EFFECT OF SOWING DATE, VARIETY AND NUTRIENT MANAGEMENT ON FINGER MILLET IN NEW ALLUVIAL ZONE OF WEST BENGAL

A Thesis
Submitted to the
Bidhan Chandra Krishi Viswavidyalaya
in partial fulfilment of the requirements
for the award of the Degree of Master of Science (Agriculture)
in
AGRONOMY

By
NIKITA DAS
(*Reg. No.* 10A06P2223)

DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
BIDHAN CHANDRA KRISHI VISWAVIDYALAYA
MOHANPUR, NADIA, WEST BENGAL, INDIA

2024

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MOHANPUR, NADIA, WEST BENGAL, INDIA 2024

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to
My Beloved Parents,
Subhash Das,
Pampa Das and
My Beloved Little Sister
Ankita Das

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This is to certify that the work recorded in the thesis entitled **"EFFECT OF SOWING DATE, VARIETY AND NUTRIENT MANAGEMENT ON FINGER MILLET IN NEW ALLUVIAL ZONE OF WEST BENGAL"** submitted by **Nikita Das** in partial fulfillment of the requirements for the award of the degree of Master of Science (Agriculture) in **Agronomy**, Faculty of **Agriculture** of the Bidhan Chandra Krishi Viswavidyalaya, is the faithful and bona fide research work carried out under my supervision and guidance. The results of the investigation reported in thesis have not so far been submitted for any other Degree or Diploma. The content of the thesis has been checked for plagiarism and the similarity level is within the permissible limit (10%) as per the university rules. The soft copy of the thesis which has been checked for similarity and the hard copy of the thesis which has been submitted for the degree are identical. The assistance/ help received during the course of investigations have been duly acknowledged.

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Date: 13.08.2024

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LIST OF ABBREVIATIONS

Abbreviation		Full Form
&	:	And
°C	:	Degree centigrade
@	:	At the rate
AICRP	:	All India Co-ordinated Research Project
ANOVA	:	Analysis of variance
B.C.K.V.	:	Bidhan Chandra Krishi Viswavidyalaya
C.D.	:	Critical difference
cm	:	Centimeter
EC	:	Electrical conductivity
et al.	:	et alia (And Others)
g	:	Gram
GDD	:	Growing degree days
g m^{-2} day^{-1}	:	Gram per meter square per day
ha	:	Hectare
ha^{-1}	:	Per hectare
HTU	:	Heliothermal units
i.e.	:	*Id est* (That is)
kg	:	Kilogram
m^2	:	Square Meter
m^{-2}	:	Per square meter
Max.	:	Maximum
Min.	:	Minimum
mm	:	Millimeter
pH	:	Negative logarithm of active hydrogen ion concentration
PTU	:	Photothermal units
R.H.	:	Relative Humidity
S. Em	:	Standard Error Of Mean
T	:	Tonne
t ha^{-1}	:	Tonnes per hectare
Temp.	:	Temperature

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ABSTRACT

A field experiment was carried out at the Instructional Farm, B.C.K.V., Jaguli, Nadia, West Bengal during *kharif* season of 2023 to study the effect of sowing date, variety, and nutrient management on finger millet in new alluvial zone of west Bengal. The duration of finger millet was reduced successively with delay in sowing from 20 July (115.2 days) to 11 August (108.9 days). Irrespective of sowing date and nutrient management, two finger millet varieties took near similar days (111.9 to 112.2 days) to complete the life-cycle. The average summed GDD, HTU and PTU for entire life cycle were recorded as 2005.3°C, 10132.1°C hour and 24038.0°C hour, respectively. Crop sown on 20 July resulted better growth attributes *viz.* plant height, tiller numbers, LAI and DM production in all the growth stages of the crop compared to 11 August sowing in the study. Application of FYM @ 20 kg RDN ha^{-1} as basal followed by top dressing with urea @ 20 kg RDN ha^{-1} at 35 DAS (N_2) recorded better growth attributes throughout the life cycle of the crop. Finger millet sown on 20 July (D_1) produced the highest grain yield (1314.8 kg ha^{-1}) which was significantly greater over 11 August sowing (1092.6 kg ha^{-1}) crop. Indravathi (V_1) produced maximum grain yield (1243.7 kg ha^{-1}) which was 80.00 kg ha^{-1} greater over GPU 67 (V_2). The application of 50% RDN through FYM as basal + 50% RDN top dressing at 35 DAS (N_2) resulted higher grain yield (1290.0 kg ha^{-1}) which was 6.7 and 15.9% higher over N_1 (50% RDN through urea as basal + 50% RDN through urea as top dressing at 35 DAS) and N_3 (25% RDN through FYM + 25% RDN through *Azospirillum* as basal + 50% RDN through urea as top dressing at 35 DAS). Mean gross return, net income and B:C ratio were ± Rs. 88,096.35 ha^{-1}, ± Rs. 32,593.65 ha^{-1} and ± 1.59. So, it could be advised to the farmers for sowing of Indravathi within mid-July under combined application of 20 kg RDN through FYM as basal + 20 kg RDN through urea as top dressing at 35 DAS during *kharif* season in lower *gangetic* plains of West Bengal to get more yield and profitable return. However, sowing of finger millet variety 'GPU 67' on 20 July under integrated nutrient management without *Azospirillum* (N_2) resulted highest gross (Rs. 1,02584.30 ha^{-1}), net return (Rs. 45,251.30 ha^{-1}) and B:C ratio (1.79) and thus, GPU 67 may be recommended as an alternative finger millet variety in lower *gangetic* plains of West Bengal during *kharif* season under integrated nutrient management system.

Chapter 1

Introduction

1. INTRODUCTION

Millets are unique cereals of dry and erratic weather conditions that can cope with relatively poor soils, and require fewer external inputs than major cereals like rice, wheat, and maize. It has been a staple food crop in many parts of Africa and Asia for thousands of years with superior nutritional qualities. They are gluten-free highly nutritious and rich in carbohydrates, proteins, dietary fiber, vitamins (especially B-complex vitamins), and minerals (such as calcium, iron, potassium, magnesium, and zinc) and have a low glycemic index, making them suitable for people with gluten intolerance or diabetes. Furthermore, millets are ecologically beneficial (Brahmachari *et al*., 2018), sequester carbon, increasing opportunities for CO_2 abatement, and support rich varietal diversity that enhances agro-biodiversity. They also facilitate mutually beneficial intercropping with other important crops (Maitra *et al*., 2000).

Finger millet, the third most widely cultivated millet behind pearl and sorghum, is mainly grown as minor millet in semi-arid tropical and subtropical regions of the world and can produce staple food in a short period. In India it is cultivated in 1.61 million ha area with a production of about 2.1 million tonnes and 1661 kg per hectare productivity (AICSMIP, 2013-14). Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Jharkhand, Uttaranchal, Maharashtra and Gujarat are the important finger millet growing states in our country. In southern Karnataka, especially in rural regions, it is the main source of food. It is eaten in many different ways, including as *ragi mudde* (a thick dish that resembles dough), *ragi rotti* (a flatbread) and *ragi dosa* (a pancake), particularly in the districts of Hassan, Mandya, Tumkur, Bangalore, Kolar, Mysore, and Chitradurga.

Grain of finger millet contains 76.32% carbohydrate, 9.2% protein, 1.29% fat, 2.24 % minerals, 3.90% ash and also rich in calcium, phosphorus, potassium, and methionine, vitamins A and B (Tomar *et al*., 2011). Compared to rice and wheat, finger millet grains have twice the phosphorus, four times the micronutrients, and ten times the calcium (Stanly and Shanmugam, 2013). Moreover, it has a high resistant starch content combined with soluble fiber and polyphenols, which slows down starch hydrolysis. This makes it more significant as the number of diabetics rises (Kumari and Sumathi, 2002).

The most significant non-monetary factor affecting crop output is the timing of sowing. The optimum sowing time increases output by creating an ideal environment

for all growth stages. A delayed seeding led to early maturity and a sharp decrease in yield compared to a regular sowing, which has a longer growing period and, as a result, offers a chance to accumulate more biomass.

Most of the finger millet varieties develop in recent years have wide adaptability, ease of cultivation, resistance to main pests and diseases, and drought tolerance, making this crop an essential component of the dry farming system. In India, finger millet is typically produced on poor, marginal soils with uneven nutrient treatments, but, these recently developed finger millet varieties respond well to additional nutrients.

In recent years, as the chemical fertilizers have been utilized at an exponential rate to boost agricultural productivity it resulted in land degradation and lower crop output over time. Nutrient management should be directed toward production sustainability, and integrated nutrient management (INM) is the best solution in this regard. Aside from nutrient availability, combining different organic manures, synthetic fertilizer, and bio-fertilizers improves soil physical characteristics such as structure, porosity, and water-holding capacity by increasing soil organic matter content. This promotes a healthy environment for microbes' growth in soil and creates a more nutrient rich soil, allowing finger millet to grow more rapidly.

Given the shifting context of global warming and climate change, producing environmentally sound and hardy millets may be a good choice for generating maximum output while maintaining food and nutritional security. The optimal sowing timing, selection of better variety and suitable nutrient management play a noteworthy role in exploiting this crop's yield potential under certain agro-climatic conditions. Keeping this in mind, the present research work was done in lower *gangetic* plains of West Bengal with the following objectives:

(i) To find out the suitable sowing date of finger millet for higher productivity during *kharif* season

(ii) To evaluate the performance of finger millet varieties in New Alluvial Zone of West Bengal

(iii) To identify the suitable nutrient management for profitable cultivation of finger millet

Chapter 2

Review of Literature

2. REVIEW OF LITERATURE

2.1 Duration and growth environment

2.1.1 Phenology

2.1.1.1 Sowing date

With delay in sowing of 3 finger millet varieties (Vakula, Srichaitanya and Tirumala) from 15 October to 15 December, the days to 50% flowering was reduced from 52 to 38 days at Agricultural Research Station, Perumallapalli, Tirupati of Acharya N.G. Ranga Agricultural University during *rabi* season of 2021-2022 (Sarala *et al.*, 2022).

The variation in sowing time had slight effect on attainment of maximum tillering, anthesis and physiological maturity of three finger millet variety (Chaitanya, Bharathi, Hima) at Agricultural College Farm, Bapatla. The days to maximum tillering was increased due to delay in sowing from 1st FN of July (20 days) to 2nd FN of July (24 days), while entire life cycle was found to varied between 99-115 days during *kharif* season in 2015 (Revathi and Rekha, 2017).

2.1.1.2 Variety

Three finger millet varieties *viz.* Chaitanya, Bharathi, Hima were tested to notice number of days required to complete the three different phenophases *i.e.* maximum tillering, anthesis and maturity at Agricultural College Farm, Bapatla when sown on 2nd fortnight of July, in 2017 by Revathi and Rekha. In this investigation it was found that there was slight difference between varieties in respect of maximum tillering (24 days) anthesis (62 days) and maturity stage (115 day). The variety Hima matured earlier (105 days) compared to other Bharathi (108 days) and Chaitanya (115 days) in the study.

2.1.2 Thermal indices

2.1.2.1 Sowing date

Revathi and Rekha (2017) noticed that irrespective of varieties, finger millet accumulated highest average GDD of 2073.33^{o}C, throughout its maturity stage when sown at 2nd FN of July; but the average accumulation of GDD was decreased to

1980.33°C and 1947.66°C for 1st FN of August and 1st FN of July, respectively at Bapatla, India.

John (2019) studied the effect of sowing date (15 May, 1 June, 15 June, 1 July and 15 July) on GDD requirement for different phonological stages of finger millet during the *kharif* season of 2018 at Instructional Farm, Kerala Agriculture University, Thrissur. At sowing to panicle initiation stage, higher (1510.7°C) and lower (1297.7°C) accumulation of GDD was observed on 1 June and 15 July, respectively.

2.1.2.2 Variety

Among eleven varieties of finger millet sown at Dry land Research Station, Krishi Vigyan Kendra, Munger during *kharif* season of 2014 and 2015, At harvest stage, GPU-67 recorded highest pooled GDD (2099.8°C) followed by GPU-28 (2051.5°C) and RAU-8 (2027.2°C) in the study (Singh *et al.*, 2017).

2.2 Growth attributes

2.2.1 Plant height

2.2.1.1 Sowing date

Nigade *et al*. (2020) reported that sowing of finger millet on 2nd week of July resulted in taller plants (88.70 cm), which was significantly greater over those sown in 4th week of June (87.50 cm), 2nd week of June (85.00 cm) and 4th week of July (77.80 cm) at Kolhapur, Maharashtra.

Pandiselvi *et al*. (2010) reported that sowing of finger millet on 24 May resulted maximum plant height (119.80 cm), which was significantly greater over 17 May (99.10 cm), 31 May (118.60 cm), 7 June (118.50 cm), 14 June (109.30 cm) and 21 June (109.00 cm) during *kharif* season 2007, at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry.

The range of variation in plant height of 3 varieties of finger millet due to differences in 3 sowing times (15 October, 15 November and 15 December) was 29.29-35.36 cm at tillering stage, 72.19-79.45 cm at flowering stage and 93.92-104.40 cm at harvesting during *rabi* season 2021-2022 at Agricultural Research Station,

Perumallapalli, Tirupati of Acharya N.G. Ranga Agricultural University (Sarala *et al*., 2022).

2.2.1.2 Variety

The variation in plant height of four finger millet varieties, sown during *kharif* season 2018 at Agricultural College Farm, Acharya N.G. Ranga Agricultural University was recorded as: VR-847 (104.78 cm), VR-762 (103.71 cm), PPR-1012 (97.18 cm) and Vakula (84.01 cm) (Radha *et al*., 2019).

Among the four of finger millet varieties (Phule Nachani, GPU 28, GPU 67 and Dapoli 1) grown during *kharif* season of 3 consecutive years (2016, 2017, 2018) at Kolhapur, Maharashtra, the highest pooled plant height was recorded in Phule Nachani (94.30 cm), followed by GPU 28 (87.00 cm), GPU 67 (82.50 cm) and Dapoli 1 (75.30 cm) (Nigade *et al*., 2020).

The plant height of two finger millet varieties at maturity stage in *kharif* season as recorded as: SM 1 (85 cm) and IE 4425 (77 cm) at the Agriculture Research and Development Centre (ARDC), Samtenling, Sarpang (Tshering *et al*., 2022).

2.2.1.3 Nutrient management

The plant height of finger millet, mean over two years was recorded higher (85.89 cm) in application of poultry manure @ 1.7 t ha^{-1} compared to FYM @ 10 t ha^{-1} (85.84 cm) and vermicompost @ 2.5 t ha^{-1} (85.21 cm) during *kharif* season 2016 and 2017 in Uttar Pradesh (Debbarma *et al*., 2024).

Among the 14 treatments, application of 100% NPK with seed, soil and seedling treatment with liquid biofertilizer consortium recorded higher plant height (102.2 cm) of finger millet at harvest during summer season of 2020-21 at Zonal Agriculture Research Station, University of Agricultural Sciences, GKVK, Bangalore (Patil *et al*., 2022).

2.2.2 Number of tillers m^{-2}

2.2.2.1 Sowing date

Sarala *et al.* (2022) found that among the 3 sowing date of finger millet (*viz.* 15 October, 15 November and 15 December), number of tiller m^{-2} decreased with delay in

sowing from 15 October to 15 December at Agricultural Research Station, Perumallapalli, Tirupati. The highest number of tiller m^{-2} (89.77) was obtained in 15 November sowing which was statistically higher from 15 October (78.38) and 15 December (73.65) at harvesting stage of finger millet crop.

Irrespective of varieties, early sowing of finger millet on 17 May significantly enhanced number of tillers $hill^{-1}$ (5.82) compared to 24 May (5.22), 31 May (4.80), 7 June (4.75), 14 June (5.63) and 21 June (5.24) sowing during *kharif* season at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry (Pandiselvi *et al*., 2010).

2.2.2.2 Variety

Among the ten finger millet varieties tested at Nagaland, the number of tillers $hill^{-1}$ at maturity stage was highest in VL 352 (4.52), followed by OEB 532 (4.37), VL 149 (4.32), GPU 66 (3.43), OUAT-2 (3.36), VL 376 (3.05), VR 847 (2.73), GPU 67 (2.37), VL 347 (1.68) and OEB 532 (1.52) (Gohain and Reddy, 2020).

Pandiselvi *et al.* (2010) reported that finger millet varieties CO14 produced highest number of tiller $hill^{-1}$ (6.06) compared to other two varieties TRY1 (5.31) and CO13 (4.35) at Karaikal, Puducherry during *kharif* season of 2007.

2.2.2.3 Nutrient management

Among the different nutrient combinations, basal application of FYM @ 10 t ha^{-1} and N:P:K @ 25:15:12.5 kg ha^{-1} along with $ZnSO_4$ (12.5 kg ha^{-1}) and Borax (5kg ha^{-1}) recorded highest number of effective tillers m^{-2} (111.7) of finger millet when the seeds are inoculated with *Azospirillum brasilense*, *Bacillus spp.* and *Pseudomonas fluorescens* @ 20 g kg^{-1} seed each before sowing during *kharif* season 2016 at Birsa Agricultural University Farm, Kanke, Ranchi (Roy *et al.*, 2018).

Application of poultry manure @ 1.7 t ha^{-1} recorded highest number of effective tillers $hill^{-1}$ (11.96) of finger millet, pooled over two years, at 90 DAT compared to FYM (11.86) and vermicompost (11.76) @ 10 and 2.5 t ha^{-1} respectively during *kharif* season 2016 and 2017 in Uttar Pradesh (Debbarma *et al*., 2024).

Patil *et al.* (2022) reported that finger millet produced higher number of tillers $plant^{-1}$ at 30 DAT (3.5 cm), 60 DAT (4.3 cm), 90 DAT (5.6 cm) and harvesting stage

(6.0 cm) when treated with 100% NPK + Seed + Soil + Seedling root dip with LBFC during summer season of 2020-21 at Bangalore.

2.2.3 Dry matter accumulation

2.2.3.1 Sowing date

Sarala *et al*. (2022) observed that the variation in sowing time of finger millet from 15 October to 15 December showed significant influence on dry matter accumulation in all growth stages of life-cycle. At harvest stage, maximum (449.87 g m^{-2}) and minimum (358.38 g m^{-2}) dry matter accumulation was obtained by 15 November and 15 October sowing, respectively at Tirupati.

Pandiselvi *et al*. (2010) reported that 17 May sown finger millet produced significantly highest dry matter (5541 kg ha^{-1}) at flowering stage, which was decrease with delay sowing of 24 May (5335 kg ha^{-1}), 31 May (4769 kg ha^{-1}), 7 June (4728 kg ha^{-1}), 14 June (4625 kg ha^{-1}) and 21 June (4460 kg ha^{-1}) at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry.

2.2.3.2 Variety

Among 3 finger millet varieties *viz.* Tirumala, Vakula and Srichaitanya, tested in Agricultural Research Station, Perumallapalli, Tirupati, maximum dry matter of 71.69 g m^{-2} at tillering, 243.62 g m^{-2} at flowering and 468.67 g m^{-2} at harvest was accumulated by Tirumala during *rabi* season of 2021-2022 (Sarala *et al*., 2022).

