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# Studies on the Management of Soil Fertility and Sustainable Productivity in Bhendi [*Abelmoschus esculentus* (L.) Moench]

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

A field experiment on COBh Hybrid Bhendi 4 was conducted in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry, during summer 2022 with the objective of comparing the effects of organics and bioenhancers on soil fertility restoration and sustained vegetable production. The experiment was laid out in a Randomized Block Design with two replications involving two factors (fertilisers and bioenhancers) forming eighteen treatment combination in a factorial way (FRBD). The study material comprised of vermicompost and goat manure (organics) as well as panchagavya and jivamirtham (bioenhancers), besides recommended FYM and N, P, K fertilisers in various combinations. Maximum plant height (118.62 cm), number of primary branches (5.02) at final harvest, maximum fruit length (15.49 cm) and fruit girth (6.89 cm), fruit weight (21.71 g), number of fruits plant-1 (51.70), highest yield (891.60 g plant-1 and 16.47 t ha-1) and maximum dry matter production (5.74 t ha-1) were recorded in the treatment receiving RDF with 3 per cent panchagavya as foliar spray on 30, 45, 60 and 75 DAS.

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## 1. INTRODUCTION

Vegetables are designated as “protective foods” in human diet due to their varying health benefits, attributable to their richness in vitamins, minerals, essential fatty acids, amino acids, dietary fiber and other important bioactive compounds [1]. India ranks second in vegetable production and the production is estimated at 191.77 m MT from an area of 10.35 m ha [2].

Bhendi [*Abelmoschus esculentus* (L.) Moench] also known as Ladies finger valued for its tender pods is one of the widely cultivated vegetables throughout the tropical and subtropical regions of the world. Globally, India ranks first in bhendi production, with an area of 5.19 m ha, producing 6.37 m MT annually with a productivity of 12 tonnes ha-1 [2].

Bhendi is of immense importance with large pharmacological, nutritional and industrial applications, with its curative property attributable to the presence of many bioactive compounds and their associated bioactivities [3].

Considering the commercial importance, many bhendi hybrids with high yield and tolerance to biotic and abiotic stresses are in wide cultivation. However, these hybrids are input intensive, resulting in various soil and environmental hazards. Among the major nutrients, nitrogen being highly responsive for environmental hazards, besides its soring cost, the search for alternate approaches, including Integrated Nitrogen Management practices in any given environment becomes inevitable [4].

Integrated Nutrient Management (INM) is a flexible approach to minimize the use of chemical fertilisers and maximize its use efficiency, thus remains the best alternative choice of growers for maintaining soil health and sustainable production [2].

Organic manures, when efficiently and effectively used could ensure sustainable crop productivity by immobilizing nutrients that are susceptible for leaching as the nutrients contained in manures are released more slowly and get stored for a longer time in the soil, ensuring longer residual effects, improved root development and hence, higher crop yields [5]. The present study was hence contemplated to determine the effect of organic sources of nutrients and bio enhancers on growth and yield of hybrid bhendi.

## 2. MATERIALS AND METHODS

A field experiment on ‘Effect of organics and bioenhancers on growth and yield of hybrid Bhendi [*Abelmoschus esculentus* (L.) Moench]’ was performed in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry, India during summer 2022. The ‘bhendi hybrid CO 4’ (COBh H 4) with a crop duration of 110 days was raised. The treatment materials for the study comprised of vermicompost, goat manure, panchagavya and jivamirtham, besides recommended Farm Yard Manure (FYM) and N, P, K fertilisers.

Panchagavya, a term used in Ayurveda represents a fermented product made out of five ingredients of cow, such as milk, urine, dung, curd and clarified butter. It is a popular foliar nutrition prepared by organic growers of Tamil Nadu as an indigenous material and used widely for agricultural and horticultural crops [6]. Jivamirtham refers to an eco-friendly organic preparation made from product of cow. The products of cow have the ability to bring the flow of cosmic energy which in turn can revitalizes the plant growth process [7].

