)	4 hours/day	60/hour	2,880.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	-	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,295.00

Table 3.4: Cost of cultivation (per acre) for treatment V_0H_3 0 g/L + 2.0 kg/acre in 2023

S.No.	**Particulars**	**Quantity/Duration**	**Rate (₹)**	**Total cost**
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	2.0 kg/acre	1,000/kg	2,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (11 times)	4 hours/day	60/hour	2,640.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	-	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,555.00

Table 3.5: Cost of cultivation (per acre) for treatment V_1H_0 2 g/L + 0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	0 kg/acre	1,000/kg	-
10.	Labour	-	-	-
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (15 times)	4 hours/day	60/hour	3,600.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		90,825.00

Table 3.6: Cost of cultivation (per acre) for treatment V_1H_1 2 g/L + 1.0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.0 kg/acre	1,000/kg	1,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1^{st}, 2^{nd} and 3^{rd})	12 L/day	280/L/day	10,080.00
16.	Irrigation (12 times)	4 hours/day	60/hour	2,880.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1^{st}, 2^{nd} and 3^{rd})	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,505.00

Table 3.7: Cost of cultivation (per acre) for treatment V_1H_2 2 g/L + 1.5 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.5 kg/acre	1,000/kg	1,500.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (11 times)	4 hours/day	60/hour	2,640.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,765.00

Table 3.8: Cost of cultivation (per acre) for treatment V_1H_3 2 g/L + 2.0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	2 kg/acre	1,000/kg	2,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (12 times)	4 hours/day	60/hour	2,880.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		93,505.00

Table 3.9: Cost of cultivation (per acre) for treatment V_2H_0 5 g/L + 0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	0 kg/acre	1,000/kg	-
10.	Labour	-	-	-
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (15 times)	4 hours/day	60/hour	3,600.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		91,050.00

Table 3.10: Cost of cultivation (per acre) for treatment V_2H_1 5 g/L + 1.0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.0 kg/acre	1,000/kg	1,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1^{st}, 2^{nd} and 3^{rd})	12 L/day	280/L/day	10,080.00
16.	Irrigation (8 times)	4 hours/day	60/hour	1,920.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1^{st}, 2^{nd} and 3^{rd})	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		91,770.00

Table 3.11: Cost of cultivation (per acre) for treatment V_2H_2 5 g/L + 1.5 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.5 kg/acre	1,000/kg	1,500.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (9 times)	4 hours/day	60/hour	2,160.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,510.00

Table 3.12: Cost of cultivation (per acre) for treatment V_2H_3 5 g/L + 2.0 kg/acre in 2023

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	2.0 kg/acre	1,000/kg	2,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (10 times)	4 hours/day	60/hour	2,400.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		93,250.00

Table 3.13: Cost of cultivation (per acre) for treatment V_0H_0 0 g/L + 0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonne/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	0 kg/acre	1,000/kg	-
10.	Labour	-	-	-
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (15 times)	4 hours/day	60/hour	3,600.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	-	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		90,115.00

Table 3.14: Cost of cultivation (per acre) for treatment V_0H_1 0 g/L + 1.0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonne/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.0 kg/acre	1,000/kg	1,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (11 times)	4 hours/day	60/hour	2,640.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	-	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		91,555.00

Table 3.15: Cost of cultivation (per acre) for treatment V_0H_2 0 g/L + 1.5 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.5 kg/acre	1,000/kg	1,500.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (10 times)	4 hours/day	60/hour	2,400.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	-	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		91,815.00

Table 3.16: Cost of cultivation (per acre) for treatment V_0H_3 0 g/L + 2.0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	2.0 kg/acre	1,000/kg	2,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (9 times)	4 hours/day	60/hour	2,160.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	0 g/L	250/kg	-
18.	Labour	-	-	-
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,075.00

Table 3.17: Cost of cultivation (per acre) for treatment V_1H_0 2 g/L + 0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	0 kg/acre	1,000/kg	-
10.	Labour	-	-	-
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (15 times)	4 hours/day	60/hour	3,600.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		90,825.00