Radha *et al*. (2019) reported that VR-847 gained higher dry matter (15572.4 kg ha^{-1}) compared to VR-762 (14673.7 kg ha^{-1}), PPR-1012 (13366.0 kg ha^{-1}) and Vakula (12694.1 kg ha^{-1}) during *kharif* season of 2018 at Acharya N.G. Ranga Agricultural University.

Among three varieties of finger millet, CO13 produced highest dry matter yield at flowering stage (5524 kg ha^{-1}) which was significantly superior over other 2 varieties *viz.* TRY1 (5080 kg ha^{-1}) and CO14 (4125 kg ha^{-1}) at Karaikal, Puducherry (Pandiselvi *et al.*, 2010).

2.2.3.3 Nutrient management

Application of 100% NPK along with seed, soil application + Seedling root dip with liquid bio-fertilizer consortium recorded highest dry matter production (39.50 g) of finger millet at harvesting stage against 13.80 g in absolutely control plots at Bangalore (Patil *et al*., 2022).

2.2.4 Leaf area index (LAI)

2.2.4.1 Sowing date

Sowing of finger millet on 17 May recorded the highest LAI values of 9.48 at flowering stage compared to late sowing on 24 May (9.32), 31 May (9.05), 7 June (8.38), 14 June (8.44) and 21 June (7.46) during *kharif* season, 2007 at Puducherry (Pandiselvi *et al.*, 2010).

Finger millet sown on 15 November recorded the highest leaf area plant^{-1} of 240.70 and 202.00 cm^2 at flowering and harvest respectively compared to early (15 October) and late (15 December) sowing during *rabi* season at Guntur, Andhra Pradesh (Sarala *et al.*, 2022).

2.2.4.2 Variety

Irrespective of spacing, the LAI values of GE-292, GE-199 and GPU-28 were recorded as 7.37, 5.83 and 6.22 respectively at flowering stage during summer, 2018 at GKVK, Bengaluru (Anjum *et al*., 2020).

Pandiselvi *et al.* (2010) in a field experiment reported significant variations on LAI among the varieties of finger millet grown during *kharif* season, 2007 at Puducherry. TRY 1 (9.00) exhibited significantly higher LAI followed by *cv.* CO 14 (8.56) and CO 13 (8.50).

2.2.4.3 Nutrient management

Shiva Kumar *et al.* (2022) reported that LAI at 90 DAS of finger millet pooled over two years was 2.61 and 2.68 in plots treated with 75% RDN through FYM + 25% through Inorganic fertilizers and 100% RDN through FYM + 25% through Inorganic fertilizers respectively at the eastern dry zone of Karnataka.

Gafoor *et al.*, (2021) reported that LAI at harvest of finger millet was 3.003 and 4.087 in fully organic and inorganic plots, respectively during summer season of 2020-2021 at Kerala, India.

2.2.5 Crop Growth rate

2.2.5.1 Variety

The CGR of finger millet variety 'BBM 10' showed an increasing tend from 0 – 30 DAS to 60 – 90 DAS and thereafter a declining trend during 90 DAS – Maturity. Irrespective of tillage condition, pooled cultivar CGR were 1.57 g m^{-2} day^{-1} at 0 – 30 DAS, 7.55 g m^{-2} day^{-1} at 30-60 DAS, 9.61 g m^{-2} day^{-1} at 60 – 90 DAS, 8.55 g m^{-2} day^{-1} at 90 DAS to maturity (Sulochna *et al*., 2022).

2.2.5.2 Nutrient management

The pooled CGR values at different growth intervals in finger millet were generally higher (1.65 g m^{-2} day^{-1} at 0 – 30 DAS, 7.79 g m^{-2} day^{-1} at 30 – 60 DAS, 10.00 g m^{-2} day^{-1} at 60 – 90 DAS, 9.67 g m^{-2} day^{-1} at 90 DAS to maturity) with sole application of vermicompost as basal compared to other organic nutrient management practices adopted at Kanke, Ranchi (Sulochna *et al*., 2022).

2.3 Yield components and associated characters

2.3.1 Panicle length

2.3.1.1 Nutrient management

Ear head length of finger millet was 9.1 cm in 75% RDN + 25% N through cotton stubbles vermicompost + 2% N through farmers practice vermicompost applied plot which was 1.8 cm longer over control without nitrogen in Hyderabad (Aparna *et al.*, 2020).

2.3.2 Number of fingers $panicle^{-1}$

2.3.2.1 Sowing date

Pandiselvi *et al.* (2010) conducted an experiment on date of sowing of finger millet at Pandit Jawaharlal Nehru College of Agriculture and Research Institute,

Karaikal, Union territory of Puducherry. From his field study, it was observed that the number of fingers earhead^{-1} decreased markedly with delay sowing on 21 June. The highest number of fingers earhead^{-1} (8.28) was obtained in 17 May sowing and the lowest value (7.71) was obtained in 21 June sowing.

2.3.2.2 Variety

Significant variation in number of fingers earhead^{-1} was noted between two finger millet variety (SM 1 and IE 4425) at Bhutan by Tshering *et al*. in 2022. Variety SM 1 recorded higher (4.66) number of fingers earhead^{-1} compared to IE 4425 (3.67).

Gohian and Raddy (2020) reported that among ten varieties of finger millet (VR 847, OEB 532, OEB 526, GPU 66, GPU 67, VL 149, VL 347, VL 352, VL 376, OUAT-2) VL 352 produced the maximum number of fingers earhead^{-1} (7.80) while OEB 526 had the lowest number of fingers earhead^{-1} (6.03) at Nagaland.

2.3.2.3 Nutrient management

Deepti *et al.* (2022) observed that application of 100% RDF along with seed, soil and seedling treatment with liquid bio-fertilizer consortium significantly increased number of fingers earhead^{-1} (7.77) of finger millet which was 84.3% higher over absolute control (1.97) at Bangaluru.

The number of fingers earhead^{-1} under organic nutrient management plots (i.e. RDN through FYM) was 5.9, while it was 6.8% higher in the plots managed by inorganic nutrient during *kharif*, 2013 at Rajendranagar, Hyderabad (Pallavi *et al*., 2017).

2.3.3 Number of seeds panicle^{-1}

2.3.3.1 Sowing date

Ray *et al.* (2024) reported that the number of grains panicle^{-1} of finger millet was decresed with delay in sowing from 20 June (1195 grains panicle^{-1}) to 20 July (965 seeds panicle^{-1}) at Experimental Block, Regional Research and Technology Transfer Station, Keonjhar, Odisha, India during the *kharif* season, 2020 and 2021.

2.3.3.2 Variety

Number of grains panicle^{-1} was significantly influenced by finger millet varieties as reported by Gohian and Raddy (2020). Variety GPU 66 produced the highest number of seed panicle^{-1} (2536), while variety VL 347 produced the lowest number of seeds panicle^{-1} (1137) at Nagaland.

2.3.3.3 Nutrient management

Application organic manures in finger millet had significant effect on number of grains panicle^{-1}. Application of 75% RDN with 25% N through cotton stubbles vermicompost and 2% rockphosphate resulted in significantly greater number of grains panicle^{-1} (854) compared to other treatments during *rabi* season, 2018-19 at Hyderabad (Aparna *et al*., 2020).

Roy *et al*. (2018) reported that application of organic manures along with bio-fertilizers had significant effect on number of grains ear head^{-1} of finger millet during *kharif* season of 2016 at Birsa Agricultural University Farm, Kanke, Ranchi. Among the different treatment combinations, maximum number of grains ear head^{-1} (1203) was produced by application of FYM (10 t ha^{-1}) + 50% RDF + Biofertilizer + $ZnSO_4$ (12.5 kg ha^{-1}) + Borax (5 kg ha^{-1}).

2.3.4 1000 seed weight

2.3.4.1 Sowing date

The variation in sowing time (24 May, 7 June and 17 June) had significant influence on 1000 seed weight of finger millet. Finger millet sown on 31 May recorded maximum seed weight (3.00 g) which was reduced to early sowing on 17 May (2.58 g) and 24 May (2.75 g) as well as delay sowing on 7 June (2.58 g), 14 June (2.70 g) and 21 June (2.68 g) at Karaikal, Puducherry (Pandiselvi *et al*., 2010).

2.3.4.2 Variety

At Puducherry, Pandiselvi *et al*. (2010) tested three finger millet varieties *viz*. TRY 1, CO 13 and C0 14 and noted that TRY 1 turned out maximum 1000 seed weight (2.92 g) and this affinity was followed by CO 14 (2.63 g) and CO 13 (2.59 g).

Among the 10 finger millet varieties tested at Nagaland by Gohian and Raddy (2020), Variety GPU 66 and VL 352 produced heavier seeds (3.68 and 3.62 g, respectively) and variety OUAT-2 produced lighter seeds (2.12 g).

2.3.4.3 Nutrient management

The combined application of FYM (10 t ha^{-1}) and 50% RDF along with biofertilizer, $ZnSO_4$ (12.5 kg ha^{-1}) and Borax (5 kg ha^{-1}) produced highest (3.45 g) 1000 seed weight of finger millet during *kharif* season of 2016 at Kanke, Ranchi (Roy *et al*., 2018).

Finger millet, sown at Hyderabad during *rabi* season, 2018-19, produced significantly higher 1000 seed weight (3.29 g) in the plots received 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate (Aparna *et al*., 2020).

2.4 Yield

2.4.1 Grain yield

2.4.1.1 Sowing date

Pandiselvi *et al*. (2010) reported that sowing of finger millet on 17 May resulted in highest grain yield (1827 kg ha^{-1}), which was significantly greater over 24 May (1569 kg ha^{-1}), 31 May (1352 kg ha^{-1}), 7 June (883 kg ha^{-1}), 14 June (1472 kg ha^{-1}), 21 June (1188 kg ha^{-1}) of sowing at Puducherry.

At Andhra Pradesh, Sarala *et al.* (2022) observed that almost 30 days delay sowing on 15 November than from 15 October, the grain yield of finger millet increased upto 255 kg ha^{-1} but, it was again reduced to 237 kg ha^{-1} due to 60 days delay sowing on 15 December.

The grain yield of 2 varieties of finger millet (PRM-1 and Local) was decreased to 14.63 and 104.8 kg ha^{-1}, respectively with delay in sowing on 30 May (1172.87 kg ha^{-1}) and 10 June (1082.70 kg ha^{-1}) compared to sowing on 23 May (1187.50 kg ha^{-1}) at Uttarakhand (Upadhyay *et al*., 2015).

Higher mean grain yield of six finger millet varieties, pooled over 3 years were recorded with early sowing on 1st FN of July (2476 kg ha^{-1}) compared to late sowing on

2nd FN of July (2158 kg ha^{-1}), 1st FN of August (1728 kg ha^{-1}) and 2nd FN of August (1191 kg ha^{-1}) at Karaikal (Sukanya *et al.*, 2022).

2.4.1.2 Variety

'GPU 66' and 'VL 376' recorded significantly highest and lowest grain yield of 2937 and 711 kg ha^{-1}, respectively among the 10 finger millet varieties, tested at Nagaland during August to December 2019 (Gohian and Raddy, 2020).

A crop improvement work on finger millet has been carried out in 5 phases (from 1931-2012) at Zonal Agricultural Research Station, VC Farm, Mandya, UAS, Bangalore. Under phase I (1931-1951), the yield potentiality of the released varieties were 285-512 kg ha^{-1}, while it was 900-2700, 3000-4500, 4500-5000 and 5000-5500 kg ha^{-1} during the phase II (1951-1964), Phase-III (1964-1986), phase-IV (1986- 2000) and phase-V (2000-2012), respectively.

2.4.1.3 Nutrient management

100% RDF + seed, soil and seedling treatment and 100% RDF + only soil treatment with liquid biofertilizer consortium significantly produced 25.73 and 24.03% higher grain yield, respectively over sole application of 100% RDF (3245 kg ha^{-1}) during summer season in Bangaluru (Deepti *et al.*, 2022).

Aparna *et al.* (2020) found that application of 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate to finger millet recorded the highest grain yield of 3540 kg ha^{-1}, which was 2087 kg higher than control treatment (1453 kg ha^{-1}) during *rabi* season, 2018-19 at Hyderabad.

At GKVK, UAS, Bengaluru, the highest grain yield of finger millet (20.96 q ha^{-1}) was obtained by applying FYM @ 10 t ha^{-1} + 100% RDF during *Kharif* season 2018, which was 20.92 q greater over the control plot (0.94 q ha^{-1}) (Prashanth *et al*., 2019).

2.4.2 Straw yield

2.4.2.1 Sowing date

Finger millet varieties 'GPU 28' sown on 2nd FN of January resulted in highest straw yield (4392 kg ha^{-1}) compared to delay sowing on 1st FN of March at karnataka (Sukanya *et al.*, 2022).

Sarala *et al.* (2022) reported that maximum straw yield (6732 kg ha^{-1}) was recorded with 15 November sown finger millet crop, which was gradually decreased with delay in sowing to 15 December (5920 kg ha^{-1}) at Agricultural Research Station, Perumallapalli, Tirupati of Acharya N.G. Ranga Agricultural University during *rabi*, 2021-2022.

2.4.2.2 Variety

Sarala *et al.* (2022) reported that finger millet variety 'Tirumala' recorded significantly higher number of straw yield (6968 kg ha^{-1}) than 'Srichaitanya' (6146 kg ha^{-1}) and 'Vikula' (5708 kg ha^{-1}) at Perumallapalli, Andhra Pradesh.

2.4.2.3 Nutrient management

Finger millet, treated with 75% RDN + 25% N through cotton stubbles vermicompost along with 2% rockphosphate, produced 5899 kg ha^{-1} straw yield, which was 57.9% higher over control plots (Aparna *et al.*, 2020).

Deepti *et al.*, (2022) reported that application of liquid biofertilizer consortium on seed, soil and seedlings along with 100% RDF significantly yielded highest mean straw yield (7810 kg ha^{-1}) over control (3710 kg ha^{-1}) at GKVK, Bengaluru, during summer, 2021.

2.4.3 Harvest index

2.4.3.1 Sowing date

Harvest index significantly reduced with delay in sowing in finger millet during *kharif* season of 2012 at "B block", College of Forestry, Ranichauri Campus, V.C.S.G. Uttarakhand University of Horticulture and Forestry. Finger millet sown on 23 May had significantly highest harvest index (39.52%), while lowest (37.44%) was recorded in 10 June sowing plots (Upadhyay *et al.*, 2015).

2.4.3.2 Variety

Gohian and Raddy (2020) reported that harvest index of the 10 finger millet cultivars *viz.* VR 847, OEB 532, OEB 526, GPU 66, GPU 67, VL 149, VL 347, VL 352, VL 376, OUAT-2 tested at Nagaland, were significantly differed between each other and it ranged between 14 to 30%.

2.4.3.3 Nutrient management

Patel and Shroff (2020) found that application of organic manures along with bio-fertilizers had no significant effect on harvest index of finger millet during *kharif* season at Anand, Gujarat. Among the different treatments, 25% N through vermicompost + *Azosprillum* + 50% N through fertilizer recorded highest harvest index of 26.97%.

The harvest index of finger millet grown during *rabi* season at Hyderabad was affected by different organic manures treatments. Application of 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate produce higher (37.50%) harvest index compared to either sole application of FYM, vermicompost and poultry manures or in combination with each other (Aparna *et al.*, 2020).

2.5 Cost of cultivation, net return and benefit-cost ratio

2.5.1 Sowing date

According to Nigade *et al.* (2020) among the 4 dates of sowing, the highest gross return (56689 Rs. ha^{-1}), net return (26334 Rs. ha^{-1}) and B:C (1.86) recorded with the sowing date of 4th week of June.

2.5.2 Variety

Among 4 finger millet varieties (*viz.* Phule Nachani, GPU 28, GPU 67 and Dapoli 1) Phule Nachani fetched highest gross returns (Rs. 56689.00 ha^{-1}), net returns (Rs. 26334.00 ha^{-1}) and benefit cost ratio (Rs 1.86) compared to other 3 varieties during *kharif* season at Kolhapur in Maharashtra (Nigade *et al.*, 2020).

2.5.3 Nutrient management

Aparna *et al.* (2020) reported that application of 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate increased the gross return (72931.00 Rs. ha^{-1}) net returns (49772.00 Rs. ha^{-1}) and B:C (3.15) in finger millet during *rabi* season at Hyderabad.

Chapter 3

Materials and Methods

3. MATERIALS AND METHODS

An investigation was carried out to find out the effect of date of sowing, variety and nutrient management on growth and yield of finger millet. The materials employed, experimental methodologies undertaken, and the techniques applied throughout the investigation are thoroughly discussed in this chapter.

3.1 Location of the study

A field experiment was taken place during *kharif* season of 2023 at Jaguli Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya (B.C.K.V.), Mohanpur, Nadia, West Bengal, India (Plate 3.1). The experimental field was on a high land with good drainage facilities.

3.2 Meteorological features of the experimental site

The farm is located at 22.93° N latitude and 88.53° E longitude, with an elevation of 9.75 meters above mean sea level, placing it within the humid subtropical climatic zone. The region experiences distinct crop seasons: the dry and warm pre-*kharif* season (March – May), the wet and warm *kharif* season (June – October), and the dry and cool *rabi* season (November – February). Summers are characterized by high temperatures, while winters are short and mild. Temperature typically increases from late February to peak in April-May, then decreases from mid-October to reach its lowest in January. The average annual rainfall is approximately 1396 mm, with the majority (70-80%) occurring during the wet (*kharif*) season following the onset of the southwest monsoon, usually around the second week of June. Relative humidity remains high during the monsoon months (July – October). Table 3.1 presents the meteorological data relevant to the experimental periods. The minimum and maximum temperatures recorded during the cropping months ranged from 17.83°C to 33.83°C. Rainfall varied across the experimental months as follows: July (165.10 mm), August (230.40 mm), September (199.50 mm), October (252.90 mm), and November (6.00 mm). Maximum relative humidity ranged from 89.90% to 94.83% throughout the study period, while minimum relative humidity ranged between 79.43% and 85.00%. Bright sunshine hours and wind speeds ranged from 3.28 to 6.60 hours and 1.00 to 2.72 km hour^{-1}, respectively, throughout the investigation period.

Table 3.1 and Fig. 3.1

Meteorological data pertaining to the period of experimentation

(July to November, 2023)

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Bright Sunshine (hour)	Wind Speed (km hour^{-1})
	Max.	Min.	Max.	Min.			
July	33.83	26.52	89.90	79.47	165.10	6.54	2.72
August	32.43	25.89	93.53	83.93	230.40	3.28	1.87
September	32.91	25.84	94.83	85.00	199.50	3.82	1.59
October	31.92	22.86	94.30	82.07	252.90	6.12	1.11
November	29.96	17.83	93.10	79.93	6.00	6.60	1.00

[Source: Department of Agricultural Meteorology and Physics, B.C.K.V., Nadia, W.B, India]

3.3 Soil

The soil at the experimental field was *gangetic* alluvial, classified as Inceptisol, with a sandy-loam texture. It exhibited medium fertility levels and was nearly neutral in pH. The physico-chemical properties of the soil of experimental field have been summarized in Table 3.2.