In the present experiment, panchagavya was applied as foliar spray at 3 per cent concentration on 30, 45, 60 and 75 days after sowing. Freshly prepared jivamirtham was applied in the soil at sowing, 20 and 40 days after sowing along with irrigation water.

The experiment was laid out in a Randomized Block Design with two replications involving eighteen treatments (Table 1) in a factorial way (FRBD) and the study comprised of 2 factors *viz*., Fertiliser (Factor 1) and Bioenhancers (Factor 2). Factor 1 represent different fertiliser combinations while factor 2 represent the bioenhancers used. There were six levels for Factor 1 and three levels for Factor 2, forming 18 treatment combinations.

### 2.1 Level of Factors

#### 2.1.1 Factor 1 – fertilisers

$F_0$ - Absolute control
$F_1$ - RDF (Recommended Dose of Fertilisers)

**Table 1. Treatment particulars**

| Sl. No. | Treatment | Treatment details |
|---|---|---|
| 1 | T1 - $F_0B_0$ | Absolute control |
| 2 | T2 - $F_0B_1$ | 3 % Panchagavya foliar spray on 30, 45, 60 and 75 DAS |
| 3 | T3 - $F_0B_2$ | Jivamirtham 500 L $ha^{-1}$ as soil application thrice with irrigation *viz*., at sowing, 20 and 45 DAS |
| 4 | T4 - $F_1B_0$ | RDF |
| 5 | T5 - $F_1B_1$ | RDF + 3 % Panchagavya foliar spray on 30, 45, 60 and 75 DAS |
| 6 | T6 - $F_1B_2$ | RDF + Jivamirtham 500 L $ha^{-1}$ as soil application thrice with irrigation *viz*., at sowing, 20 and 45 DAS |
| 7 | T7 - $F_2B_0$ | 75 % N + RDP + RDK + RDFYM + 25 % N through Vermicompost |
| 8 | T8 - $F_2B_1$ | 75 % N + RDP + RDK + RDFYM + 25 % N through Vermicompost + 3% Panchagavya foliar spray on 30, 45, 60 and 75 DAS |
| 9 | T9 - $F_2B_2$ | 75 % N + RDP + RDK + RDFYM + 25 % N through Vermicompost + Jivamirtham 500 L $ha^{-1}$ as soil application thrice with irrigation *viz*., at sowing, 20 and 45 DAS |
| 10 | T10 - $F_3B_0$ | 75 % N + RDP + RDK + RDFYM + 25 % N through Goat manure |
| 11 | T11 - $F_3B_1$ | 75 % N + RDP + RDK + RDFYM + 25 % N through Goat manure + 3 % Panchagavya foliar spray on 30, 45, 60 and 75 DAS |
| 12 | T12 - $F_3B_2$ | 75 % N + RDP + RDK + RDFYM + 25 % N through Goat manure + Jivamirtham 500 L $ha^{-1}$ as soil application thrice with irrigation *viz*., at sowing, 20 and 45 DAS |
| 13 | T13 - $F_4B_0$ | 50 % N + RDP + RDK + RDFYM + 50 % N through Vermicompost |
| 14 | T14 - $F_4B_1$ | 50 % N + RDP + RDK + RDFYM + 50 % N through Vermicompost + 3% Panchagavya foliar spray on 30, 45, 60 and 75 DAS |
| 15 | T15 - $F_4B_2$ | 50% N + RDP + RDK + RDFYM + 50% N through Vermicompost + Jivamirtham 500 L $ha^{-1}$ as soil application thrice with irrigation *viz*., at sowing, 20 and 45 DAS |
| 16 | T16 - $F_5B_0$ | 50 % N + RDP + RDK + RDFYM + 50 % N through Goat manure |
| 17 | T17 - $F_5B_1$ | 50 % N + RDP + RDK + RDFYM + 50 % N through Goat manure + 3% Panchagavya foliar spray on 30, 45, 60 and 75 DAS |
| 18 | T18 - $F_5B_2$ | 50 % N + RDP + RDK + RDFYM + 50 % N through Goat manure + Jivamirtham 500 L $ha^{-1}$ as soil application thrice with irrigation *viz*., at sowing, 20 and 45 DAS |