Table 3.18: Cost of cultivation (per acre) for treatment V_1H_1 2 g/L + 1.0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.0 kg/acre	1,000/kg	1,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (12 times)	4 hours/day	60/hour	2,880.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,505.00

Table 3.19: Cost of cultivation (per acre) for treatment V_1H_2 2 g/L + 1.5 kg/acre

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.5 kg/acre	1,000/kg	1,500.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (11 times)	4 hours/day	60/hour	2,640.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,765.00

Table 3.20: Cost of cultivation (per acre) for treatment V_1H_3 2 g/L + 2.0 kg/acre

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	2 kg/acre	1,000/kg	2,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (9 times)	4 hours/day	60/hour	2,160.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	2 g/L	250/kg	150.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,785.00

Table 3.21: Cost of cultivation (per acre) for treatment V_2H_0 5 g/L + 0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	0 kg/acre	1,000/kg	-
10.	Labour	-	-	-
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (15 times)	4 hours/day	60/hour	3,600.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		91,050.00

Table 3.22: Cost of cultivation (per acre) for treatment V_2H_1 5 g/L + 1.0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.0 kg/acre	1,000/kg	1,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (9 times)	4 hours/day	60/hour	2,160.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,010.00

Table 3.23: Cost of cultivation (per acre) for treatment V_2H_2 5 g/L + 1.5 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
Field preparations				
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
Nutrient management (As per PAU Recommendation)				
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
Moisture conservation practice				
9.	Hydrogel (Fasal Amrit)	1.5 kg/acre	1,000/kg	1,500.00
10.	Labour	5 L/day	280/L/day	1,400.00
Seedling				
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
Intercultural practices				
15.	Weeding (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
16.	Irrigation (7 times)	4 hours/day	60/hour	1,680.00
Biostimulant				
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
Harvesting				
18.	Picking and sorting (1st, 2nd and 3rd)	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		92,030.00

Table 3.24: Cost of cultivation (per acre) for treatment V_2H_3 5 g/L + 2.0 kg/acre in 2024

S.No.	Particulars	Quantity/Duration	Rate (₹)	Total cost
		Field preparations		
1.	Ploughing by tractor (Diesel, rent, labour)	45 minutes	2,000	2,000.00
2.	Ridge and channel making by tractor	45 minutes	2,000	2,000.00
		Nutrient management (As per PAU Recommendation)		
3.	FYM	10 tonnes/acre	3,000/tonne	30,000.00
4.	Urea (N)	110 kg/acre	50/kg	5,500.00
5.	SSP (P)	155 kg/acre	27/kg	4,185.00
6.	MOP (K)	20 kg/acre	30/kg	600.00
7	Transportation	1 hour	450/hour	450.00
8.	Labour	7 L/day	280/L/day	1,960.00
		Moisture conservation practice		
9.	Hydrogel (Fasal Amrit)	2.0 kg/acre	1,000/kg	2,000.00
10.	Labour	5 L/day	280/L/day	1,400.00
		Seedling		
11.	Nishant F1 hybrid Advanta Seeds (Seedlings)	14,500 seedlings	1/Seedling	14,500.00
12.	Transportation	1 hour	450/hour	450.00
13.	First irrigation	4 hours/day	60/hour	240.00
14.	Labour	12 L/day	280/L/day	3,360.00
		Intercultural practices		
15.	Weeding (1^{st}, 2^{nd} and 3^{rd})	12 L/day	280/L/day	10,080.00
16.	Irrigation (10 times)	4 hours/day	60/hour	2,400.00
		Biostimulant		
17.	Arka Vegetable Special spray (2 times)	5 g/L	250/kg	375.00
18.	Labour	2 L/day	280/L/day	560.00
		Harvesting		
18.	Picking and sorting (1^{st}, 2^{nd} and 3^{rd})	12 L/day	280/L/day	10,080.00
19.	Packing (Material cost)	1 kg	100/kg	100.00
20.	Transportation	1 hour	450/hour	450.00
21.	Labour	2 L/day	280/L/day	560.00
	General cost of cultivation	**Grand total**		93,250.00