3.4 Previous cropping history

The field was occupied by maize during *rabi*, 2022. Subsequently, it remained fallow throughout the entire pre-*kharif* season of 2023.

3.5 Experimental details

A field study was conducted to find out the effect of date of sowing, variety and nutrient management on growth and yield of finger millet in New Alluvial Zone of West Bengal during *kharif* season of 2023. The design of the experiment was split-split plot with 3 replications comprising different date of sowing in main plots, varieties in sub plots and nutrient management in sub-sub plots. Other cultivation practices were done as per standard recommendations. Details of the treatments used in the study are described in Table 3.3.

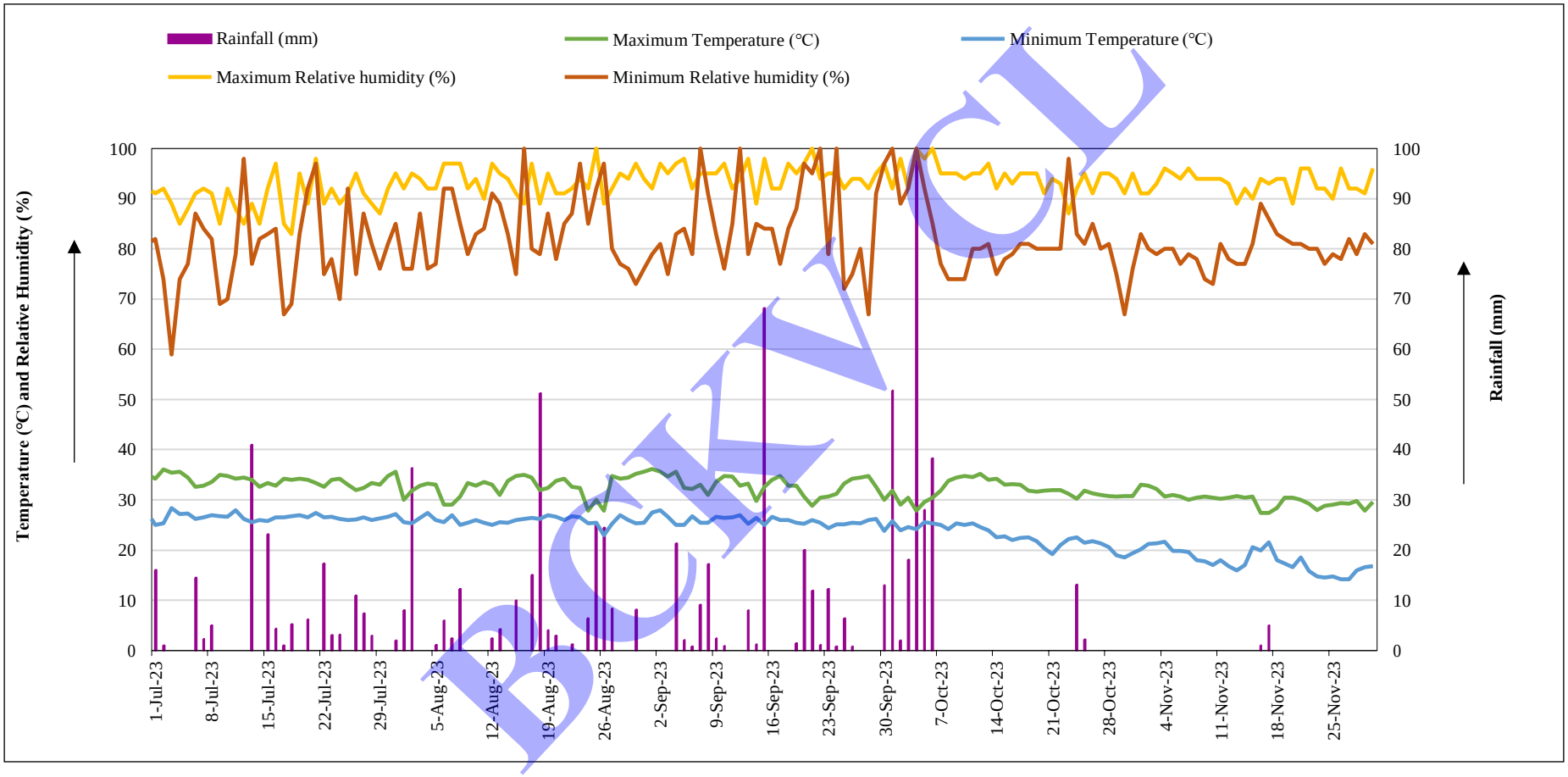


Fig. 3.1: Meteorological conditions pertaining to the period of experimentation (July – November, 2023)

Table 3.2

Physico-chemical properties of the experimental soil (0 – 15 cm depth)

Sl. No.	Property	Value	Method used
1	Mechanical Composition Sand (%) Silt (%) Clay (%)	 40.7 32.3 27.0	International pipette method (Piper, 1950)
2	Soil texture	Sandy loam	USDA system (Brady, 1996)
3	Soil pH	6.9	Blackman's pH meter method (Jackson, 1973)
4	Organic carbon (%)	0.45 (Low)	Walkley and Black method (Jackson, 1973)
5	Available nitrogen (kg ha^{-1})	158.44	Macro Kjeldahl method (Jackson, 1973)
6	Available P_2O_5 (kg ha^{-1})	41.75	Olsen's method (Jackson, 1973)
7	Available K_2O (kg ha^{-1})	144.50	Flame photometric method (Jackson, 1973)

3.6 Collection of seeds

The seeds of 2 finger millet varieties were collected from Regional Research Station (RRS), B.C.K.V, Jhargram, West Bengal and Assistant Director of Agriculture, Para Block, Purulia, West Bengal during May, 2023. The details of the varieties are given in Table 3.4.

3.7 Field and cultural operations

Proper care was taken for management of experimental plots beginning with land preparation to harvest of finger millet crop. A schedule of various operations is given in Table 3.5.

Table 3.3

Details of treatments of the experiment

Treatment	Treatment code	Particular
Main plot	**D_1**	20 July, 2023
2 sowing dates	**D_2**	11 August, 2023
Sub plot	**V_1**	Indravathi
2 varieties	**V_2**	GPU 67
Sub-sub plot		
3 Nutrient management	**N_1**	20 kg RDN ha^{-1} through urea as basal + 20 kg RDN ha^{-1} through urea as top dressing at 35 DAS
	N_2	20 kg RDN ha^{-1} through FYM as basal + 20 kg RDN ha^{-1} through urea as top dressing at 35 DAS
	N_3	10 kg RDN ha^{-1} through FYM with *Azospirillum* @ 2 kg ha^{-1} as basal + 20 kg RDN ha^{-1} through urea as top dressing at 35 DAS

3.7.1 Preparation of land

Due to very small seed size, proper care was taken at the time of sowing of finger millet to get maximum germination percentage (%). Therefore, one ploughing with disk plough followed by harrowing was done to make the soil loose and friable. The weeds and stubbles were removed from the field and then levelling off the ground was done.

3.7.2 Layout

After proper levelling, the whole experimental field was divided into 3 blocks. Each block was then divided into 2 main plots for assigning two date of sowing, each of which was again sub-divided into 2 sub-plots for varieties and again each sub-plot is divided into 3 sub-sub-plots of 3 m × 3 m size for allotting three nutrient management practices (Fig.3.2).

Table 3.4

Details of Finger millet varieties used in the experiment

Variety	Duration	Institute where developed	Special characteristics
Indravathi (CFMV 1)	110-115	ANGRAU, ARS Vizianagaram	Non lodging, Resistant to finger blast, neck blast, foot rot and banded blight.
GPU 67	114-118	PC Unit, Bangalore	Non lodging and semi dwarf in nature.

Fig.3.2: Layout of experiment on finger millet during *kharif* season at Instructional Farm, Jaguli, B.C.K.V., Mohanpur

3.7.3 Sowing of seeds

Furrows (1.5 – 2 cm deep) at 30 cm apart were opened with the help of a tyne in the experimental units. The seeds of finger millet @ 5 kg ha^{-1} were mixed with sand and they were dropped continuously in furrows manually. Then the seed were covered with light soil (Plate 3.1).

3.7.4 Thinning

Thinning was done at 15 DAS to remove excess unhealthy seedlings and to maintain optimum plant population in each experimental plot.

3.7.5 Nutrient management

Urea, FYM and *Azospirillum* were given as per treatment schedule, while a uniform dose of 20:20 kg ha^{-1} of P_2O_5 and K_2O were applied in the form of single super phosphate and muriate of potash in all the experimental units (Plate 3.1).

Table 3.5

Schedule of field operations during the period of experimentation

Sl. no.	Parameters	Date
1.	Ploughing	18.07.2023 (1st SD) and 9.08.2023 (2nd SD)
2.	Lay out preparation and manure application	19.07.2023 (1st SD) and 10.08.2023 (2nd SD)
3.	Basal application of fertilizer or manure	19.07.2023 (1st SD) and 10.08.2023 (2nd SD)
4.	Sowing of seeds	20.07.2023 (1st SD) and 11.08.2023 (2nd SD)
5.	Thinning	04.08.2023 (1st SD) and 25.08.2023 (2nd SD)
6.	1st hand weeding 2nd hand weeding	20.08.2023 and 11.09.2023 (1st SD) 21.09.2023 and 12.10.2023 (2nd SD)
7.	Top Dressing	24.08.2023 (1st SD) and 15.09.2023 (2nd SD)
8.	Irrigation	No irrigation was given
9.	Harvesting	10.11.2023 (1st SD) and 30.11.2023 (2nd SD)

[SD = Sowing date]

3.7.6 Irrigation management

Due to sufficient rainfall during the first three months, the crop did not face any moisture stress situation throughout its growing period and thus no additional irrigation was given.

3.7.7 Weed control

Due to sufficient amount of moisture in the soil and slow growth at early stages of finger millet, the weed infestation was relatively more. So, two hand weeding were done at 30 and 60 DAS to keep the field under weed-free condition (Table 3.5).

3.7.8 Harvesting and threshing

As the finger millet was sown at 2 different dates at 15 days interval during *kharif* season, the harvesting dates varied from second to last week of November. At 80% panicle maturity stage, the crop was harvested by cutting the panicles and whole plants separately with sickle from each net plot area. The plot-wise panicles and bundles of plants were carried to the threshing floor and sundried for 4-5 days. Threshing was done by beating with sticks to separate the seeds from the panicles. After proper cleaning and drying, the seeds and straw of each net plot were weighed separately and yield was calculated in terms of kg ha^{-1}.

3.8 Methods of determining phenological development and calculating growth environment

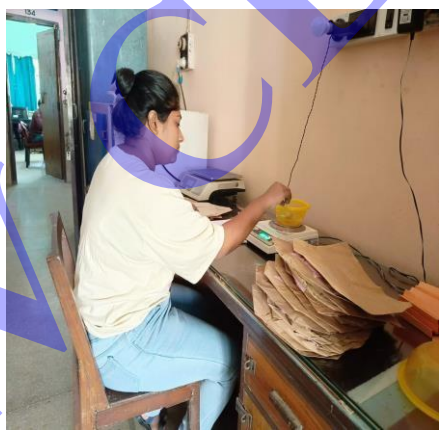
3.8.1 Phenological development

Each plot was visited at 1-2 days regular interval beginning from sowing to maturity to note the phenological development of the finger millet crop. The attainment of different phenophases were determined in the study as: (i) 4^{th} leaf emergence, when >50% of seedlings of a plot had 4 number of leaves after germination (ii) flower initiation, when the first flower was initiated in a plot (iii) 50% flowering, when >50% of plants of a plot enter flowering stage, and (iv) maturity, when >80% finger turned reddish-brown colour and seeds inside the finger became mature (Plate 3.1).

Instructional Farm, B.C.K.V.

Application of Urea (Basal)

Line opening with tyne



Taking dry weight

Observation on plant height

Winnowing operation

Plate 3.1: Field and laboratory activities on finger millet at B.C.K.V., West Bengal, India

3.8.2 Growing degree days (GDD)

Degree day was determined as the difference between the mean daily temperature and the base temperature (Nuttonson, 1955):

$$GDD = \sum_{i=1}^{n}[(\frac{T_{max}+T_{min}}{2})-T_b]$$

where, T_{max} and T_{min} were the maximum and minimum air temperature of a day; T_b was the base temperature and n was the number of days to attain a phenophase. 10°C was considered as base temperature (T_b) for finger millet crop during *kharif* season in New Alluvial Zone.

The degree days for different phenophases of the crop were calculated separately and then they were summed up for the entire life cycle.

3.8.3 Heliothermal units (HTU)

The degree day when multiplied by actual duration of bright sunshine hour for the corresponding day was termed as heliothermal unit (Singh *et. al.*, 1990).

$$HTU = \sum_{i=1}^{n}[GDD \times \text{Bright sunshine hour}]$$

The heliothermal units for different phenological stages were determined, which were summed up for entire duration of the crop.

3.8.4 Photothermal units (PTU)

The photothermal unit was calculated by the following formula as suggested by Nuttonson (1948).

$$PTU = \sum_{i=1}^{n}[GDD \times \text{Average day length (hour)}]$$

The photothermal units for different phenophases were calculated and summed up for entire crop growing period.

3.9 Methods of recording growth attributes

3.9.1. Plant height

Three plants were randomly selected in each plot and they were tagged for repeated observations during the cropping period. The height of 3 tagged plants in each plot was measured from the ground level to the tip of plant canopy at 30, 60, 90 DAS and at harvest, and then the mean plant height was worked out (Plate 3.1).

3.9.2 Number of tillers m^{-2}

The number of tillers of 3 tagged plants in each plot was recorded at 30, 60, 90 DAS and at harvest, and converted into number of tillers m^{-2} area.

3.9.3 Leaf area index (LAI)

10 leaves, randomly chosen from 5 plant samples, were cut into a rectangular bit of 10 cm length. The width of each leaf was measured and the area was calculated. Green leaf laminae of each five hills were dried and weighed individually. The area-weight relationship between the crop's total green foliage and its chopped leaves was then used to calculate the total leaf area. The leaf area index (LAI) was computed using the following formula because it seemed to represent the area of the land surface (Watson, 1958).

$$LAI = \frac{\text{Leaf area per pant } (cm^2)}{\text{Land covered by individual plant } (cm^2)}$$

3.9.4 Dry matter accumulation

The dry weights of the various plant parts were noted during the observation period and summed up to produce the amount of dry matter (g) in a 1 m^2 area (Plate 3.1).

3.9.5 Crop growth rate (CGR)

Crop growth rate (CGR) was calculated using the following formula:

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} g\ m^{-2}\ day^{-1}$$

where, W_1 and W_2 were the dry weights of aerial plant parts per unit land area at times t_1 and t_2, respectively.

3.10 Methods of recording yield components and determining yield

3.10.1 Panicle length

From each plot, length of 5 randomly chosen panicles was measured, and the mean was calculated.

3.10.2 Number of fingers panicle^{-1}

The number of fingers of 3 tagged plants was counted separately at the harvesting stage in each plot and the average was worked out to determine the number of fingers panicle^{-1}.

3.10.3 Number of seeds panicle^{-1}

The number of seeds from 5 panicles of 3 tagged plants was counted separately in each plot at the harvesting stage and then the average number of seeds panicle^{-1} was worked out.

3.10.4 Test weight

After threshing, 1000 well-filled seeds from each plot were counted, and the weight (g) was recorded using an Accoset precision balance (India).

3.10.5 Grain yield

After threshing, winnowing was done to remove dry plant parts, dirt and other crop or weed seeds, etc. from the grains collected from each plot. Then, it was sun-dried to get moisture content of 8–9%. The grain yield plot^{-1} was weighed and transformed to kg ha^{-1}.

3.10.6 Straw yield

The stalk of finger millet plants excluding panicles were kept under sun at threshing floor for proper drying and then the weight was noted to determine the straw yield in terms in kg ha^{-1}.

3.10.7 Harvest index (HI)

Harvest index was calculated by the following formula:

$$HI = \frac{\text{Economic (grain) yield (kg ha}^{-1}\text{)}}{\text{Biological (grain + straw) yield (kg ha}^{-1}\text{)}}$$

3.11 Methods of Economic analysis

The cost of cultivation ha^{-1} was determined by adding the cost of seed, land preparation, manuring, weeding, harvesting, threshing, and other costs. The gross return was computed using the local market pricing for finger millet grain and straw. Then, considering the gross return and cultivation expenses as well, the net return and benefit-cost ratio were calculated. The local market and the Instructional Farm at B.C.K.V., Jaguli, Nadia, West Bengal, confirmed the experiment's wage rate, input costs, and produce value.

3.12 Methods of statistical analysis

All the data collected in the experiment were subjected to statistical analysis in online OPSTAT software using analysis of variance (ANOVA) method suitable for split-split-plot design (Gomez and Gomez, 1984). Fisher's F test for suitable degrees of freedom was used to evaluate the significance of various sources of variation. To test "F" statistics and calculate the critical difference (C.D.) at the 5% level of significance, the Fisher and Yates table was consulted.

Chapter 4

Results and Discussion

4. RESULTS AND DISCUSSION

4.1 Phenology and growth environment

4.1.1 Phenological development and duration

Finger millet had 3 major growth stages: vegetative, reproductive and ripening (Plate 4.1). In the experiment, a total of 4 phenophases of finger millet crop were studied *i.e.* sowing to 4th leaf stage (S – 4LS), 4th leaf stage to 1st flowering (4LS – 1st F), 1st flowering to 50% flowering (1st F – 50% F) and 50% flowering to maturity (50% F – M).

4.1.1.1 Effect of sowing date

Delay in sowing of finger millet from 20 July (D_1) to 11 August shortened the duration of the crop by 6.33 days (Table 4.1). Finger millet sown on 20 July (D_1) and 11 August (D_2) required 115.22 and 108.89 days to complete life cycle, respectively. The crop sown on 20 July (D_1) took more time to complete all four phenophases, while delayed sowing on 11 August shortened the length of all the phenophases of finger millet, studied in this experiment.

Sarala *et al.* (2022) reported the similar trend of successive decrease in duration of finger millet for delay sowing from 15 October to 15 December at Tirupati, India.

4.1.1.2 Effect of variety

Mean cultivar days from sowing to 4th leaf stage, 1st flowering, 50% flowering and maturity of finger millet were 16.00, 63.72, 73.39 and 112.05 days respectively (Table 4.1) Both the varieties took more or less similar days to complete all the four phenophases in the study (Table 4.1).

4.1.1.3 Effect of nutrient management

There was no significant difference in length of phenophages as well as in duration of finger millet due to variation in nutrient management practices adopted in the experiment (Table 4.1).