$F_2$ - 75 % N + RDP + RDK + RDFYM + 25 % N through Vermicompost
$F_3$ - 75 % N + RDP + RDK + RDFYM + 25 % N through Goat manure
$F_4$ - 50 % N + RDP + RDK + RDFYM + 50 % N through Vermicompost
$F_5$ - 50 % N + RDP + RDK + RDFYM + 50 % N through Goat manure

#### 2.1.2 Factor 2 – bioenhancers

$B_0$ - Absolute control
$B_1$ - 3 % Panchagavya foliar spray on 30, 45, 60 and 75 DAS
$B_2$ - Jivamirtham 500 L ha-1 as soil application thrice with irrigation *viz.,* at sowing, 20 and 45 DAS

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Organics and Bioenhancers on Growth Parameters in Bhendi

The influence of various treatments of the study on growth attributes of hybrid bhendi is presented in Table 2. The application of RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F1B1) has recorded the earliest flowering (38.52 days). The earliness in flowering observed with the application of RDF and panchagavya might be due to the accelerated photosynthesis and rapid translocation of photosynthates towards initiating flower buds as reported by Ramesh et al. [8] from their study in tomato. The earliness could also be ascribed to the role played by the timely supply of adequate nutrients to the plants through the use of recommended dose fertilisers (200:100:100 kg ha-1) as supply of phosphorus, to plants at right time in optimal quantity play a pivotal role in initiation of flower primordia as reported earlier by Singh et al. [9] and Singh et al. [10].

Flowering at the lowermost node is a preferred trait in bhendi and it was observed under RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F1B1 – 4.90) as well as RDF and soil application of jivamirtham 500 L ha-1 thrice with irrigation *viz.,* at sowing, 20 and 45 DAS.

(F1B2 – 4.90). The influence on node of first flower anthesis in bhendi with the application of RDF might be due to timely availability and uptake of major plant nutrients. The increased uptake of NPK nutrients by plants, could have resulted from increased plant metabolites in soil solution which are helpful in building the plant tissues of bhendi as the nutrient acquisition power of a plant greatly depends on the concentration of the ions in soil solution resulting in better growth and development as reported by Prabhu et al. [11] and Verma et al. [12].

The tallest plants at final harvest (118.62 cm) observed in plots treated with RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS as reported earlier by Muthuvel [13] could be the result of the growth enzymes present in panchagavya, favouring rapid cell division and multiplication as reported by Verma et al. [12]. Panchagavya is also reported to contain macronutrients such as N, P, K, micronutrients, vitamins, amino acids and growth regulators such as auxins and gibberellins, which are essentially required for proper growth and development of plants resulting in increased plant height as reported by Hathi et al. [14]. Nitrogen is the main constituent of protoplasm, cell nucleus, amino acids, proteins, chlorophyll and many other plant metabolic products, while phosphorus is an essential constituent of the energy molecule adenosine tri-phosphate (ATP), thus play in a key role in photosynthesis. Potassium plays a vital role in controlling water economy in the plants giving improved drought tolerance. The gradual increase in plant height with increasing dose of NPK and FYM, could thus, prove beneficial for root and shoot growth of plants as suggested by Amran et al. [15] and Tyagi et al. [16] in bhendi.

The application of RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F1B1) has recorded maximum branches plant$^{-1}$ at first flowering and final harvest (4.35 and 5.02). The combined use of organic and inorganic fertilisers could increase cell permeability and supply plant nutrients in a sustained manner (Kuppusamy et al.) [17] resulting in increased number of branches plant-1 as reported by Majanbu et al. [18].

The effect of bioenhancers on internodal length of bhendi in the present study was insignificant and such a report has been reported earlier by Jadhav et al. [19], while Oroka and Oke [20] reported significant influence of fertilisers on internodal length of bhendi.