Table 4.1
Effect of sowing date, variety and nutrient management on phenological development of finger millet during *kharif* season

Treatment	Phenophase (days)				Life-cycle
	S – 4LS	4LS – 1st F	1st F – 50% F	50% F – M	S – M
Date of sowing					
D_1	17.4	48.6	9.7	39.4	115.2
D_2	14.6	46.8	9.6	37.9	108.9
SEm (±)	0.24	0.28	0.24	0.171	0.54
CD at 5%	1.45	1.72	NS	1.042	3.31
Variety					
V_1	16.1	47.8	9.7	38.7	112.2
V_2	15.9	47.61	9.7	38.7	111.9
SEm (±)	0.10	0.25	0.35	0.09	0.43
CD at 5%	NS	NS	NS	NS	NS
Nutrient management					
N_1	16.0	47.8	9.8	38.8	112.3
N_2	16.0	47.8	9.5	38.5	111.8
N_3	16.0	47.7	9.8	38.8	112.2
SEm (±)	0.32	0.30	0.25	0.32	0.67
CD at 5%	NS	NS	NS	NS	NS
Interaction effect					
$D_1V_1N_1$	17.67	48.67	10.00	39.0	115.3
$D_1V_1N_2$	17.33	48.67	10.00	39.0	115.0
$D_1V_1N_3$	17.67	48.67	9.67	40.0	116.0
$D_1V_2N_1$	17.00	48.33	10.00	40.7	116.0
$D_1V_2N_2$	17.67	48.67	9.00	39.0	114.3
$D_1V_2N_3$	17.33	48.67	9.67	39.0	114.7
$D_2V_1N_1$	14.67	47.00	9.33	38.0	109.0
$D_2V_1N_2$	14.33	46.67	9.33	38.0	108.3
$D_2V_1N_3$	14.67	47.33	9.67	38.0	109.7
$D_2V_2N_1$	14.67	47.00	9.67	37.3	108.7
$D_2V_2N_2$	14.67	47.00	9.67	38.0	109.3
$D_2V_2N_3$	14.33	46.00	10.00	38.0	108.3

	D×V	V×N	D×V	V×N	D×V	V×N	D×V	V×N	D×V	V×N
SEm (±)	0.15	0.50	0.35	0.41	0.49	0.35	0.12	0.45	0.61	0.95
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	D×N	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**
SEm (±)	0.45	0.64	0.41	0.58	0.35	0.49	0.45	0.64	0.95	1.34
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

S – 4LS = Sowing to 4th leaf stage; 4LS – 1st F = 4th leaf stage to first flowering; 1st F – 50% F = first flowering to 50% flowering; 50% F – M = 50% flowering to maturity; S – M = Sowing to maturity

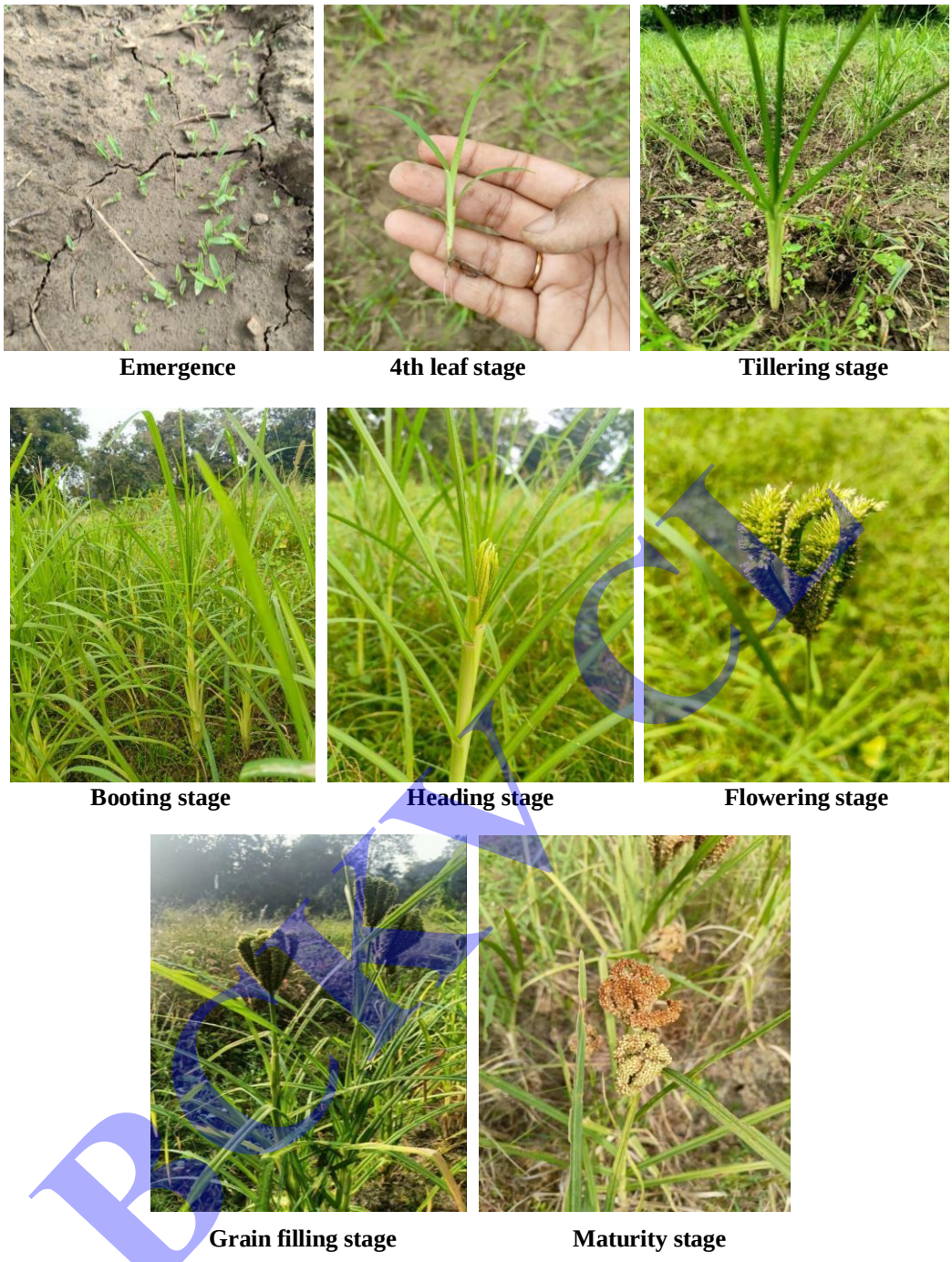


Plate 4.1: Different phenological stages of finger millet during *kharif* season

4.1.1.4 Interaction effect between sowing date, variety and nutrient management

The interaction between sowing date, variety and nutrient management did not show any significant influence on attainment of phenophases and life cycle of finger millet in the investigation (Table 4.1).

4.1.2 Growing degree days (GDD)

4.1.2.1 Effect of sowing date

Summed GDD for entire life cycle of finger millet was gradually decreased with delay in sowing from 20 July (2113.8°C) to 11 August (1896.8°C) (Table 4.2). It may be due to reduction in number of days for delayed sowings of finger millet during *kharif* season.

Same trend was reported by Revathi and Rekha (2017), Where 2nd fort night of July sown finger millet accumulated the highest GDD of (2073.33°C) for its life cycle; but the accumulation of GDD was decreased to 1980.33°C for sowing on 1st fort night of August at Bapatla, India.

Like the decreasing trend in duration of phenophases due to delay in sowing of finger millet, the GDD recorded in phenophases were also gradually reduce with delay in sowing from 20 July (D_1) to 11 August (D_2) in the study (Table 4.2). 11 August sown finger millet (D_2) required less day (14.6 *vs.* 17.4, 46.8 *vs.* 48.6, 9.6 *vs.* 9.7 and 37.9 *vs.* 39.4 days) during the phenophases of sowing to 4th leaf stage (S – 4LS), 4th leaf stage to 1st flowering (4LS – 1st F), 1st flowering to 50% flowering (1st F – 50% F) and 50% flowering to maturity (50% F – M) compared to 20 July sowing (D_1) at Jaguli, Nadia, West Bengal.

4.1.2.2 Effect of variety

Varieties had no significant influence on accumulation of GDD at all the four phenophases and life cycle, in the investigation (Table 4.2). Mean cultivar GDD from sowing to 4th leaf stage, 4th leaf stage to 1st flowering, 1st flowering to 50% flowering, 50% flowering to maturity and sowing to maturity of finger millet were 309.4, 919.7, 175.6, 600.6 and 2005.3°C, respectively.

Table 4.2
Effect of sowing date, variety and nutrient management on growing degree days of finger millet during *kharif* season

Treatment	Growing degree days (°C)				Life-cycle
	S – 4LS	4LS – 1st F	1st F – 50% F	50% F – M	S – M
Date of sowing					
D_1	338.9	941.4	179.7	653.8	2113.8
D_2	279.8	898.1	171.5	547.4	1896.8
SEm (±)	5.47	5.62	1.99	2.60	5.51
CD at 5%	33.27	34.18	NS	15.80	33.52
Variety					
V_1	311.4	921.7	174.5	600.2	2007.8
V_2	307.3	917.8	176.8	600.9	2002.8
SEm (±)	3.13	4.95	5.06	2.29	5.66
CD at 5%	NS	NS	NS	NS	NS
Nutrient management					
N_1	308.9	920.4	179.0	603.4	2011.7
N_2	308.8	920.3	171.8	594.7	1995.6
N_3	310.4	918.6	176.0	603.7	2008.7
SEm (±)	5.56	6.02	4.78	5.29	9.14
CD at 5%	NS	NS	NS	NS	NS
Interaction effect					
$D_1V_1N_1$	345.17	942.68	183.85	647.70	2119.40
$D_1V_1N_2$	339.00	941.90	184.93	649.10	2114.93
$D_1V_1N_3$	345.00	942.28	178.55	663.40	2129.23
$D_1V_2N_1$	326.23	936.68	185.25	674.60	2122.77
$D_1V_2N_2$	339.00	942.62	166.88	637.63	2086.13
$D_1V_2N_3$	339.17	942.07	178.73	650.43	2110.40
$D_2V_1N_1$	282.80	899.73	165.02	550.75	1898.30
$D_2V_1N_2$	275.35	895.08	166.08	542.37	1878.88
$D_2V_1N_3$	281.27	908.58	168.28	548.10	1906.23
$D_2V_2N_1$	281.27	902.45	181.82	540.63	1906.17
$D_2V_2N_2$	282.02	901.38	169.27	549.63	1902.30
$D_2V_2N_3$	276.13	881.32	178.78	552.67	1888.90

	D×V	V×N	D×V	V×N	D×V	V×N	D×V	V×N	D×V	V×N
SEm (±)	4.43	7.86	7.01	8.51	7.15	6.75	3.40	7.48	7.99	12.92
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	D×N	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**
SEm (±)	11.12	0.64	8.51	12.01	6.75	9.55	7.48	10.58	12.92	18.27
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

S – 4LS = Sowing to 4th leaf stage; 4LS – 1st F = 4th leaf stage to first flowering; 1st F – 50% F = first flowering to 50% flowering; 50% F – M = 50% flowering to maturity; S – M = Sowing to maturity

4.1.2.3 Effect of nutrient management

Like variety, nutrient management also had no significant influence on accumulation of GDD at different phenophases of finger millet during *kharif* season of 2023 (Table 4.2).

4.1.2.4 Interaction effect between sowing date, variety and nutrient management

Interaction effect between sowing date, variety and nutrient management on accumulated GDD at various phenophases of finger millet was found non-significant in the experiment (Table 4.2).

4.1.3 Heliothermal units (HTU)

4.1.3.1 Effect of sowing date

There was a variation in accumulated heliothermal units at different phenophases as well as life cycle of finger millet crop during *kharif* season in 2023 due to the variation in mean daily temperature and bright sunshine hour among two sowing dates studied in the experiment (Table 4.3). Early sowing (20 July) of finger millet recorded the highest summed total HTU (10358.9^{o}C hour) for entire life cycle, which was gradually decreased due to delay in sowing on 11 August (9905.2^{o}C hour) in the investigation.

4.1.3.2 Effect of variety

Like GDD, Varieties had no significant influence on accumulation of HTU at all the four phenophases and life cycle, in the investigation (Table 4.3). Mean cultivar HTU from sowing to 4th leaf stage, 4th leaf stage to 1st flowering, 1st flowering to 50% flowering, 50% flowering to maturity and sowing to maturity of finger millet were 1421.3, 3683.6, 956.8, 4070.3 and 10132.0^{o}C, respectively.

4.1.3.3 Effect of nutrient management

The influence of nutrient management on accumulated HTU at different phenophases of finger millet was not found significant during the year of investigation (Table 4.3).

Table 4.3
Effect of sowing date, variety and nutrient management on heliothermal unit development of finger millet during *kharif* season

Treatment	Heliothermal unit (°C hour)				Life-cycle
	S – 4LS	4LS – 1st F	1st F – 50% F	50% F-M	S – M
Date of sowing					
D_1	1769.2	3552.5	566.8	4470.4	10358.9
D_2	1073.3	3814.7	1346.9	3670.3	9905.2
SEm (±)	11.86	40.66	28.75	17.71	37.00
CD at 5%	72.17	247.44	174.95	107.77	225.14
Variety					
V_1	1425.6	3696.1	930.4	4095.8	10147.8
V_2	1416.9	3671.2	983.3	4044.9	10116.3
SEm (±)	6.13	46.70	41.18	29.94	37.26
CD at 5%	NS	NS	NS	NS	NS
Nutrient management					
N_1	1417.4	3710.7	958.0	4095.0	10181.0
N_2	1430.4	3671.3	930.7	4028.7	10061.1
N_3	1415.9	3668.9	981.9	4087.3	10154.0
SEm (±)	14.02	72.88	37.89	49.17	65.52
CD at 5%	NS	NS	NS	NS	NS
Interaction effect					
D_1V_1 N_1	1777.9	3594.9	525.1	4502.5	10400.4
D_1V_1 N_2	1777.9	3515.7	604.3	4463.6	10361.5
D_1V_1 N_3	1777.9	3543.8	576.2	4581.2	10479.0
D_1V_2 N_1	1725.9	3548.8	574.6	4552.0	10401.4
D_1V_2 N_2	1777.9	3570.0	542.4	4296.0	10186.2
D_1V_2 N_3	1777.9	3542.0	578.0	4426.9	10324.8
D_2V_1 N_1	1112.0	3818.9	1269.1	3712.5	9912.4
D_2V_1 N_2	1054.0	3770.4	1294.2	3661.4	9780.0
D_2V_1 N_3	1054.0	3932.8	1313.2	3653.5	9953.4
D_2V_2 N_1	1054.0	3880.0	1463.2	3613.0	10010.1
D_2V_2 N_2	1112.0	3829.1	1281.8	3693.9	9916.8
D_2V_2 N_3	1054.0	3656.9	1459.9	3687.8	9858.6
	D×V **V×N**	**D×V** **V×N**	**D×V** **V×N**	**D×V** **V×N**	**D×V** **V×N**
SEm (±)	8.67 19.82	66.05 103.06	58.23 53.58	42.34 69.53	52.70 92.66
CD at 5%	NS NS	NS NS	NS NS	NS NS	NS NS
	D×N **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**
SEm (±)	19.82 28.03	103.06 145.76	53.58 75.77	69.53 98.33	92.66 131.04
CD at 5%	NS NS	NS NS	NS NS	NS NS	NS NS

NS = Not significant

S – 4LS = Sowing to 4th leaf stage; 4LS – 1st F = 4th leaf stage to first flowering; 1st F – 50% F = first flowering to 50% flowering; 50% F – M = 50% flowering to maturity; S – M = Sowing to maturity

4.1.3.4 Interaction effect between sowing date, variety and nutrient management

Sowing date × variety × nutrient management interaction effect on HTU was found non-significant at all four phonological stages of finger millet during *kharif* season (Table 4.3).

4.1.4 Photothermal units (PTU)

4.1.4.1 Effect of sowing date

Temperature generally governed the onset of different phenophases in finger millet crop, but day length had also influence on photothermal requirements of the crop. Significant effect of sowing date on photothermal units of finger millet was noticed for all the four phenophases as well as entire life cycle in the study (Table 4.4) and summed PTU for entire life cycle followed the same trend of as of summed GDD and Summed HTU for entire life cycle (Table 4.2 and Table 4.3).

4.1.4.2 Effect of variety

Like GDD and HTU, variety had no significant effect on photothermal units at all four phenophases as well as total life-cycle of finger millet in the study (Table 4.4). Mean cultivar PTU, from sowing to 4th leaf stage, 4th leaf stage to 1st flowering, 1st flowering to 50% flowering, 50% flowering to maturity and sowing to maturity of finger millet were 3916.7, 11198.9, 2064.7, 6856.7 and 24038.0^{o}C hour, respectively.

4.1.4.3 Effect of nutrient management

No significant effect due to nutrient management was noted on photothermal units at all phenophases of finger millet during *kharif* season in New Alluvial Zone of West Bengal (Table 4.4).

4.1.4.4 Interaction effect between sowing date, variety and nutrient management

The non-significant interaction effects on summed PTU at different phenophases were noted during the year of study (Table 4.4).

Table 4.4
Effect of sowing date, variety and nutrient management on photothermal unit of finger millet during *kharif* season

Treatment	Photothermal unit (°C hour)				Life-cycle
	S – 4LS	4LS – 1st F	1st F – 50% F	50% F-M	S – M
Date of sowing					
D_1	4338.9	11584.1	2134.8	7539.0	25596.7
D_2	3494.6	10815.6	1994.7	6174.4	22479.3
SEm (±)	69.38	67.18	23.23	32.80	60.08
CD at 5%	422.16	408.78	NS	199.61	365.59
Variety					
V_1	3943.0	11222.4	2051.0	6850.6	24066.9
V_2	3890.4	11177.4	2078.4	6862.8	24009.1
SEm (±)	39.73	57.64	59.35	26.34	65.32
CD at 5%	NS	NS	NS	NS	NS
Nutrient management					
N_1	3909.78	11207.2	2104.5	6888.0	24109.5
N_2	3910.34	11206.0	2019.6	6791.1	23927.1
N_3	3929.99	11186.3	2070.1	6891.0	24077.4
SEm (±)	69.896	68.40	55.98	61.38	101.91
CD at 5%	NS	NS	NS	NS	NS
Interaction effect					
D_1V_1 N_1	4418.0	11596.8	2183.1	7464.9	25662.8
D_1V_1 N_2	4340.1	11591.9	2196.7	7484.0	25612.7
D_1V_1 N_3	4416.1	11592.2	2120.5	7644.2	25772.9
D_1V_2 N_1	4176.8	11533.9	2202.4	7776.3	25689.4
D_1V_2 N_2	4340.1	11596.0	1982.5	7362.0	25280.6
D_1V_2 N_3	4342.0	11593.9	2123.6	7502.4	25561.8
D_2V_1 N_1	3531.6	10832.4	1918.6	6212.2	22494.7
D_2V_1 N_2	3439.4	10783.5	1932.2	6121.0	22276.0
D_2V_1 N_3	3512.7	10937.4	1955.1	6177.1	22582.2
D_2V_2 N_1	3512.7	10865.8	2114.0	6098.7	22591.2
D_2V_2 N_2	3521.8	10852.6	1967.0	6197.5	22538.9
D_2V_2 N_3	3449.2	10621.9	2081.1	6240.3	22392.5
	D×V **V×N**	**D×V** **V×N**	**D×V** **V×N**	**D×V** **V×N**	**D×V** **V×N**
SEm (±)	56.19 98.85	81.51 96.73	83.93 79.70	37.24 86.80	92.38 144.13
CD at 5%	NS NS	NS NS	NS NS	NS NS	NS NS
	D×N **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**
SEm (±)	98.88 139.79	96.73 136.80	79.70 111.96	86.80 122.75	144.13 203.83
CD at 5%	NS NS	NS NS	NS NS	NS NS	NS NS

NS = Not significant

S– 4LS = Sowing to 4th leaf stage; 4LS – 1st F = 4th leaf stage to first flowering; 1st F – 50% F = first flowering to 50% flowering; 50% F – M = 50% flowering to maturity; S – M = Sowing to maturity

4.2 Growth attributes

4.2.1 Plant height

Mean plant height of finger millet, averaged over either of two sowing times, two varieties or three nutrient management practices, was 38.3, 68.8, 87.1 and 98.9 cm at 30, 60 and 90 DAS and at harvest, respectively (Table 4.5), which indicated that height of finger millet was increased rapidly during the period from 30 to 60 DAS and thereafter slowly due to exertion of panicles in the investigation.

4.2.1.1 Effect of sowing date

Sowing date had significant influence on plant height of finger millet at 30, 60 and 90 DAS and at harvest (Table 4.5) (Fig. 4.1). Early sowings on 20 July (D_1) resulted in greater plant height in all the growth stages of finger millet compared to delay sowings in 11 August (D_2) in the study. This might be due to the fact that slightly rising temperature (avg. temperature 30.18°C) and more than 6 hours bright sunshine hour during July had favourable influence on vegetative growth of finger millet plants sown on July (D_1) compared to sowing on August (avg. temperature 29.16°C and bright sunshine hour 3.28).

4.2.1.2 Effect of variety

Significant variation was noted among the two varieties tested in the experiment with regard to plant height at all growth stages of the finger millet during *kharif* season. On the basis of the final plant height at maturity, two varieties of finger millet could be arranged as: Indravathi (101.37 cm) > GPU 67 (96.43cm) (Table 4.5) (Fig. 4.2).

4.2.1.3 Effect of nutrient management

Plant height of finger millet was significantly influenced by three treatments at all stages of observation. Perusal of data revealed that the plants nourished with 20 kg RDN through urea as basal + 20 kg RDN through urea as top dressing at 35 DAS (N_1) produced taller plants than other treatments at 30, 60 and 90 DAS and at harvest (Table 4.5) (Fig. 4.3). Based on final plant height at maturity three nutritional treatments could be arranged in the following order: N_1 (99.74 cm) > N_2 (99.67 cm) > N_3 (97.29 cm).

Table 4.5
Effect of sowing date, variety and nutrient management on plant height at different stages of finger millet during *kharif* season

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
Date of sowing				
D_1	40.0	71.1	89.1	101.4
D_2	36.6	66.5	85.1	96.4
SEm (±)	0.50	0.75	0.52	0.30
CD at 5%	3.05	4.56	3.13	1.83
Variety				
V_1	40.4	72.5	93.3	105.8
V_2	36.3	65.0	80.9	92.0
SEm (±)	0.76	0.60	0.44	0.68
CD at 5%	2.98	2.34	1.73	2.68
Nutrient management				
N_1	40.2	70.4	88.0	99.7
N_2	38.5	69.4	87.8	99.7
N_3	36.3	66.5	85.5	97.3
SEm (±)	0.75	0.83	0.57	0.70
CD at 5%	2.24	2.48	1.71	2.11
Interaction effect				
D_1V_1 N_1	50.0	79.5	104.5	119.0
D_1V_1 N_2	41.4	73.7	97.9	111.3
D_1V_1 N_3	37.0	77.3	99.4	110.3
D_1V_2 N_1	36.5	67.5	76.8	89.5
D_1V_2 N_2	38.4	67.7	77.2	88.2
D_1V_2 N_3	36.8	60.8	78.9	89.8
D_2V_1 N_1	37.5	68.7	85.2	93.7
D_2V_1 N_2	38.8	68.7	87.4	101.2
D_2V_1 N_3	37.4	67.3	85.2	99.0
D_2V_2 N_1	36.9	65.8	85.6	96.7
D_2V_2 N_2	35.3	67.7	88.5	98.0
D_2V_2 N_3	33.9	60.7	78.5	90.0
	D×V **V×N**	**D×V** **V×N**	**D×V** **V×N**	**D×V** **V×N**
SEm (±)	1.07 1.06	0.84 1.17	0.62 0.81	0.97 0.99
CD at 5%	NS NS	3.76 3.38	2.66 2.38	2.93 NS
	D×N **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**
SEm (±)	1.06 1.49	1.17 1.66	0.81 1.14	0.99 1.41
CD at 5%	NS 4.48	NS NS	2.51 3.43	2.60 4.22

DAS = Days after sowing, NS = Not significant

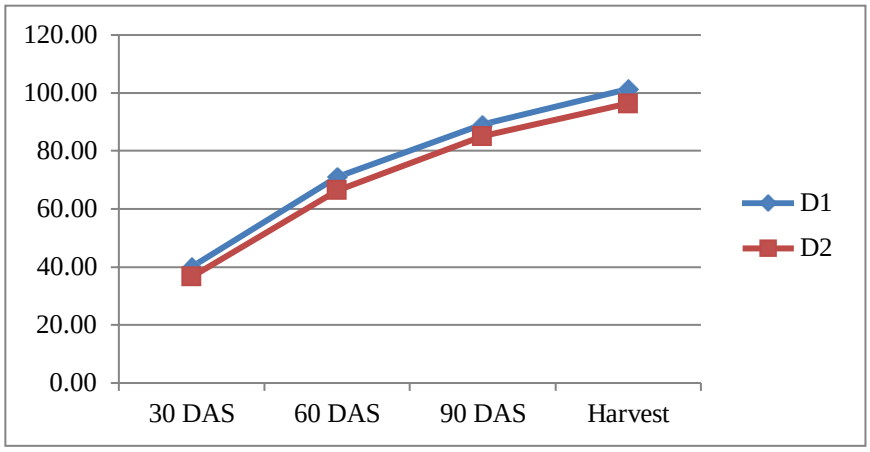


Fig 4.1: Effect of date of sowing on plant height (cm) of finger millet

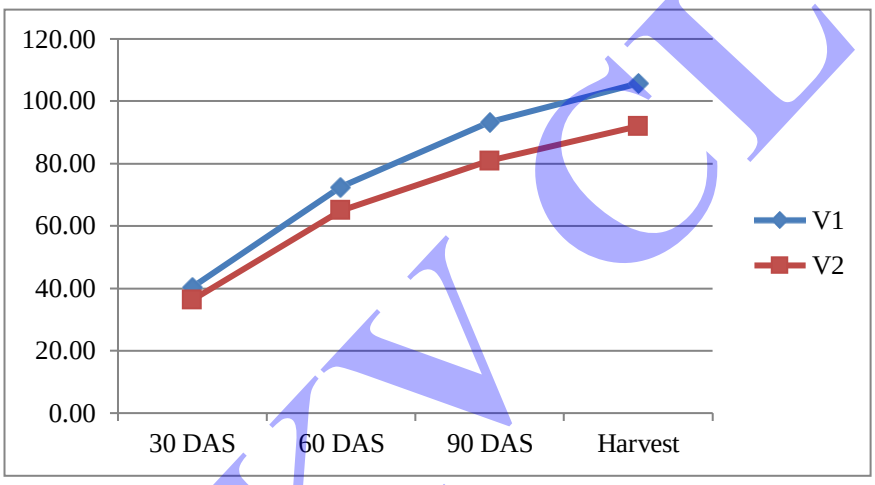


Fig 4.2: Effect of Variety on plant height (cm) of finger millet

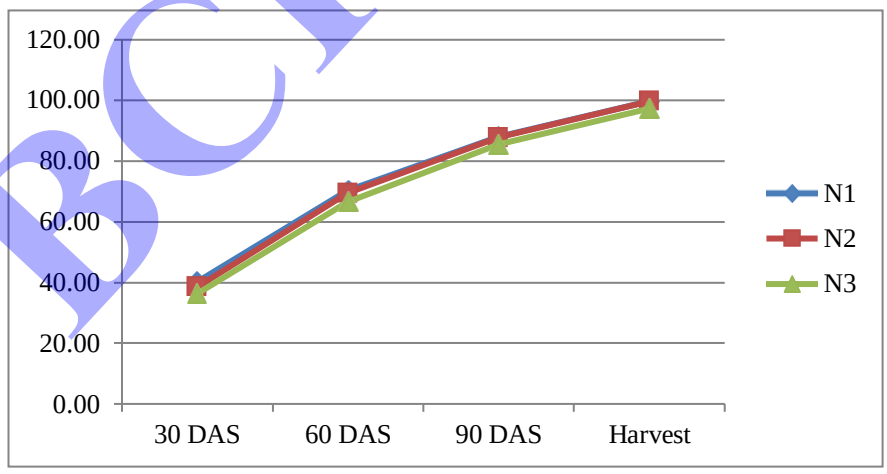


Fig 4.3: Effect of Nutrient management on height (cm) of finger millet

Debbarma *et al*. (2024) reported similar range of variation in plant height of finger millet due to sole application of FYM, vermicompost and poultry manure during *Kharif* season of 2016 and 2017 in Uttar Pradesh.

4.2.1.4 Interaction effect between sowing date, variety and nutrient management

Interaction effect of plant height between main plots, sub plots and sub-sub plots was found significant at 90 DAS and at harvest except interaction between variety and nutrient management at harvest (Table 4.1). However, no clear pattern of interaction between various treatment combinations was noted during early growth stages (30 and 60 DAS) of the crop.

4.2.2 Number of tiller m^{-2}

The number of tillers m^{-2} of finger millet increased rapidly from 30 to 60 DAS due to rapid vegetative growth and thereafter slowly increased upto 90 DAS due to intermingle of vegetative and reproductive stage resulting slow vegetative growth and declined toward at maturity mainly due to death or withering of some late or unproductive tillers (Table 4.6).

4.2.2.1 Effect of sowing date

There was significant variation among two sowing date for number of tillers m^{-2} of finger millet in the experiment (Table 4.6) (Fig. 4.4). Finger millet sown on 20 July (D_1) usually produced the highest number of tillers in 1 m^2 area compared to delay sowing (11 August) at all the stages of observation.

4.2.2.2 Effect of variety

Both Indravathi (V_1) and GPU 67 produced nearly similar number of tiller m^{-2} throughout the experiment and therefore, the number of tillers m^{-2} was non-significantly influenced by varieties tested in the experiment except at 90 DAS (Table 4.6) (Fig. 4.5).

4.2.2.3 Effect of nutrient management

The effect of nutrient management on production of tiller m^{-2} was found significant at all the observation periods in the investigation (Table 4.6) (Fig. 4.6). Combined application of FYM @ 20 kg RDN as basal with top dressing of urea @ 20

Table 4.6
Effect of sowing date, variety and nutrient management on number of tillers at different stages of finger millet during *kharif* season

Treatment	Number of tillers m^{-2}			
	30 DAS	60 DAS	90 DAS	At harvest
Date of sowing				
D_1	48.7	108.5	121.3	100.8
D_2	40.1	87.0	109.5	91.9
SEm (±)	0.38	1.40	1.26	1.12
CD at 5%	2.32	8.50	7.67	6.79
Variety				
V_1	44.6	99.3	118.0	98.0
V_2	44.2	96.2	112.8	94.8
SEm (±)	1.02	1.98	1.24	1.19
CD at 5%	NS	NS	4.86	NS
Nutrient management				
N_1	44.5	95.4	114.6	96.0
N_2	46.0	103.2	120.0	100.0
N_3	42.7	94.6	111.6	93.1
SEm (±)	0.86	1.98	1.80	1.07
CD at 5%	2.58	5.93	5.40	3.20
Interaction effect				
$D_1V_1N_1$	47.7	102.1	124.3	103.0
$D_1V_1N_2$	43.7	102.7	113.4	94.8
$D_1V_1N_3$	49.6	123.6	137.3	111.4
$D_1V_2N_1$	45.8	107.3	111.2	93.5
$D_1V_2N_2$	56.3	121.8	134.0	110.9
$D_1V_2N_3$	48.8	93.7	107.4	91.3
$D_2V_1N_1$	46.1	92.5	118.0	99.0
$D_2V_1N_2$	44.2	101.8	122.6	102.2
$D_2V_1N_3$	36.5	73.2	92.3	77.5
$D_2V_2N_1$	38.3	79.7	105.0	88.6
$D_2V_2N_2$	39.8	86.8	110.1	92.3
$D_2V_2N_3$	35.8	87.9	109.2	92.2
	D×V V×N	D×V V×N	D×V V×N	D×V V×N
SEm (±)	1.44 1.21	2.80 2.80	1.75 2.55	1.68 1.51
CD at 5%	NS 4.26	NS NS	NS 7.25	NS 5.13
	D×N D×V×N	D×N D×V×N	D×N D×V×N	D×N D×V×N
SEm (±)	1.21 1.72	2.80 3.95	2.55 3.60	1.51 2.13
CD at 5%	3.19 5.16	NS 11.86	7.29 10.80	4.98 6.39

DAS = Days after sowing, NS = Not significant

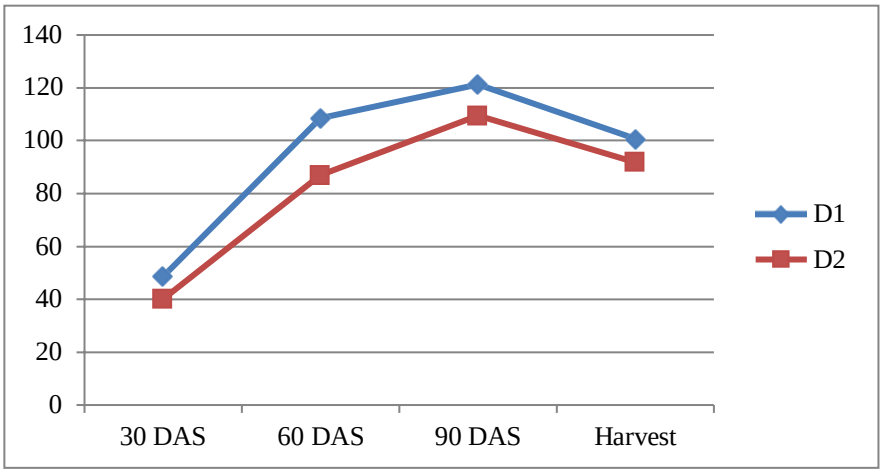


Fig. 4.4: Effect of date of sowing on no. of tillers m^{-2} of finger millet

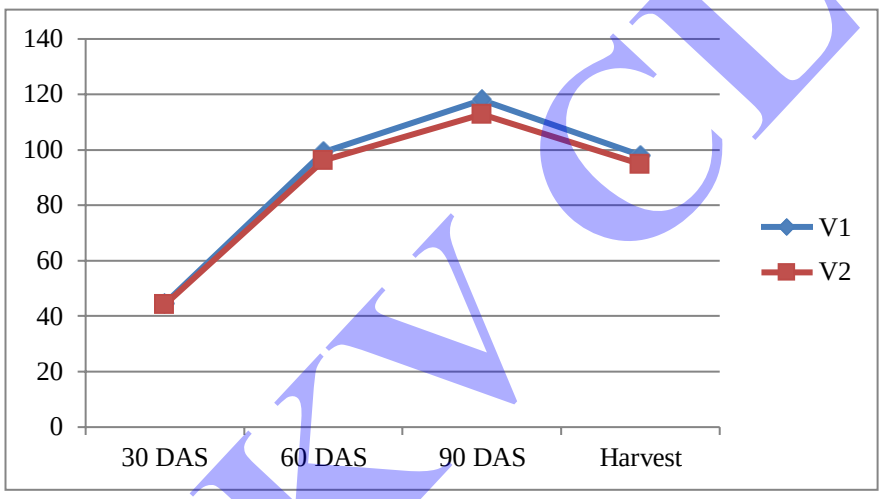


Fig. 4.5: Effect of variety on no. of tillers m^{-2} of finger millet

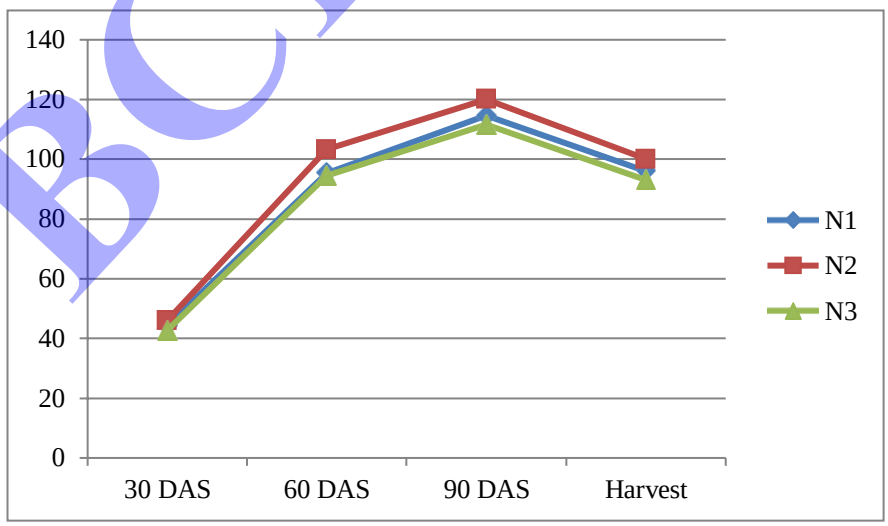


Fig. 4.6: Effect of nutrient management on no. of tillers m^{-2} of finger millet

kg RDN at 35 DAS recorded greater number of tillers m^{-2} at 30 (46.0 m^{-2}), 60 (103.2 m^{-2}) and 90 (120.0 m^{-2}) DAS and at harvest (100.0 m^{-2}) over sole application of inorganic fertilizers (N_1) and integrated nutrient management with biofertilizer (N_3) in the study.

4.2.2.4 Interaction effect between sowing date, variety and nutrient management

The interaction effect between sowing date × variety and sowing date × variety × nutrient management on tiller number of finger millet was found non-significant and significant, respectively at all dates of observation (Table 4.2). While, sowing date × nutrient management and variety × nutrient management had significant interaction at all the crop growth stages except at 60 DAS.

4.2.3 Leaf area index

The foliage growth of finger millet in terms of LAI was increased consistently upto 60 DAS and declined thereafter due to drying and withering of lower leaves during the ripening phase (Table 4.7) (Fig. 4.7). Mean value of pooled LAI, averaged over sowing time, variety and nutrient management, was 0.86, 4.10 and 2.50 at 30, 60 and 90 DAS, respectively.

4.2.3.1 Effect of sowing date

Finger millet sown on 20 July (D_1) significantly recorded the highest LAI values throughout the cropping period compared to late plantings (11 August) during *kharif* season at B.C.K.V. (Table 4.7) (Fig. 4.8).