**Table 2. Effect of organics and bioenhancers on growth attributes of bhendi**

| Treatment | Days to lowering | Node of first flower anthesis | Plant height at flowering (cm) | Plant height at final harvest (cm) | Primary branches plant$^{-1}$ at flowering | Primary branches plant$^{-1}$ at final harvest | Internodal length (cm) | Dry matter production (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ - $F_0B_0$ | 44.25 | 5.50 | 19.78 | 44.84 | 2.35 | 3.10 | 2.30 | 0.33 |
| $T_2$ - $F_0B_1$ | 49.00 | 5.40 | 17.06 | 51.72 | 2.60 | 3.20 | 2.49 | 0.85 |
| $T_3$ - $F_0B_2$ | 51.80 | 5.40 | 17.22 | 49.93 | 2.57 | 3.13 | 2.49 | 0.57 |
| $T_4$ - $F_1B_0$ | 40.40 | 5.00 | 24.51 | 104.99 | 4.20 | 4.70 | 3.34 | 3.81 |
| $T_5$ - $F_1B_1$ | 38.52 | 4.90 | 23.27 | 118.62 | 4.35 | 5.02 | 3.48 | 5.74 |
| $T_6$ - $F_1B_2$ | 39.50 | 4.90 | 23.72 | 118.24 | 4.32 | 4.80 | 3.39 | 4.17 |
| $T_7$ - $F_2B_0$ | 41.71 | 5.20 | 25.43 | 87.54 | 3.40 | 4.10 | 2.93 | 3.02 |
| $T_8$ - $F_2B_1$ | 41.10 | 5.00 | 24.59 | 103.49 | 4.02 | 4.60 | 3.28 | 3.76 |
| $T_9$ - $F_2B_2$ | 41.12 | 5.10 | 24.90 | 97.41 | 4.00 | 4.52 | 3.23 | 3.76 |
| $T_{10}$ - $F_3B_0$ | 42.20 | 5.20 | 25.66 | 87.26 | 3.37 | 4.10 | 2.93 | 2.89 |
| $T_{11}$ - $F_3B_1$ | 41.37 | 5.10 | 25.08 | 96.12 | 3.80 | 4.40 | 3.26 | 3.62 |
| $T_{12}$ - $F_3B_2$ | 41.60 | 5.20 | 25.22 | 92.96 | 3.50 | 4.40 | 3.08 | 3.61 |
| $T_{13}$ - $F_4B_0$ | 46.37 | 5.30 | 30.90 | 69.87 | 2.85 | 3.60 | 2.73 | 1.47 |
| $T_{14}$ - $F_4B_1$ | 42.50 | 5.20 | 25.92 | 83.13 | 3.37 | 4.10 | 2.90 | 2.76 |
| $T_{15}$ - $F_4B_2$ | 44.80 | 5.30 | 28.20 | 75.34 | 3.15 | 3.75 | 2.93 | 2.58 |
| $T_{16}$ - $F_5B_0$ | 46.62 | 5.40 | 30.96 | 55.66 | 2.70 | 3.33 | 2.71 | 1.40 |
| $T_{17}$ - $F_5B_1$ | 42.50 | 5.30 | 27.79 | 79.32 | 3.30 | 4.00 | 2.85 | 2.75 |
| $T_{18}$ - $F_5B_2$ | 45.97 | 5.30 | 29.82 | 73.85 | 2.92 | 3.70 | 2.84 | 1.56 |

| Factor | SEd | CD (p=0.05) | SEd | CD (p=0.05) | SEd | CD (p=0.05) | SEd | CD (p=0.05) | SEd | CD (p=0.05) | SEd | CD (p=0.05) | SEd | CD (p=0.05) | SEd | CD (p=0.05) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fertilisers** | 1.246 | 2.63 | 0.136 | 0.29 | 1.349 | 2.84 | 5.620 | 11.86 | 0.271 | 0.57 | 0.236 | 0.50 | 0.223 | 0.47 | 0.853 | 1.80 |
| **Bioenhancers** | 0.881 | NS | 0.096 | NS | 0.954 | NS | 3.974 | 8.39 | 0.191 | NS | 0.167 | NS | 0.158 | NS | 0.603 | NS |
| **Fertilisers x Bioenhancers** | 2.159 | NS | 0.236 | NS | 2.338 | NS | 9.740 | NS | 0.470 | NS | 0.410 | NS | 0.387 | NS | 1.478 | NS |