4.2.3.2 Effect of variety

The variations in LAI values among two cultivars were significant at 30 and 90 DAS but, it was non-significant at 60 DAS when both the varieties recorded maximum LAI (Table 4.7) (Fig. 4.9). In between two varieties, Indravathi (V_1) always produced slightly higher LAI over GPU 67 (V_2) during entire experimentation period.

4.2.3.3 Effect of nutrient management

The significant variation in LAI values due to nutrient management practices was observed throughout the cropping period (Table 4.7). Sole applications of urea fertilizers as basal and top dressing @ 20 kg RDN ha^{-1} each (N_1) resulted in highest

Table 4.7
Effect of sowing date, variety and nutrient management on leaf area index at different stages of finger millet during *kharif* season

Treatment	Leaf area index		
	30 DAS	60 DAS	90 DAS
Date of sowing			
D_1	1.01	4.64	2.97
D_2	0.72	3.56	2.04
SEm (±)	0.02	0.11	0.05
CD at 5%	0.14	0.64	0.30
Variety			
V_1	0.98	4.16	2.64
V_2	0.75	4.03	2.37
SEm (±)	0.03	0.06	0.05
CD at 5%	0.14	NS	0.20
Nutrient management			
N_1	0.91	4.48	2.74
N_2	0.91	4.17	2.82
N_3	0.78	3.64	1.95
SEm (±)	0.03	0.10	0.17
CD at 5%	0.08	0.31	0.50
Interaction effect			
D_1V_1 N_1	1.22	5.32	3.21
D_1V_1 N_2	1.07	4.10	3.63
D_1V_1 N_3	0.99	4.51	2.56
D_1V_2 N_1	0.96	5.19	3.27
D_1V_2 N_2	0.92	4.51	3.00
D_1V_2 N_3	0.88	4.19	2.13
D_2V_1 N_1	0.71	3.67	2.21
D_2V_1 N_2	0.95	3.92	2.63
D_2V_1 N_3	0.92	3.46	1.56
D_2V_2 N_1	0.73	3.76	2.27
D_2V_2 N_2	0.68	4.16	2.00
D_2V_2 N_3	0.31	2.41	1.54
	D×V	**V×N**	**D×V**	**V×N**	**D×V**	**V×N**
SEm (±)	0.05	0.04	0.09	0.05	0.04	0.09
CD at 5%	NS	0.14	NS	NS	0.14	NS
	D×N	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V ×N**
SEm (±)	0.04	0.05	0.14	0.04	0.05	0.14
CD at 5%	0.11	0.16	0.47	0.11	0.16	0.47

DAS = Days after sowing, NS = Not significant

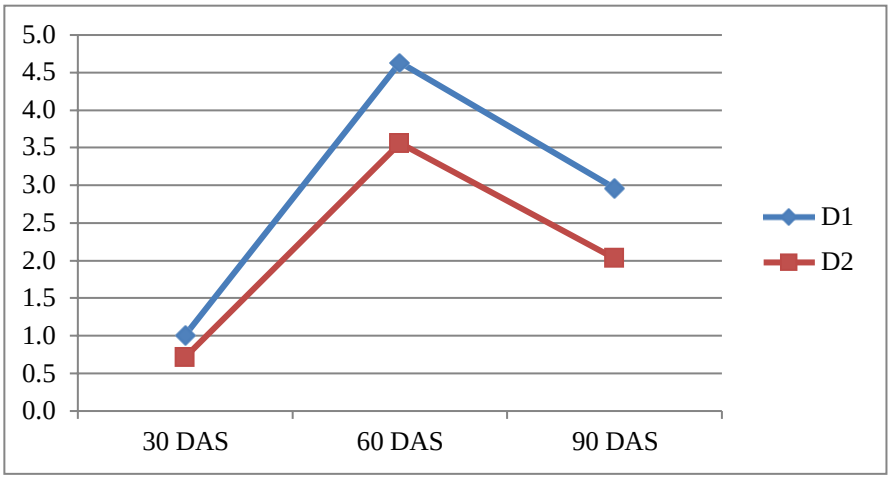


Fig. 4.7: Effect of date of sowing on LAI of finger millet

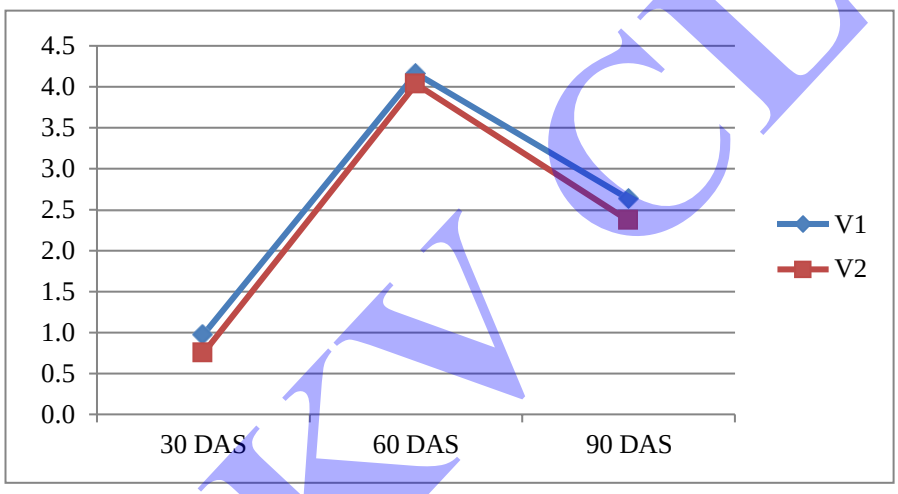


Fig. 4.8: Effect of variety on LAI of finger millet

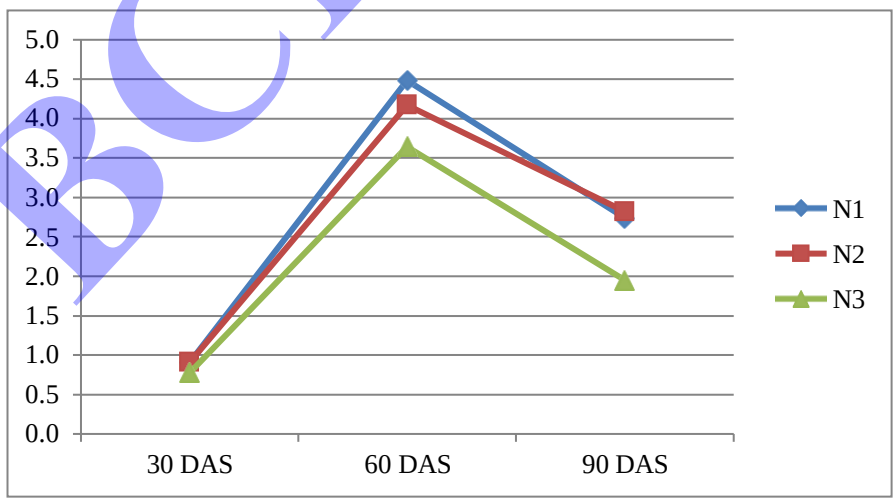


Fig. 4.9: Effect of nutrient management on LAI of finger millet

maximum LAI values (4.48) at 60 DAS, which was statistically at par with combined application of FYM and urea fertilizer (4.17) in the experiment.

Contrary to this, Gafoor *et al.* (2021) reported that LAI of finger millet was 4.09 at harvest in fully inorganic treated plots which was significantly higher than fully organic treated plots (3.00) during summer season at Kerala, India.

4.2.3.4 Interaction effect between sowing date, variety and nutrient management

Interaction effect between sowing date, variety and nutrient management were not significant towards LAI at 60 and 90 DAS but, it was found significant at 30 DAS in the investigation (Table 4.7).

4.2.4 Dry matter accumulation

A continuous increasing trend in dry matter accumulation of finger millet was observed with the advancement of crop growth upto 90 DAS (Table 4.8).

4.2.4.1 Effect of sowing date

Finger millet sown on 20 July (D_1) produced highest dry matter at 30 (28.70 g m^{-2}), 60 (90.06 g m^{-2}) and 90 DAS (258.89 g m^{-2}) mainly due to production of a greater number of tillers m^{-2} and foliage growth than sowing on 11 August (D_2) (Table 4.8) (Fig. 4.10).

4.2.4.2 Effect of variety

Mean cultivar dry matter production of finger millet was 27.7, 80.0 and 242.6 g m^{-2} at 30, 60 and 90 DAS, respectively. Among two varieties, Indravathi (V_1) produced significantly higher dry matter (28.2 g m^{-2} at 30 DAS, 81.7 g m^{-2} at 60 DAS and 247.2 g m^{-2} at 90 DAS) than GPU 67 (V_2) at all the stages of observation (Table 4.8) (Fig. 4.11).

4.2.4.3 Effect of nutrient management

The diverse combinations of nutrient sources in the study had significant effect on dry matter yield of finger millet at all three stages of observation (Table 4.8) (Fig. 4.12). Perusal of data revealed that finger millet when nourished with chemical fertilizers (N_1) and integrated nutrient management without *Azospirillium* (N_2) could produce statistically at par dry matter in unit area at 60 (81.5 and 81.3 g m^{-2}) and 90 (244.3 and 245.5 g m^{-2}) DAS compared to integrated nutrient management with

Table 4. 8
Effect of sowing date, variety and nutrient management on dry matter accumulation at different stages of finger millet during *kharif* season

Treatment	Dry matter accumulation (g m^{-2})		
	30 DAS	60 DAS	90 DAS
Date of sowing			
D_1	28.7	90.1	258.9
D_2	26.7	69.9	226.3
SEm (±)	0.03	1.28	1.44
CD at 5%	0.20	7.77	8.77
Variety			
V_1	28.2	81.7	247.2
V_2	27.2	78.3	238.0
SEm (±)	0.08	0.57	0.73
CD at 5%	0.32	2.23	2.87
Nutrient management			
N_1	28.5	81.5	244.3
N_2	27.6	81.3	245.5
N_3	27.0	77.1	238.0
SEm (±)	0.21	1.25	1.94
CD at 5%	0.64	3.74	5.83
Interaction effect			
D_1V_1 N_1	29.6	104.3	264.1
D_1V_1 N_2	26.8	90.2	285.1
D_1V_1 N_3	30.2	82.7	233.0
D_1V_2 N_1	28.1	89.7	249.5
D_1V_2 N_2	29.4	100.4	287.1
D_1V_2 N_3	28.1	73.1	234.7
D_2V_1 N_1	28.6	68.4	256.5
D_2V_1 N_2	28.4	81.2	221.5
D_2V_1 N_3	25.4	63.1	223.1
D_2V_2 N_1	27.5	63.4	207.1
D_2V_2 N_2	25.8	53.6	188.2
D_2V_2 N_3	24.3	89.4	261.4
	D×V **V×N**	**D×V** **V×N**	**D×V** **V×N**
SEm (±)	0.11 0.30	0.80 1.76	1.03 2.75
CD at 5%	0.34 0.78	NS 4.64	6.34 7.07
	D×N **D×V×N**	**D×N** **D×V ×N**	**D×N** **D×V ×N**
SEm (±)	0.30 0.43	1.76 2.49	2.75 3.89
CD at 5%	0.75 1.28	5.77 7.48	7.99 11.65

DAS = Days after sowing, NS = Not significant

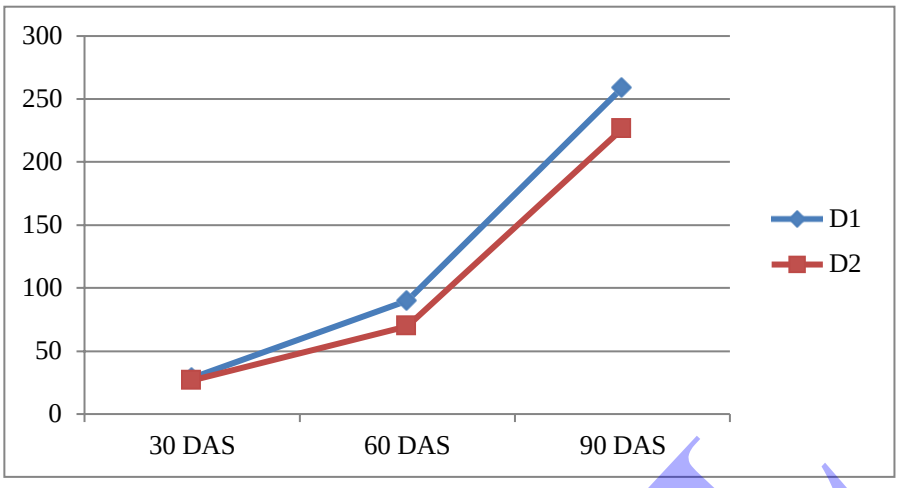


Fig. 4.10: Effect of date of sowing on DMA (g m^{-2}) of finger millet

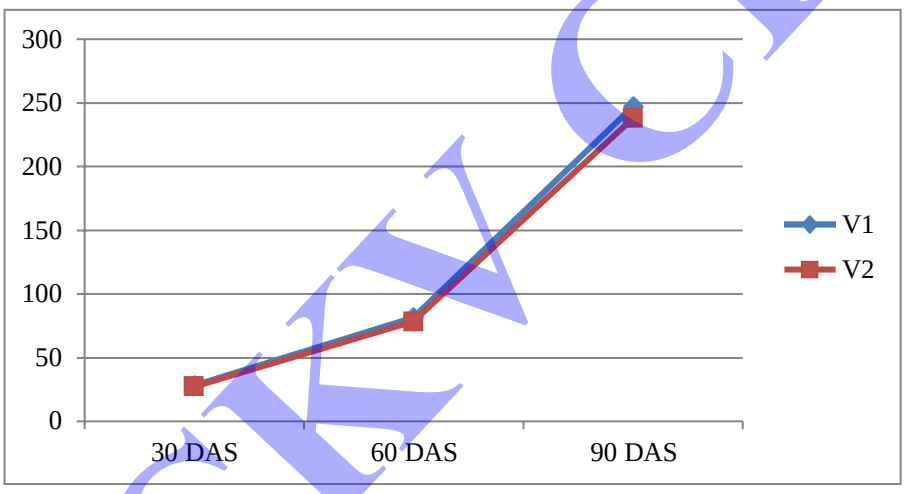


Fig. 4.11: Effect of variety on DMA (g m^{-2}) of finger millet

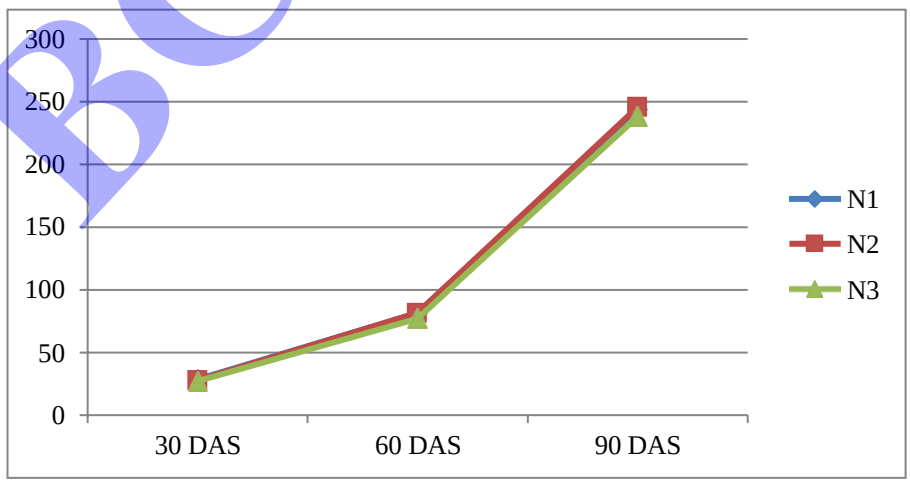


Fig. 4.12: Effect of nutrient management on DMA (g m^{-2}) of finger millet

Azospirillium (77.1 and 238.0 g m^{-2} at 60 and 90 DAS, respectively) in the investigation.

4.2.4.4 Interaction effect between sowing date, variety and nutrient management

Interaction effect between sowing date, varieties and nutrient management of finger millet towards accumulation of DM were found significant at all stages of recording observations (Table 4.8).

4.2.5 Crop growth rate (CGR)

CGR, irrespective of sowing time, variety or nutritional treatments, increased from 30 – 60 DAS to 60 – 90 DAS in the experiment (Table 4.9).

4.2.5.1 Effect of sowing date

Sowing time had significant effect on CGR of finger millet at 30 – 60 DAS, while, it was non-significant at 60 – 90 DAS in the study (Table 4.9).

4.2.5.2 Effect of variety

CGR, as influenced by dry matter accumulation in unit area in unit time, differed significantly due to varieties (Table 4.9). Indravathi (V_1) accumulated greater dry matter per unit area per unit time between 30 – 60 and 60 – 90 DAS (Table 4.8) and thus recorded higher CGR (2.1 g m^{-2} day^{-1} at 30 – 60 DAS and 5.5 g m^{-2} day^{-1} at 60 – 90 DAS) compared to GPU 67 (1.4 and 5.3 g m^{-2} day^{-1} at 30 – 60 and 60 – 90 DAS, respectively) in the experiment.

4.2.5.3 Effect of nutrient management

The variations in CGR values of finger millet at 30 days intervals due to nutrient management practices were not significant during the year of investigation (Table 4.9).

4.2.5.4 Interaction effect between sowing date, variety and nutrient management

Significant interaction between variety × nutrient management, sowing date × nutrient management and sowing date × *variety* × nutrient management was noticed for CGR in all the stages of observation. On the other hand, sowing date × *variety* was found non-significant for CGR at 30 – 60 and 60 – 90 DAS at Jaguli, Nadia, West Bengal.

Table 4.9
Effect of sowing date, variety and nutrient management on crop growth rate at different stages of finger millet during *kharif* season

Treatment	Crop growth rate (g m^{-2} day^{-1})	
	30 – 60 DAS	60 – 90 DAS
Date of sowing		
D_1	2.1	5.6
D_2	1.4	5.2
SEm (±)	0.04	0.08
CD at 5%	0.26	NS
Variety		
V_1	2.1	5.5
V_2	1.4	5.3
SEm (±)	0.04	0.02
CD at 5%	0.26	0.09
Nutrient management		
N_1	1.8	5.4
N_2	1.8	5.5
N_3	1.7	5.4
SEm (±)	0.04	0.05
CD at 5%	NS	NS
Interaction effect		
D_1V_1 N_1	2.5	5.3
D_1V_1 N_2	2.1	6.5
D_1V_1 N_3	1.8	5.0
D_1V_2 N_1	2.1	5.3
D_1V_2 N_2	2.4	6.2
D_1V_2 N_3	1.5	5.4
D_2V_1 N_1	1.3	6.3
D_2V_1 N_2	1.8	4.7
D_2V_1 N_3	1.3	5.3
D_2V_2 N_1	1.2	4.8
D_2V_2 N_2	0.9	4.5
D_2V_2 N_3	2.2	5.7
	D×V **V×N**	**D×V** **V×N**
SEm (±)	0.20 0.06	0.33 0.07
CD at 5%	NS 0.15	NS 0.19
	D×N **D×V×N**	**D×N** **D×V×N**
SEm (±)	0.06 0.08	0.07 0.11
CD at 5%	0.19 0.24	0.30 0.32

DAS = Days after sowing, NS = Not significan

4.3 Yield components and associated characters

4.3.1 Panicle length

4.3.1.1 Effect of sowing date

Panicle length of finger millet was significantly influenced by two sowing date during *kharif* season of 2023 (Table 4.10) (Fig. 4.13). Finger millet sown on 20 July (D_1) and 11 August (D_2) recorded higher (8.1 cm) and lower (7.9 cm) panicle length, respectively.

4.3.1.2 Effect of variety

Varietal difference in panicle length of finger millet was noted in the study (Table 4.9) (Fig. 4.13). The panicles of Indrabathi (V_1) were slightly higher (8.1 cm) compared to GPU 67 (7.9 cm) during *kharif* season in New Alluvial soil.

4.3.1.3 Effect of nutrient management

Nutrient management practices could significantly influence the panicle length of finger millet in the study (Table 4.10) (Fig. 4.13). Combination of FYM @ 20 kg RDN ha^{-1} as basal and Urea @ 20 kg RDN ha^{-1} as top dress at 35 DAS (N_2) resulted maximum panicle length (8.3 cm), which was 0.6 and 0.4 cm higher over sole inorganic fertilization through urea (N_1) and integration of FYM, Urea and *Azospirillum* (N_3), respectively.

4.3.1.4 Interaction effect between sowing date, variety and nutrient management

Interaction effect between main plots, sub plots and sub-sub plots on panicle length was found significant in the study (Table 4.10).

4.3.2 Number of fingers $panicle^{-1}$

4.3.2.1 Effect of sowing date

Sowing date had significant effect on the number of fingers $panicle^{-1}$of finger millet during *kharif* season in 2023 (Table 4.10) (Fig. 4.14). Delay in sowing from 20 July (D_1) to 11 August (D_2) resulted in successive decrease in number of fingers $panicle^{-1}$ (6.74 *vs.* 6.28), in the study.

Table 4.10
Effect of sowing date, variety and nutrient management on yield attributing characteristics of finger millet during *kharif* season

Treatment	Yield attributing characteristics			
	Panicle length (cm)	No. of fingers panicle^{-1}	No. of seeds panicle^{-1}	1000 grain weight (g)
Date of sowing				
D_1	8.1	6.7	576.6	4.7
D_2	7.9	6.3	528.5	4.6
SEm (±)	0.01	0.05	6.35	0.21
CD at 5%	0.07	0.30	38.66	NS
Variety				
V_1	8.1	6.6	573.8	4.6
V_2	7.9	6.4	531.4	4.7
SEm (±)	0.05	0.03	7.63	0.22
CD at 5%	0.21	0.13	29.97	NS
Nutrient management				
N_1	7.9	6.6	548.8	4.7
N_2	8.3	7.2	571.0	4.6
N_3	7.7	5.7	537.9	4.7
SEm (±)	0.10	0.06	8.02	0.15
CD at 5%	0.31	0.19	24.05	NS
Interaction effect				
D_1V_1 N_1	8.9	6.1	551.5	4.6
D_1V_1 N_2	8.8	7.7	679.6	4.4
D_1V_1 N_3	7.2	7.1	534.8	4.4
D_1V_2 N_1	6.9	6.0	561.0	5.0
D_1V_2 N_2	8.5	6.6	535.9	5.0
D_1V_2 N_3	8.1	7.0	597.1	5.0
D_2V_1 N_1	7.5	5.5	457.2	4.9
D_2V_1 N_2	8.2	7.0	576.2	4.8
D_2V_1 N_3	7.9	6.1	643.3	4.9
D_2V_2 N_1	8.3	5.3	625.6	4.3
D_2V_2 N_2	7.6	7.4	492.2	4.5
D_2V_2 N_3	7.8	6.4	376.4	4.5
	D×V	**V×N**	**D×V**	**V×N**	**D×V**	**V×N**	**D×V**	**V×N**
SEm (±)	0.08	0.14	0.05	0.09	10.79	11.35	0.32	0.22
CD at 5%	0.22	0.39	0.24	0.24	NS	35.99	NS	NS
	D×N	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**
SEm (±)	0.14	0.20	0.09	0.13	11.35	16.05	0.22	0.31
CD at 5%	0.36	0.62	0.26	0.38	NS	48.11	NS	NS

NS = Not significant

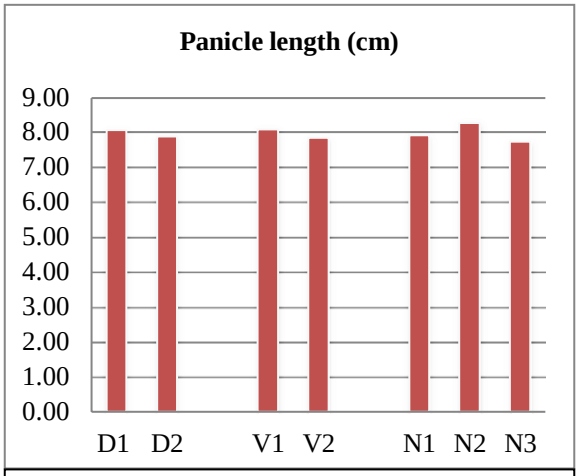


Fig. 4.13: Effect of sowing date, variety and nutrient management on panicle length of finger millet

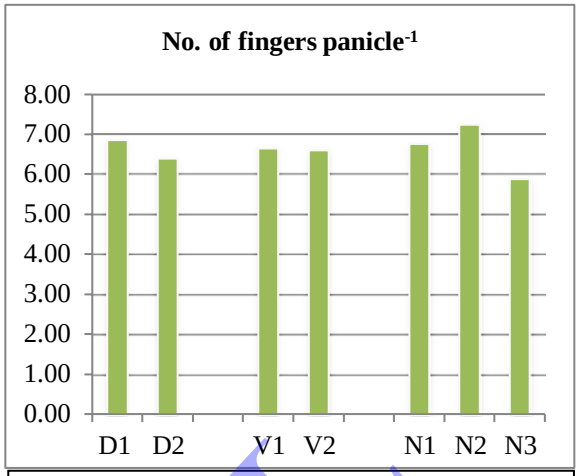


Fig. 4.14: Effect of sowing date, variety and nutrient management on no. of fingers panicle^{-1} of finger millet

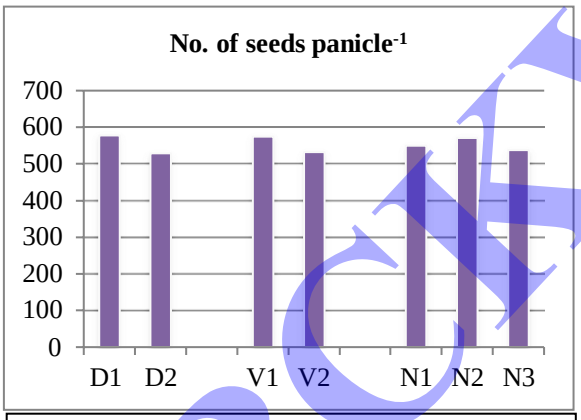


Fig. 4.15: Effect of sowing date, variety and nutrient management on no. of seeds panicle^{-1} of finger millet

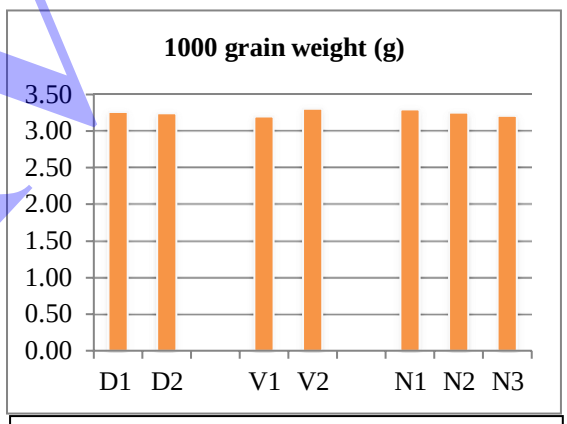


Fig. 4.16: Effect of sowing date, variety and nutrient management on 1000 grain weight of finger millet

4.3.2.2 Effect of variety

The number of fingers panicle^{-1} was significantly influenced by cultivars tested in the investigation (Table 4.10) (Fig. 4.14). Indravathi (V_1) produced relatively more number of fingers panicle^{-1} (6.58) than GPU 67 (6.44) in the experiment.

4.3.2.3 Effect of nutrient management

The number of fingers panicle^{-1} varied significantly among three nutrient management practices adopted in the study (Table 4.10) (Fig. 4.14). Integrated supply of nutrients (50% RDN as FYM + 50% RDN as Urea) resulted in maximum number of fingers in 1 m^2 area, while basal application of *Azospirillum* @ 2 kg ha^{-1} along with FYM @ 50% RDN followed by top dressing with urea @ 50% RDN at 35 DAS (N_3) led to the production of lowest number of fingers panicle^{-1} during wet season in *gangetic* alluvial soil.

4.3.2.4 Interaction effect between sowing date, variety and nutrient management

The interaction effect between sowing date, variety and nutrient management on number of fingers panicle^{-1} was significant in the study (Table 4.10).

4.3.3 Number of seeds panicle^{-1}

4.3.3.1 Effect of sowing date

Number of seeds panicle^{-1} was found to very significantly between two sowing dates during *kharif* season of 2023 at Jaguli, Nadia, West Bengal (Table 4.10) (Fig. 4.15). Finger millet sown on 20 July (D_1) recorded higher number of seeds panicle^{-1} (576.64) compared to 21 days late plantings (11 August) during the period of experimentation (Table 4.10).

4.3.3.2 Effect of variety

There was significant variation among two finger millet varieties with regard to the number of seeds panicle^{-1} during the experimental period of 2023 (Table 4.9). Based on number of seeds panicle^{-1}, two varieties of finger millet tested could be arranged as: Indravathi (573.76) > GPU 67 (531.35) in the investigation.

4.3.3.3 Effect of nutrient management

The number of seeds panicle^{-1} of finger millet was significantly influenced by three nutrient management practices in the investigation (Table 4.10) (Fig. 4.15). The finding suggested the use of FYM in combination with urea for better number of seeds panicle^{-1} (571.0) of finger millet instead of sole inorganic nutrient management system (N_1).

4.3.3.4 Interaction effect between sowing date, variety and nutrient management

The interaction effect between sowing date × variety and sowing date × nutrients management was found non-significant, while interaction between variety × nutrients management and sowing date × variety × nutrients management was significant in the experiment (Table 4.10) (Fig. 4.15).

4.3.4 1000 grain weight

4.3.4.1 Effect of sowing date

Sowing of finger millet at two different dates (20 July and 11 August) did not register any significant variation in test weight of grains during investigation year (Table 4.10) (Fig. 4.16).

4.3.4.2 Effect of variety

Though test weight is a varietal character but no significant variation was observed among two varieties of finger millet tested in the experiment (Table 4.10) (Fig. 4.16), which indicated that they had nearly similar grain size.

4.3.4.3 Effect of nutrient management

Being a genetical character, the varied combination of sources of nutrients had no significant effect on 1000 grain weight of finger millet in lower *gangetic* plains of West Bengal (Table 4.10) (Fig. 4.16); but Aparna *et al*. (2020) reported significant influence of nutrient management on 1000 grain weight of finger millet at Hyderabad during *rabi* season of 2018-2019.

4.3.4.4 Interaction effect between sowing date, variety and nutrient management

No significant interaction between sowing date × variety × nutrient management on test weight of grain was noted in the experiment (Table 4.10).

4.4 Yield

4.4.1 Grain yield

4.4.1.1 Effect of sowing date

Grain yield differed significantly among sowing dates during the year of investigation (Table 4.11) (Fig. 4.17). Finger millet sown on 20 July (D_1) produced 1314.8 kg ha^{-1} grain yield, which was 20.3% greater over sowing on 11 August (D_2) at Jaguli, Nadia, West Bengal. Similar types of findings for finger millet was reported by Sukanya *et al.* (2022), where sowing on 2nd FN of July resulted in higher grain yield, pooled over three years (2158.0 kg ha^{-1}) compared to late sowing on 1st FN of August (1728 kg ha^{-1}) and 2nd FN of August (1191 kg ha^{-1}) at Karaikal.

4.4.1.2 Effect of variety

Grain yield, an end product of interaction among yield components, was influenced significantly due to the varieties tested in the investigation (Table 4.11) (Fig. 4.17). Among the two varieties, Indravathi (V_1) produced the highest grain yield (1243.7 kg ha^{-1}), which was 80.0 kg ha^{-1} greater over GPU 67 (V_2).

4.4.1.3 Effect of nutrient management

Based on grain yield, three nutrient management could be arranged as: N_2 (1290.04 kg ha^{-1}) > N_1 (1208.26 kg ha^{-1}) > N_3 (1112.71 kg ha^{-1}) (Table 4.11) (Fig. 4.17), which indicated that, integrated nutrient management with 50% RDN through FYM + 50% RDN through urea at 35 DAS produced 6.8 and 15.9% greater yield over sole application of chemical fertilizers (N_1) and integrated nutrient management with *Azospirillum*, FYM and chemical fertilizers (N_3), respectively.

Prashanth *et al.* (2019) got higher seed yield of finger millet (2096 kg ha^{-1}) by applying FYM @ 10 t ha^{-1} + 100 % RDF during *Kharif* season, 2018 at GKVK, UAS, Bengaluru.

4.4.1.4 Interaction effect between sowing date, variety and nutrient management

Except sowing time × variety, all other interaction effect on grain yield was found significant in the study (Table 4.11). Based on pooled data, when GPU 67 was sown on 20 July (D_1) and nourished under integrated nutrient management through FYM and chemical fertilizer (N_2) produced the highest grain yield (1407.0 kg ha^{-1}) at Nadia, West Bengal (Table 4.11).

4.4.2 Straw yield

4.4.2.1 Effect of sowing date

With delay in sowing from 20 July (D_1) to 11 August (D_2), the straw yield of finger millet was progressively decreased from 2627.3 to 2491.5 kg ha^{-1}, during *kharif* season of 2023 (Table 4.11) (Fig. 4.18).

4.4.2.2 Effect of variety

Straw yield varied significantly among two finger millet varieties tested in the experiment (Table 4.11) (Fig. 4.18). Indravathi produced significantly taller plant height at harvest (Table 4.5) and thus recorded higher straw yield (2591.4 kg ha^{-1}) compared to GPU 67 (2527.4 kg ha^{-1}) at Jaguli, Nadia, West Bengal.

4.4.2.3 Effect of nutrient management

Straw yield of all three nutrient management was found significantly different in years of experimentation (Table 4.11) (Fig. 4.18). N_2 produced higher (2608.48 kg ha^{-1}) and N_3 produced lower (2481.33 kg ha^{-1}) straw yield of finger millet during rainy season in New Alluvial Zone of West Bengal.

4.4.2.4 Interaction effect between sowing date, variety and nutrient management

The interaction effect between the main plots × sub plots and sub plots × sub-sub plots were non-significant but main plots × sub-sub plots and main plots × sub plots × sub-sub plots were significant towards the straw yield of finger millet (Table 4.11).

Table 4.11
Effect of sowing date, variety and nutrient management on grain yield, straw yield and harvest index of finger millet during *kharif* season

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Date of sowing			
D_1	1314.8	2627.3	0.33
D_2	1092.6	2491.5	0.30
SEm (±)	3.52	9.22	0.001
CD at 5%	21.39	56.13	0.007
Variety			
V_1	1243.7	2591.4	0.32
V_2	1163.7	2527.4	0.31
SEm (±)	19.22	16.02	0.003
CD at 5%	75.45	62.91	NS
Nutrient management			
N_1	1208.3	2588.4	0.32
N_2	1290.0	2608.5	0.33
N_3	1112.7	2481.3	0.31
SEm (±)	19.65	27.49	0.004
CD at 5%	58.91	82.42	0.011
Interaction effect			
D_1V_1 N_1	1286.8	2767.6	0.32
D_1V_1 N_2	1388.3	2601.7	0.35
D_1V_1 N_3	1302.0	2518.1	0.34
D_1V_2 N_1	1265.4	2494.1	0.34
D_1V_2 N_2	1407.0	2729.5	0.34
D_1V_2 N_3	1239.0	2653.0	0.32
D_2V_1 N_1	1022.0	2490.1	0.29
D_2V_1 N_2	1318.3	2499.9	0.34
D_2V_1 N_3	1144.5	2671.0	0.30
D_2V_2 N_1	1258.8	2601.7	0.33
D_2V_2 N_2	1046.5	2602.8	0.29
D_2V_2 N_3	765.3	2083.2	0.27

	D×V	**V×N**	**D×V**	**V×N**	**D×V**	**V×N**
SEm (±)	27.18	27.79	22.66	38.88	0.004	0.005
CD at 5%	NS	89.14	NS	106.60	NS	0.016
	D×N	**D×V×N**	**D×N**	**D×V×N**	**D×N**	**D×V×N**
SEm (±)	27.79	39.30	38.88	54.98	0.005	0.007
CD at 5%	68.83	117.82	NS	164.84	NS	0.022

NS = Not significant

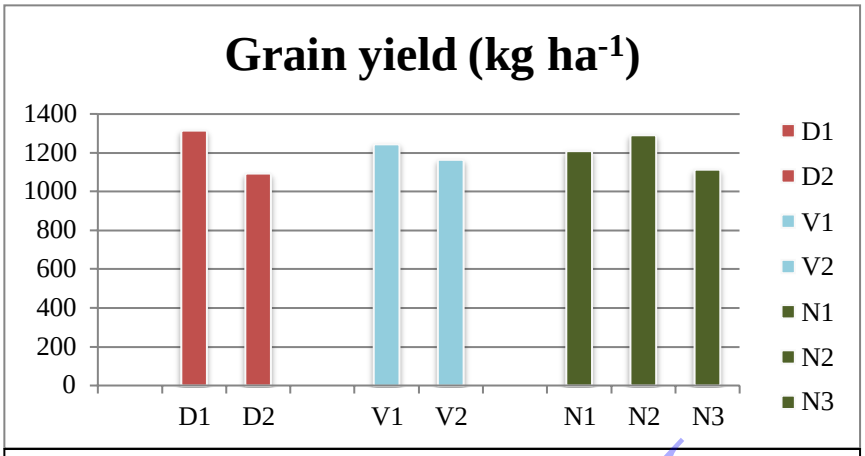


Fig. 4.17: Effect of sowing date, variety and nutrient management on grain yield of finger millet

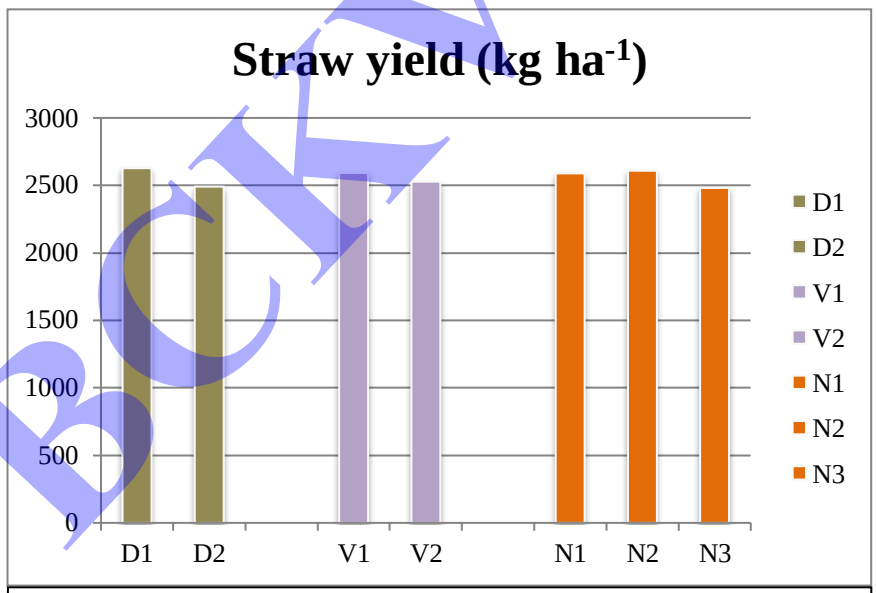


Fig. 4.18: Effect of sowing date, variety and nutrient management on straw yield of finger millet

4.4.3 Harvest index

4.4.3.1 Effect of sowing date

Sowing of finger millet on 20 July (D_1) resulted significantly greater harvest index (33%) over 11 August sowing (30%) in the experiment (Table 4.11).