**Table 3. Effect of organics and bioenhancers on yield attributes of bhendi**

| Treatment | Fruit length (cm) | | Fruit girth (cm) | | Individual fruit weight (g) | | Number of fruits plant$^{-1}$ | | Yield plant$^{-1}$ (g) | | Yield hectare$^{-1}$ (tonnes) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ - $F_0B_0$ | 11.60 | | 5.49 | | 12.26 | | 12.75 | | 126.40 | | 2.90 | |
| $T_2$ - $F_0B_1$ | 12.40 | | 6.23 | | 14.17 | | 15.66 | | 170.65 | | 3.88 | |
| $T_3$ - $F_0B_2$ | 11.83 | | 5.85 | | 12.65 | | 12.90 | | 140.35 | | 3.76 | |
| $T_4$ - $F_1B_0$ | 15.05 | | 6.86 | | 19.65 | | 39.22 | | 676.40 | | 16.22 | |
| $T_5$ - $F_1B_1$ | 15.49 | | 6.89 | | 21.71 | | 51.70 | | 891.60 | | 16.47 | |
| $T_6$ - $F_1B_2$ | 15.07 | | 6.89 | | 20.56 | | 49.45 | | 880.80 | | 16.35 | |
| $T_7$ - $F_2B_0$ | 14.01 | | 6.66 | | 17.91 | | 36.00 | | 588.05 | | 13.97 | |
| $T_8$ - $F_2B_1$ | 14.74 | | 6.85 | | 19.54 | | 38.30 | | 646.15 | | 15.42 | |
| $T_9$ - $F_2B_2$ | 14.70 | | 6.84 | | 19.20 | | 37.50 | | 622.45 | | 15.02 | |
| $T_{10}$ - $F_3B_0$ | 13.88 | | 6.60 | | 17.70 | | 35.80 | | 579.00 | | 11.67 | |
| $T_{11}$ - $F_3B_1$ | 14.31 | | 6.77 | | 18.42 | | 36.90 | | 594.90 | | 14.15 | |
| $T_{12}$ - $F_3B_2$ | 14.23 | | 6.72 | | 18.17 | | 36.30 | | 592.30 | | 14.05 | |
| $T_{13}$ - $F_4B_0$ | 12.99 | | 6.37 | | 15.36 | | 22.50 | | 326.35 | | 5.70 | |
| $T_{14}$ - $F_4B_1$ | 13.67 | | 6.54 | | 16.95 | | 35.20 | | 548.60 | | 7.03 | |
| $T_{15}$ - $F_4B_2$ | 13.26 | | 6.47 | | 16.46 | | 31.90 | | 493.10 | | 6.80 | |
| $T_{16}$ - $F_5B_0$ | 12.56 | | 6.29 | | 14.35 | | 16.32 | | 181.75 | | 5.27 | |
| $T_{17}$ - $F_5B_1$ | 13.53 | | 6.53 | | 16.60 | | 35.02 | | 503.65 | | 6.90 | |
| $T_{18}$ - $F_5B_2$ | 13.23 | | 6.42 | | 16.16 | | 23.60 | | 334.15 | | 6.61 | |
| **Factor** | **SEd** | **CD (p=0.05)** | **SEd** | **CD (p=0.05)** | **SEd** | **CD (p=0.05)** | **SEd** | **CD (p=0.05)** | **SEd** | **CD (p=0.05)** | **SEd** | **CD (p=0.05)** |
| **Fertilisers** | 0.635 | 1.34 | 0.200 | 0.42 | 0.854 | 1.80 | 2.461 | 5.19 | 38.551 | 81.34 | 2.946 | 6.22 |
| **Bioenhancers** | 0.449 | NS | 0.142 | NS | 0.604 | 1.27 | 1.740 | 3.67 | 27.259 | 57.51 | 2.083 | NS |
| **Fertilisers x Bioenhancers** | 1.101 | NS | 0.348 | NS | 1.480 | NS | 4.265 | NS | 66.804 | NS | 5.105 | NS |