4.4.3.2 Effect of variety

Varietal difference in harvest index of finger millet was not seen in the study (Table 4.11).

4.4.3.3 Effect of nutrient management

The variation in nutrient sources significantly influenced the harvest index of finger millet during the period of experimentation (Table 4.11).

4.4.3.4 Interaction effect between sowing date, variety and nutrient management

Like straw yield, similar type of interaction effect between main, sub and sub-sub plots was noticed in the study (Table 4.11).

4.5 Economics of production and benefit:cost ratio

4.5.1 Cost of cultivation

The common cost of cultivation of finger millet was Rs. 51,509.00 which included the cost of land preparation, sowing, weeding, harvesting, threshing, etc., excluding the cost of seeds, chemical fertilizers, organic manures and *Azospirillum* needed following treatment schedule in the study (Table 4.12).

4.5.1.1 Effect of sowing date

The common and total cost of cultivation of finger millet irrespective of sowing date was calculated as Rs. 51,509.00 and Rs. 55,502.00, respectively during *kharif* season at Jaguli, Nadia, West Bengal, India (Table 4.12).

Table 4.12
Common cost of cultivation (Rs. ha^{-1})

Particular	Quantity / No. unit^{-1} ha^{-1}	Rate (Rs. Unit^{-1})	Cost (Rs. ha^{-1})
Land preparation	2 man-days	363	**726**
	Ploughing by tractor	-	**3750**
SSP	125 kg	13	**1625**
MOP	33 kg	34	**1122**
Application of basal fertilizers	2 man-days	363	**726**
Sowing of seeds	20 man-days	363	**7260**
Thinning	20 man-days	363	**7260**
Weeding	40 man-days	363	**14520**
Harvesting and threshing	40 man-days	363	**14520**
Total			**51509**

Table 4.13
Effect of sowing date, variety and nutrient management on cost of cultivation of Finger millet

Treatment	Common cost of cultivation (Rs. ha^{-1})	Variable cost of cultivation (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})
Date of sowing			
D_1	51509	0	55502
D_2	51509	0	55502
Variety			
V_1	51509	750	55502
V_2	51509	750	55502
Nutrient management			
N_1	51509	1422	53681
N_2	51509	5074	57333
N_3	51509	3234	55493
Interaction effect			
D_1V_1 N_1	51509	-	53681
D_1V_1 N_2	51509	-	57333
D_1V_1 N_3	51509	-	55493
D_1V_2 N_1	51509	-	53681
D_1V_2 N_2	51509	-	57333
D_1V_2 N_3	51509	-	55493
D_2V_1 N_1	51509	-	53681
D_2V_1 N_2	51509	-	57333
D_2V_1 N_3	51509	-	55493
D_2V_2 N_1	51509	-	53681
D_2V_2 N_2	51509	-	57333
D_2V_2 N_3	51509	-	55493

Table 4.14
Effect of sowing date, variety and nutrient management on economics of Finger millet

Treatment	Economics		
	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Date of sowing			
D_1	95973.89	40471.56	1.73
D_2	80218.01	24715.67	1.45
SEm (±)	233.44	233.44	0.00
CD at 5%	1420.46	1420.46	0.02
Variety			
V_1	90943.77	35441.43	1.64
V_2	85248.13	29745.80	1.54
SEm (±)	1355.35	1355.35	0.02
CD at 5%	5321.76	5321.76	0.10
Nutrient management			
N_1	88460.64	34779.64	1.65
N_2	94215.64	36882.64	1.64
N_3	81611.57	26118.57	1.47
SEm (±)	1388.85	1388.85	0.03
CD at 5%	4163.77	4163.77	0.08
Interaction effect			
D_1V_1 N_1	94229.68	40548.68	1.76
D_1V_1 N_2	101085.83	43752.83	1.76
D_1V_1 N_3	94917.20	39424.20	1.71
D_1V_2 N_1	92316.83	38635.83	1.72
D_1V_2 N_2	102584.30	45251.30	1.79
D_1V_2 N_3	90709.50	35216.50	1.63
D_2V_1 N_1	75275.20	21594.20	1.40
D_2V_1 N_2	96033.23	38700.23	1.68
D_2V_1 N_3	84121.45	28628.45	1.52
D_2V_2 N_1	92020.83	38339.83	1.71
D_2V_2 N_2	77159.18	19826.18	1.35
D_2V_2 N_3	56698.13	1205.13	1.02
	D×V **V×N**	**D×V** **V×N**	**D×V** **V×N**
SEm (±)	1916.75 1964.13	1916.75 1964.13	0.03 0.04
CD at 5%	NS 6294.97	NS 6294.97	NS 0.11
	D×N **D×V×N**	**D×N** **D×V×N**	**D×N** **D×V×N**
SEm (±)	1964.13 2777.7	1964.13 2777.7	0.03 0.05
CD at 5%	4858.58 8327.54	4858.58 8327.54	0.09 0.15

NS = Not significant

*Price of finger millet grain and straw was Rs. 70.00 and 1.50 kg^{-1}, respectively

4.5.1.2 Effect of variety

As the common cost of cultivation and treatment cost was same for both the varieties, so total cost required for cultivating was same (Rs. 55502.00 ha^{-1}) in the experiment (Table 4.13).

4.5.1.3 Effect of nutrient management

The variable cost among nutrition-based treatments was noted between Rs. 1422.00 (N_1) and Rs. 5074.00 ha^{-1} (N_2) (Table 4.13), which might be due to differences in doses, types, quantities and rates of organic manures, chemical fertilizers and *Azospirillum* used in the experiment. Based on these, total cost of cultivation was increased by Rs. 3652.00 ha^{-1} (Rs. 57,333.00 *vs.* Rs. 53,681.00 ha^{-1}) for organic nutrient management (50% RDN through FYM + 50% RDN through urea) instead of 100% RDN through urea (Table 4.13).

4.5.1.4 Interaction effect between sowing date, variety and nutrient management

Though the common cost of cultivation (Rs. 51,509.00 ha^{-1}) for all the treatment combinations was same, but total cost of cultivation varied between Rs. 53,681.00 ha^{-1} ($D_1V_1N_1$ or $D_1V_2N_1$ or $D_2V_1N_1$ or $D_2V_2N_1$) and Rs. 57,333.00 ha^{-1} ($D_1V_1N_2$ or $D_1V_2N_2$ or $D_2V_1N_2$ or $D_2V_2N_2$) due to variation in different nutrition-based treatments caused (Table 4.13).

4.5.2 Gross return, net return and benefit:cost ratio

4.5.2.1 Effect of sowing date

With delay in planting from 20 July (D_1) to 11 August (D_2), the gross and net return was reduced by Rs. 15,755.90 ha^{-1} (Rs. 95,973.90 and Rs. 40,471.60 *vs.* Rs. 80,218.00 and Rs. 24,715.7 ha^{-1}) which led to higher B:C ratio in D_1 (1.73) over D_2 (1.45) in the study (Table 4.14).

4.5.2.2 Effect of variety

Among the two varieties, Indravathi (V_1) gave higher gross return (Rs. 90,943.80 ha^{-1}), net return (Rs.35,441.40 ha^{-1}) and B:C ratio (1.64) than GPU 67 (Rs.85,248.10 and 29,745.80 ha^{-1} and 1.54) in the study mainly due to greater economic yield (Table 4.14).

4.5.2.3 Effect of nutrient management

The nutrition-based treatments with regard to gross and net return could be arranged as: N_2 (Rs. 94,215.6 and 36,882.6 ha^{-1}) > N_1 (Rs. 88,460.6 and 34,779.6 ha^{-1}) > N_3 (Rs. 81,611.6 and 26,118.6 ha^{-1}) in the study (Table 4.14).

4.5.2.4 Interaction effect between sowing date, variety and nutrient management

Among the 12 different treatment combinations, sowing of finger millet variety 'GPU 67' on 20 July under integrated nutrient management without *Azospirillum* (N_2) resulted highest gross (Rs. 1,02584.30 ha^{-1}), net return (Rs. 45,251.30 ha^{-1}) and B:C ratio (1.79) which was followed by sowing of Indravathi on the same date under same nutrient management (gross return, net return and B : C ratio was Rs. 1,01085.80 ha^{-1}, Rs. 43,752.80 ha^{-1} and 1.76, respectively) in the experiment (Table 4.14).

Chapter 5

Summary and Conclusion

5. SUMMARY AND CONCLUSION

A field experiment entitled "EFFECT OF SOWING DATE, VARIETY AND NUTRIENT MANAGEMENT ON FINGER MILLET IN NEW ALLUVIAL ZONE OF WEST BENGAL" was conducted at the 'Instructional Farm of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal, India. The salient findings of the present investigation are summarized below:

The duration of finger millet was reduced successively with delay in sowing from 20 July (115.2 days) to 11 August (108.9 days). Mean cultivar days from sowing to 4th leaf stage, flower initiation, 50% flowering and maturity of finger millet were 16.0, 47.7, 9.7, 38.7 and 112.0, respectively. Irrespective of sowing date and nutrient management, two finger millet varieties took near similar days (111.9 to 112.2 days) to complete the life-cycle. The average summed GDD, HTU and PTU for entire life cycle were recorded as 2005.3^{o}C, 10132.1^{o}C hour and 24038.0^{o}C hour, respectively.

Irrespective of treatments, plant height, tiller number and dry matter yield of finger millet was increased consistently from emergence to maturity, whereas, LAI was increased upto 60 DAS and decreased thereafter. Crop sown on 20 July resulted better growth attributes *viz.* plant height, tiller numbers, LAI and DM production in all the growth stages of the crop compared to 11 August sowing in the study. Among two varieties, Indravathi recorded the highest maximum plant height at maturity (105.8 cm), number of tillers m^{-2} (118.0) at 90 DAS, LAI (4.16) at 60 DAS and dry matter production (247.2 g m^{-2}) at 90 DAS in the investigation. Variation in nutrient management with different sources showed significant influence on plant height, tiller production, dry matter accumulation and LAI of finger millet during *kharif* season in New Alluvial Zone of West Bengal. Application of FYM @ 20 kg RDN ha^{-1} as basal followed by top dressing with urea @ 20 kg RDN ha^{-1} at 35 DAS (N_2) recorded better growth attributes throughout the life cycle of the crop.

Among yield contributing characters, panicle length, number of fingers panicle^{-1} and number of seeds panicle^{-1} were significantly influenced by sowing dates, varieties and nutrient management in the study and thus primarily determined the variations in grain yield. Finger millet sown on 20 July (D_1) produced the highest grain yield (1314.8 kg ha^{-1}) which was significantly greater over 11 August sowing (1092.6 kg ha^{-1}) crop.

Indravathi (V_1) produced maximum grain yield (1243.7 kg ha^{-1}) which was 80.00 kg ha^{-1} greater over GPU 67 (V_2). The application of 50% RDN through FYM as basal + 50% RDN top dressing at 35 DAS (N_2) resulted higher grain yield (1290.0 kg ha^{-1}) which was 6.7 and 15.9% higher over N_1 (50% RDN through urea as basal + 50% RDN through urea as top dressing at 35 DAS) and N_3 (25% RDN through FYM + 25% RDN through *Azospirillum* as basal + 50% RDN through urea as top dressing at 35 DAS).

Though the common cost of cultivation (Rs. 51,509.00 ha^{-1}) was same for all the treatment combinations, but total cost of cultivation was varied between sole urea (Rs. 53,681.00 ha^{-1}) and FYM + urea (Rs. 57,333.00 ha^{-1}) applied plot. Mean gross return, net income and B:C ratio were ± Rs. 88,096.35 ha^{-1}, ± Rs. 32,593.65 ha^{-1} and ± 1.59. Among different treatment combinations, $D_1V_2N_2$ appeared most profitable due to maximum gross return (Rs. 102584.3 ha^{-1}), net income (Rs. 45251.3 ha^{-1}) and B:C ratio (1.79).

Thus, the results described above led to the following conclusions:

Finger millet sown on 20 July (D_1) resulted better growth and yield attributes and ultimately produced the highest grain yield (1314.8 kg ha^{-1}) over late sowing on 11 August (D_2). So, it could be advised to the farmers for sowing of finger millet within mid-July during *kharif* season in lower gangetic plains of West Bengal.

Among the two varieties, Indravathi (V_1) performed better in terms of grain yield (1243.7 kg ha^{-1}) than GPU 67 (1163.7 kg ha^{-1}). Therefore, Indravathi could be identified as promising finger millet variety in New Alluvial Zone of West Bengal.

Based on grain yield and net income, three nutrient management could be arranged as N_2 (1290.0 kg ha^{-1} and Rs. 36882.6) > N_1 (1208.3 kg ha^{-1} and Rs. 34779.6) > N_3 (1112.7 kg ha^{-1} and Rs. 26118.6). So, 20 kg RDN through FYM as basal + 20 kg RDN through urea as top dressing at 35 DAS could be practiced in finger millet field during *kharif* season for better economic return.

However, among the 12 treatment combinations, sowing of finger millet variety 'GPU 67' on 20 July under integrated nutrient management without *Azospirillum* (N_2) resulted highest gross (Rs. 1,02584.30 ha^{-1}), net return (Rs. 45,251.30 ha^{-1}) and B:C ratio (1.79) and thus, GPU 67 may be recommended as an alternative finger millet variety in lower *gangetic* plains of West Bengal during *kharif* season under integrated nutrient management system.

Chapter 6

Future Scope of Research

6. FUTURE SCOPE OF RESEARCH

In the investigation, the impact of sowing date, variety and nutrient management on finger millet has been studied during wet (*kharif*) season in New Alluvial Zone of West Bengal. However, there are many of opportunities to carry out future research programme on the following areas:

Since the experiment only lasted a year, it ought to be conducted again for a minimum of two years at the same place as well as in other parts of the state to validate the results and provide strong recommendations.

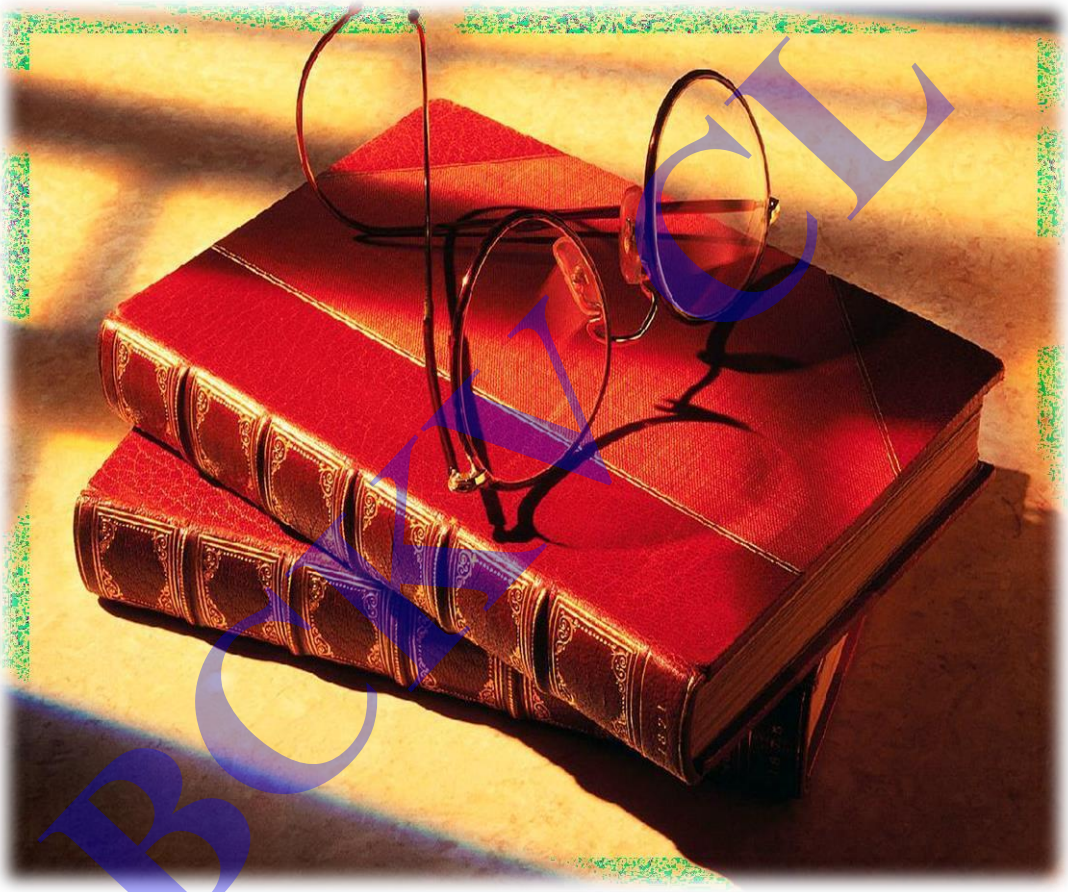
Research projects may be carried out to standardize cultural techniques such as planting dynamics, weed and water management, etc for identifying potential finger millet varieties in various locations.

Field studies could be carried out to examine the impact of additional locally accessible organic manures on finger millet in addition to FYM to develop an integrated nutrient management system that is unique to a given site.

Seed quality of finger millet such as protein, carbohydrate, Ca, Fe etc. should be determined.

The suitability of the other finger millet varieties in various agroclimatic zones of West Bengal could be determined by evaluating them based on their variable yield potentiality and grain quality.

It may be useful to formulate a future strategy for the development of finger millet by conducting a survey-based study in native areas to learn more about farmers' perceptions of agronomic practices, post-harvest processing, storage methods, value addition, marketing, etc., as well as to identify socio-economic constraints.



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