The application of RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F1B1) has recorded maximum dry matter production (5.74).The dry matter production of the crop is an index of the plant growth and the dry matter yield determines partly or fully the yield of thecrop. This is attributable to the increased availability of nitrogen with the combined use of organic and inorganic sources of nutrients. This was in accordance with the findings of Anburani and Manivannan [21] in brinjal. The increased dry matter production is further attributable to the well established root system in addition to increased plant height, number of branches and leaves as reported by Tripathy et al. [22] with the combined application of chemical fertilisers and stimulants.

### 3.2 Effect of Organics and Bioenhancers on Yield Parameters in Bhendi

The effect of treatment on yield parameters of hybrid bhendi is given in Table 3. The longest fruits observed in RDF with foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F1B1 - 15.49 cm) could have resulted from the supplementation of micronutrients by organic sources applied with inorganic sources of nitrogen, phosphorus and potassium as expressed by Singh et al. [23] in bhendi. The application of nitrogen also favours the metabolic and auxin activities in plant [24] and on decomposition releases nutrient in a sustained manner throughout the plant life cycle leading to higher fruit length [25].

The improved fruit girth (6.89 cm) recorded in F1B1 could be attributed to the increased availability of NPK at critical stages of the crop growth resulting in early establishment, vigorous growth and development of plants thus leading to longer and wider fruits as observed by Naidu et al. [26]. Further, the integrated use of chemical fertiliser and vermicompost resulting in balanced fertilization could have enhanced the photosynthetic activity through increased leaf area and resulted in buildup of adequate food reserve for formation and elongation of cells. The synthesized photosynthates might have got translocated to the growing fruits which are in greater demand of assimilates consequently leading to greater thickness of fruit [27].

The maximum fruit weight of bhendi was observed in RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F1B1 – 21.71 g).The increased photosynthetic area and better translocation of photosynthates resulting out of the supply of adequate nutrients in the treatment could have been responsible for large sized fruits with more number of seeds fruits-1 resulting in increased fruit weight as reported earlier by Mal et al. [28]. The increased concentration of chlorophyll content of panchagavya treated plants resulting in enhanced photosynthetic efficiency might have also contributed to the fruit weight (Swarnam et al.) [29], as fermented Panchagavya is reported to be rich in N, P, K, S and micronutrients.

The application of inorganic and organic sources of nutrients in right proportion in the treatment receiving RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS has lead to the production of more number of fruits plant$^{-1}$ (F1B1 - 51.70) which could be attributable to the maximum number of flowers produced with improved nutrient availability (Kuppusamy et al.) [17]. Accumulation of cytokinin and auxin in the auxillary buds as reported by Swain et al. [30] in panchagavya treated plants could have also resulted in more number of fruits plant-1.

The maximum yield (891.60 g plant-1 / 16.47 t ha-1) was observed in treatments receiving RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F1B1). This could have resulted from the improved metabolic and auxin related activities in plants under optimal nutritional level as reported by Singh et al. [10]. Foliar spray of panchagavya at 3 per cent could have resulted in enhanced yield as panchagavya is reported to contain beneficial microbes namely lactic acid bacteria (*Lactobacillus*), yeast (*Saccharomyces*), actinomyces (*Streptomyces*), photosynthetic bacteria (*Rhodopseudomonas*) and certain fungi *(Aspergillus)*, as reported by Verma et al. [12].

## 4. CONCLUSION

The results of the experiment clearly revealed the significance of applying 100 per cent RDF along with foliar spray of 3 per cent panchagavya at 30, 45, 60 & 75 DAS in terms of growth and yield parameters in bhendi.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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